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Pancreatic Resection Results in a Statewide Surgical Collaborative

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Abstract

Background—A strong relationship between hospital caseload and adverse outcomes has been demonstrated for pancreatic resections. Participation in regional surgical collaboratives may mitigate this phenomenon. This study sought to investigate changes over time in adverse outcomes after pancreatectomy across hospitals with different caseloads in a statewide surgical collaborative.

Methods—The study investigated patients undergoing pancreatic resection from January 2008 to August 2013 at Michigan Surgical Quality Collaborative (MSQC) hospitals (1007 patients in 19 academic and community hospitals). Risk-adjusted rates of major complications, mortality, and failure to rescue were compared between hospitals based on caseloads (low, medium, and high) in early (2008–2010) and later (2011–2013) periods. Finally, the degree to which different complications explained changes in hospital outcome variation was assessed.

Results—Adjusted rates of major complications and mortality decreased over time, driven largely by improvements at low-caseload hospitals. In 2008–2010, risk-adjusted major complication rates were higher for low-caseload than for high-caseload hospitals (27.8 vs. 17.8 %; $p = 0.02$). However, these differences were attenuated in 2011–2013 (22.2 vs. 20.0 %; $p = 0.74$). Similarly, adjusted mortality rates were higher in low-caseload hospitals in 2008–2010 (6.2 vs. 0.8 %; $p = 0.02$), but these differences were attenuated in 2011–2013 (3.3 vs. 1.1 %; $p = 0.18$). Variation in major complications decreased, largely due to decreased variation in “medical” complication rates, with less change in surgical-site complications.

Conclusion—Participation in regional quality collaboratives by lower-volume hospitals can attenuate the volume–outcome relationship for pancreatic surgery. Continued work in

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collaboratives with an emphasis on technical and intraoperative aspects of care may improve overall quality of care.

Pancreatic resections are complex and associated with a high risk of complications. Hospitals with a higher volume of pancreatectomies have been shown to have better postoperative outcomes than lower-volume hospitals.^{1–9} This has led various groups to recommend regionalizing pancreatic resections (i.e., limiting them to centers that perform a threshold number of procedures annually).^{1,10,11} As such, there is an increasing concentration of pancreatic resections to fewer hospitals, further amplifying the so-called volume–outcome effect.¹²

However, regionalization as a stand-alone strategy for quality improvement has limitations and potential unintended consequences. Despite increased regionalization, postoperative morbidity and mortality for pancreatic resections remain high, and access to care may be limited by confining pancreatic surgery to only a few centers within a region.^{2,12–16}

An alternative strategy for outcomes improvement is to engage hospitals and surgeons in regional collaboration with the goal of improving the performance of all hospitals.^{17–20} Through robust outcome measurement, tracking, and reporting, both national- and regional-level programs have demonstrated the ability to improve global adverse event rates for participating hospitals.^{16,20,21} Although regional collaboratives have shown improved outcomes in general, it remains unclear whether such results apply specifically to pancreatic resections.²¹

In this context, we evaluated pancreatic surgery outcomes over time within a regional surgical quality collaborative in the state of Michigan. We used clinical registry data to assess morbidity, mortality, and failure-to-rescue rates across a diverse group of Michigan hospitals, including both high- and low-volume hospitals. Additionally, we examined trends in specific complication rates to determine whether variation in adverse event rates across hospitals was attributable to changes in medical versus surgical complications.

Methods

Data Source and Study Population

For the current study, we used data from the Michigan Surgical Quality Collaborative (MSQC) clinical registry. The MSQC is a payer-sponsored 52-hospital regional consortium. Details about data collection and data integrity have been described previously.¹⁷ In brief, trained personnel in each hospital collect patient demographic and comorbidity data, intra- and postoperative process details, and 30-day outcomes data for patients undergoing general and vascular surgery throughout the state. The MSQC uses a case-sampling method designed to minimize selection bias. Regular data audits ensure data accuracy.

