Relation between hospital surgical volume and outcome for pancreatic resection for neoplasm in a publicly funded health care system

Evidence

Études

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Abstract

Background: Recent studies from the United States have shown that institutions with higher numbers of pancreatic resection procedures for neoplasm have lower mortality rates associated with this procedure. However, minimal work has been done to assess whether the results of similar volume–outcome studies within a publicly financed health care system would differ from those obtained in a mixed public–private health care system.

Methods: A population-based retrospective analysis was used to examine pancreatic resection for neoplasm in Ontario for the period 1988/89 to 1994/95. Outcomes examined included in-hospital case fatality rate and mean length of stay in hospital. For each hospital, total procedure volume for the study period was defined as low (fewer than 22), medium (22–42) or high (more than 42). Regression models were used to measure volume–outcome relations.

Results: The likelihood of postoperative death was higher in low-volume and medium-volume centres than in high-volume centres (odds ratio 5.1 and 4.5 respectively; $p < 0.01$ for both). Mean length of stay was greater in low- and medium-volume centres than in high-volume centres (by 7.7 and 9.2 days respectively, $p < 0.01$ for both).

Interpretation: This study adds to growing evidence that, for pancreatic resection for neoplasm, patients may have better outcomes if they are treated in high-volume hospitals rather than low-volume hospitals.

Résumé

Contexte : Des études récentes réalisées aux États-Unis ont montré que dans les établissements qui réalisent plus de résections du pancréas à cause d'un néoplasme, les taux de mortalité associés à cette intervention sont moins élevés. On a toutefois réalisé très peu d'analyses pour déterminer si les conclusions de telles études sur les volumes et les résultats réalisées dans un système de soins de santé financé par le secteur public diffèrent de celles qu'on obtient dans un système de soins de santé public et privé mixte.

Méthodes : On a utilisé une analyse rétrospective stratifiée représentative pour examiner les résections du pancréas réalisées à cause d'un néoplasme en Ontario pendant la période de 1988–1989 à 1994–1995. Les résultats analysés ont inclus le taux de létalité par cas hospitalisé et la durée moyenne du séjour à l'hôpital. Pour chaque hôpital, on a établi que le volume total des interventions était bas (moins de 22), moyen (22 à 42) ou élevé (plus de 42). On a utilisé des modèles de régression pour mesurer les relations volume–résultat.

Résultats : La probabilité de mortalité postopératoire était plus élevée dans les centres où le volume est bas et moyen que dans ceux où il est élevé (coefficient de probabilité de 5,1 et 4,5 respectivement; $p < 0,01$ dans les deux cas). Le séjour est en moyenne plus long dans les établissements où le volume est bas et

moyen que dans ceux où il est élevé (par 7,7 et 9,2 jours respectivement; $p <$ 0,01 dans les deux cas).

Interprétation : Cette étude augmente les données probantes de plus en plus nombreuses selon lesquelles, dans un cas de résection du pancréas à cause d'un néoplasme, les patients peuvent obtenir de meilleurs résultats s'ils sont traités dans des hôpitaux où le volume est élevé que s'ils sont traités dans ceux où il est faible.

Positive volume–outcome relations, which suggest better quality of care with greater volume of service, have been documented for surgical procedures as different as cholecystectomy and coronary artery bypass grafting.[1–3] Three recent studies analysing data from the United States showed that institutions with higher surgical volumes for pancreatic resection for neoplasm had lower mortality rates and shorter mean lengths of stay associated with these procedures than low-volume centres.[4–6] A fourth study, which used data from the US Department of Defense, did not find positive volume–outcome effects among 100 hospitals providing surgery for pancreatic cancer.[7] In explaining their findings, the authors of this study raised an important question: Do financial or logistic barriers to care, which are present in the wider US health care system, with its mix of private and public insurance coverage, lead to the selective referral of lower-risk patients to high-volume centres and thus lead to better outcomes in those centres?

In this study we examined volume–outcome relations for pancreatic resection for neoplasm in Ontario (population 9.7 million). The outcomes studied included in-hospital case fatality rate and length of stay in hospital. By using data from a publicly funded health care system, we were better able to isolate volume–outcome relations from potential economic or logistic barriers to care. We also considered the impact of early readmission data on measures of outcome.

Methods

Data sources and inclusion criteria

Every hospital admission in Ontario leads to a discharge abstract, coded and collected by the Canadian Institute for Health Information (CIHI). This discharge database uses the *Canadian Classification of Diagnostic, Therapeutic and Surgical Procedures*[8] for coding surgical procedures and the *International Classification of Diseases*, 9th revision, clinical modification[9] (ICD-9-CM) for coding diagnoses. For fiscal years (Apr. 1 to Mar. 31) 1988/89 to 1994/95, we defined pancreatic resection for neoplasm as procedure codes 645 (total pancreatectomy) and 646 (radical pancreaticoduodenectomy) if linked to a diagnosis code in the range 140 to 239 (all neoplasms).

Relevant patient and hospital characteristics were abstracted from the database, including patient's discharge status (dead or alive), length of hospital stay from date of admission, age, sex, comorbid conditions, admission status (elective or urgent/emergent), hospital affiliation (teaching or non-teaching institution) and hospital size (number of beds). Outcomes examined included length of stay and case fatality rate. Length of stay may be considered a marker of quality of care, because patients experiencing postoperative complications would presumably have a greater length of stay. Where necessary, length of stay was truncated to the 95th percentile (64 days, calculated from data for all patients), to prevent skewing by a few patients whose length of stay was much longer than 64 days.[10]

Case fatality rates were first calculated on the basis of death occurring during the index admission, regardless of length of stay. We then studied readmission data to capture additional deaths and length of stay that might be attributable to the original procedure. Because 95% of the patients had been discharged from their initial admission by 64 days, we constructed a 64-day window from the date of admission to capture early readmissions. A readmission included either a second admission to any hospital or transfer to a convalescent or other acute care institution. Data were attributed to the original hospital providing the surgery, and readmission length of stay was calculated as the date of original admission to the date of final discharge.

Analysis

For the 7-year period of the study, we determined annual surgical volumes for the province, the number of hospitals providing the procedures, case fatality rate and mean length of stay. We first observed the distribution of surgical volumes for each hospital and defined total procedure volume as low (fewer than 22 procedures over the period or fewer than 3 procedures/year), medium (22–42 procedures over the period or 3–6 procedures/year) or high (more than 42 procedures over the period or more than 6 procedures/year). The volume gradients chosen combined the need for statistical stability and clinical relevance. Patient and hospital characteristics were determined for the 3 groups, and, where appropriate, the χ^2 test or analysis of variance was used to determine the statistical significance of the differences.

Logistic regression was used to assess relations between surgical volume and mortality rate, and linear regression was used to assess relations between surgical volume and length of stay. The linear regression models considered only patients who were discharged alive. With case fatality rate and length of stay as the dependent variables, all regression models included the following independent variables: patient age, sex,

comorbidity, admission status, hospital teaching status and hospital size. The validated modification of a comorbidity index for ICD-9-CM of Deyo and associates[11] was used to define comorbidity.

The regression models were also designed to include additional data for case fatality rate and length of stay for patients readmitted within the constructed 64-day window.

Results

There were 842 pancreatic resections for neoplasm from 1988/89 to 1994/95 in Ontario, performed at a total of 68 centres; the provincial in-hospital case fatality rate was 9.7% and the mean length of stay was 32.3 days. During the study period there was no marked change from year to year in the number of hospitals providing this type of surgery, and there was no discernible pattern of change in the provincial in-hospital case fatality rate or the mean length of stay.

Table 1 shows the various hospital and patient characteristics for the 3 volume groups. The 56 low-volume hospitals provided 42% of all procedures. Case fatality rates for the low-, medium- and high-volume groups were 11.3%, 12.4% and 3.4% respectively. When data from early readmissions was included, the case fatality rates were 14.4%, 12.8% and 3.4% respectively. Length of stay was consistently lower in the high–volume group. Fewer women underwent surgery in high-volume centres, and the patients undergoing surgery in these centres were generally younger.

Our regression models, as detailed in Table 2, examined outcomes during the initial stay in hospital. The models adjusted for different distributions, among the 3 volume groups, of hospital and patient characteristics, such as the younger age of patients treated in high-volume centres and the tendency for surgery in those centres to be done on a nonurgent basis. The odds of dying from pancreatic resection were 5.1 times greater (confidence interval [CI] 1.9–13.5, $p < 0.01$) and the average length of stay for patients was 7.7 days longer (CI 3.9–11.5, $p < 0.01$) in low-volume than in high-volume

Table 1: Hospital and patient characteristics by surgical volume group for pancreatic resection for neoplasm performed in Ontario, 1988/89 to 1994/95

Characteristic	Low-volume centres (< 22 procedures)	Medium-volume centres (22–42 procedures)	High-volume centres (> 42 procedures)	*p* value
No. (and %) of cases	354 (42.0)	282 (33.5)	206 (24.5)	NA
No. of hospitals	56	10	2	NA
Hospital size, mean no. of beds	419.3	613.2	1200.0	< 0.05*
Procedures performed in teaching hospitals, %	39.3	64.9	100.0	< 0.01†
In-hospital case fatality rate, %				
Without readmissions	11.3	12.4	3.4	< 0.01†
Readmissions included	14.4	12.8	3.4	< 0.01†
Mean length of stay, d				
Without readmissions	30.5	33.5	25.3	< 0.05*
Readmissions included	36.8	39.9	32.2	< 0.05*
Female patients, %	50.3	43.6	43.2	NS†
Age, % of patients				
< 60 yr	37.6	30.5	43.7	< 0.05†
60–69 yr	35.0	40.8	34.0	
> 69 yr	27.4	28.7	22.3	
Comorbidity index,‡ % of patients				
Score 0	78.0	79.1	80.1	NS†
Score 1	19.5	18.8	18.4	
Score 2	2.5	2.1	1.5	
Admission status, % urgent or emergent	64.1	53.6	27.7	< 0.01†

Note: NA = not applicable, NS = not significant.
*Test for significance based on analysis of variance for continuous variables.
†Test for significance based on χ^2 test for categorical variables.
‡Definition of comorbidity index from Deyo and associates.[11]

centres. Similarly, the odds ratio for in-hospital death was 4.5 (CI 1.8–11.4, $p < 0.01$) and the average length of stay was 9.2 days longer (CI 5.8–12.6, $p < 0.01$) in medium-volume than in high-volume centres. The inclusion of readmission data accentuated the positive influence of volume on case fatality rate and length of stay. When readmission data were included in the analysis, the odds ratio for in-hospital case fatality in the low-volume group was 5.7 (CI 2.2–14.9, $p < 0.01$) relative to the high-volume group, and the difference in length of stay was 8.5 days (CI 3.9–13.0, $p < 0.01$).

Female patients, younger patients and those with lower comorbidity scores had a lower probability of postoperative death. Length of stay was shorter for younger patients, those with lower comorbidity score, those undergoing surgery on an elective basis and those at smaller hospitals. For patients undergoing surgery in teaching hospitals, the odds ratio for death during the index admission was 2.0 (CI 1.1–3.5, $p < 0.05$) relative to patients undergoing surgery in nonteaching hospitals. Ten of the 12 patients who died during readmission originally underwent surgery in nonteaching hospitals, and when readmission deaths were included in the analysis, hospital teaching status was not statistically significant as a predictor of death (OR 1.5, CI 0.9–2.5, $p > 0.05$).

After completing our initial analysis, we conducted sensitivity analyses, in which we varied the volume cutoffs by 1 to 3 procedures/year in both directions; the results of this analysis indicated that our model was robust. The lower odds of in-hospital death in the high-volume group became nonsignificant only when the lower limit of that group was reduced below 4 procedures/year and a greater number of high-mortality, medium-volume centres were reclassified as "high-volume." It is important to recognize that within the low- and medium-volume groups, individual hospitals had widely differing mortality rates (Fig. 1).

Interpretation

This study supports the hypothesis that there is a positive relation between surgical volume and patient outcome after pancreatic resection for neoplasm; that is, patients treated in institutions with a higher volume of

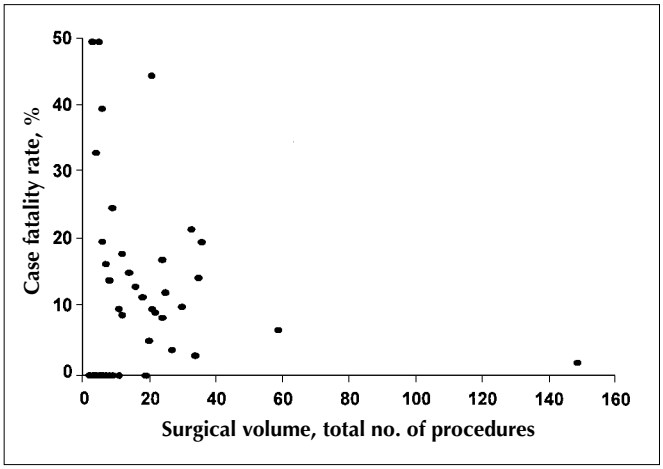

Fig. 1: Case fatality rate for pancreatic resection for neoplasm as a function of total number of procedures performed over the period 1988/89 to 1994/95 for 68 hospitals in Ontario.

Table 2: Regression models for pancreatic resection for neoplasm

	In-hospital case fatality rate		Additional length of stay, days	
Explanatory variables*	Odds ratio (and 95% CI)	*p* value	Mean (and 95% CI)	*p* value
Volume of procedures				
Medium (22–42)	4.5 (1.8 to 11.4)	< 0.01	9.2 (5.8 to 12.6)	< 0.01
Low (< 22)	5.1 (1.9 to 13.5)	< 0.01	7.7 (3.9 to 11.5)	< 0.01
Female sex	0.5 (0.3 to 0.8)	< 0.01	–1.9 (–4.0 to 0.2)	NS
Age, yr				
60–69	1.7 (0.9 to 3.2)	NS	1.8 (–0.6 to 4.3)	NS
> 69	3.4 (1.8 to 6.4)	< 0.01	5.1 (2.3 to 7.8)	< 0.01
Comorbidity index				
Score 1	2.2 (1.3 to 3.8)	< 0.01	3.9 (1.2 to 6.7)	< 0.01
Score 2	3.2 (1.0 to 10.2)	NS	7.8 (–0.4 to 15.9)	NS
Urgent admission	1.3 (0.8 to 2.1)	NS	5.1 (2.9 to 7.3)	< 0.01
Teaching hospital	2.0 (1.1 to 3.5)	< 0.05	0.3 (–2.3 to 2.9)	NS
Hospital size, no. of beds				
300–600	0.9 (0.5 to 1.6)	NS	–3.4 (–6.3 to –0.6)	< 0.05
< 300	0.9 (0.3 to 2.3)	NS	–3.4 (–7.6 to 0.8)	NS

Note: CI = confidence interval.
*Reference comparisons were high volume of procedures, male sex, age less than 60 years, comorbidity score 0, nonurgent admission, nonteaching hospital and number of beds greater than 600 respectively.

procedures have better outcomes, in terms of postoperative death and mean length of stay, than those treated in institutions with a lower volume of procedures. Our results are consistent with 3 other population-based studies,[4-6] which used US data (Table 3). In each jurisdiction studied, only 1 or 2 hospitals were considered to have a high volume of procedures and achieved optimal outcomes, and there was no clear linear volume–outcome improvement within the lower-volume groups. This raises the possibility that the better outcomes are the result of the expertise and resources available in the high-volume centres rather than a direct result of greater surgical volume. Further research is needed to assess the impact on outcome of factors such as specialized surgical training, expertise in diagnostic and interventional radiology, and critical care resources. In addition, for studying length of stay, institutional practices such as admission for preoperative testing or a lack of community-based supportive services should be considered.

Wade and associates,[7] using US Department of Defense data, did not find a positive volume–outcome relation for pancreatic resection and suggested that the absence of financial and logistic barriers to care in their study sample prevented worse outcomes in the low-volume institutions in their study. By extension, they theorized that these same financial and logistic barriers to care, which are present in the wider mixed public–private health care system in the US, led to the selective referral of lower-risk patients to, and thus better outcomes in, high-volume institutions, as reported by Lieberman and colleagues[5] and Gordon and collaborators.[6]

However, the results of these latter 2 papers, as well as those of Glasgow and associates,[4] are similar to our own, even though we used data from Ontario's publicly funded health care system, where there are minimal financial and logistic barriers to care. Thus a positive volume–outcome relation, in favour of high-volume institutions, has been demonstrated in both a fully funded public health care system and a mixed public–private system. In addition, it is more likely that the lack of a positive volume–outcome relation in the study by Wade and associates[7] resulted from a lack of high-volume centres (those performing more than 6 procedures/year) than from the absence of a referral bias among US military medical institutions.

When readmission data were included in our regression analyses, both the odds of in-hospital death and the greater length of stay for the low-volume centres (relative to the high-volume centres) increased. As well, teaching hospital status was no longer predictive of in-hospital death. Given that the direction of transfer for patients with postoperative complications will probably be from lower- to higher-volume hospitals, exclusion of readmission data in volume–outcome studies may bias results against high-volume centres.

There is always a concern when large databases are used for retrospective analyses that risk adjustment or data accuracy is suboptimal. Previous studies have shown that the CIHI database is accurate for coding of major procedures or main diagnoses.[12] Among the 3 volume groups, comorbidity scores were evenly distributed. Disparities in admission status should have little clinical impact on the results of surgery and more likely reflect different approaches to the coding of admissions — curative surgery for pancreatic neoplasm should rarely be considered urgent. With regard to the selection of volume categories, sensitivity analyses showed that our results were robust when volume gradients were changed. Overall, we are satisfied with the accuracy of our data and the ability of our models to control for the impact of various patient and hospital characteristics on in-hospital case fatality rate and mean length of stay.

It is interesting that in our study and the previous 3 studies supporting positive volume–outcome relations for pancreatic resection, only 1 or 2 institutions achieved optimal outcomes. To transfer all patients scheduled for pancreatic resection to this small number of hospitals would be impractical. It may be more feasible to designate regional centres as pancreatic resection sites on the basis of factors such as population, geography, proven results, and a teaching and research capacity. Active support from involved clinicians, hospital administrators, policy-makers

Table 3: In-hospital case fatality rates after pancreatic resection for neoplasm in various jurisdictions and low- and high-volume centres

Study	Jurisdiction	Period of study	Case fatality rate, %		
			Overall	Low-volume centres	High-volume centres
Gordon et al[6]	Maryland	1988–1993	7.7	13.0–19.1	2.2
Lieberman et al[5]	New York	1984–1991	12.9	21.8	4.0
Glasgow et al[4]	California	1990–1994	9.9	14.1	3.5
Present study	Ontario	1988/89 to 1994/95	9.7	11.3	3.4

and patient representatives would be necessary to achieve such regionalization.

These results for pancreatic resection for neoplasm in a publicly funded health care system parallel those from a mixed public–private system. Where possible, early readmission data should be included in studies of this sort to more accurately reflect relations between volume and outcome.

Competing interests: None declared.

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