For this study, we identified all patients undergoing open pancreatic resections from January 2008 to August 2013 using relevant Current Procedural Terminology codes as follows: pancreaticoduodenectomy (CPT 48150 and 48152), pancreaticoduodenectomy with pylorus preservation (CPT 48153-4), distal pancreatectomy (CPT 48140, 48145, and 48146), and total pancreatectomy (CPT 48155). We excluded patients who underwent emergent

procedures, patients with American Society of Anesthesiologists (ASA) class 5 or higher, and patients in hospitals with less than 4 years of participation during the study period to reduce the risk of chance temporal variation caused by short duration of hospital participation. Using these exclusion criteria, we excluded 133 patients in 19 community and academic hospitals from the analysis. For temporal comparison, we divided the study cohort equally into two periods: early (January 2008 to October 2010) and late (October 2010 to August 2013).

Independent Variables

The patient clinical and demographic data included age, sex, race, body mass index, presence of a primary hepatopancreaticobiliary cancer, hypertension, preoperative dialysis requirement, peripheral vascular disease, diabetes, preoperative ascites, and ASA class. The procedural data included concurrently performed procedures (extended lysis of adhesions, extended lymphadenectomy, additional organ resection, and/or vascular reconstruction derived from CPT codes), prolonged operative duration (defined as operative duration >75th percentile for each primary procedure type, e.g., pancreaticoduodenectomy, distal pancreatectomy, etc.), and length of hospital stay.

Outcome Variables

The main outcome measures in this study were rates of major complications, 30-day mortality, and failure to rescue (FTR), defined as mortality after a major complication.²² Major complications were derived from standardized registry definitions and included cardiopulmonary problems (cardiac arrest, myocardial infarction, unplanned intubation, pneumonia), surgical site (deep or organ-space surgical-site infection [SSI]), venous thromboembolism (deep venous thrombosis or pulmonary embolism), sepsis or septic shock, stroke, and acute renal insufficiency. For further analysis, we divided complications into medical (cardiopulmonary problems, venous thromboembolism, acute renal failure, or stroke) and surgical site (deep or organ space SSI) categories.

Statistical Analyses

This study aimed to characterize temporal changes in postoperative complication and mortality rates based on hospital caseload, and to identify which outcomes were responsible for any changes. We grouped hospitals according to their annual case submission into three categories: low (<10 cases submitted/year), middle (10–20 cases/year), and high (>20 cases/year) caseload centers. These case volumes do not represent all pancreatic resections in these hospitals but rather the number captured in the registry based on a robust sampling frame. However, these categories do reflect overall case volumes and help to minimize errors based on small individual hospital sample sizes. These cutoffs were chosen empirically based on the distribution of patients in the data set. All hospitals remained in their initial category (low, middle, high caseload) to allow for comparison across periods. Hospital characteristics such as bed size, teaching status, and for-profit status are as defined by the American Hospital Association Annual Survey.²³

To calculate adjusted rates of major complications, mortality, and FTR, we used mixed-effects logistic regression models for each outcome. To account for patient differences

across centers, each model was adjusted for patient age, sex, race, total number of comorbidities, cancer diagnosis, and procedure type (pancreaticoduodenectomy, distal pancreatectomy, or total pancreatectomy). Adjusted outcome rates then were compared across hospital caseload groups.

To investigate which outcomes were driving the temporal changes, we assessed how overall hospital variation in select outcomes changed between the study periods. For this portion of the analysis, adjusted rates of overall major complications, medical complications (cardiopulmonary problems, venous thromboembolism, acute renal failure, or stroke), and surgical-site complications (deep or organ space SSI) were calculated at the hospital level.

Hospital-specific adjusted outcome rates were calculated using hierarchical regression models and empirical Bayes' techniques. This approach has been described in detail elsewhere.^{24,25} In brief, in addition to adjusting for patient comorbidities and procedure type, hospital-specific outcome rates are further adjusted using empirical Bayes techniques to account for random variation caused by low sample sizes. Findings have shown this technique to be of particular importance for operations such as pancreatic resection because hospitals often have a low absolute number of these cases.²⁶ The overall group variance between the highest- and lowest-performing hospitals then was assessed for each time for overall complications, medical complications, and surgical-site complications. Change in variation (ν) then was defined as the proportional change of this overall variance in the hierarchical models between the two periods.

We performed all analyses using Stata release 13 (StataCorp, College Station, TX, USA). All reported p values are two-sided with alpha set at a p value of 0.05. Data collection for MSQC is Institutional Review Board (IRB) exempt at participating hospitals, and this study was deemed nonregulated by the University of Michigan's institutional review board.

Results

For this study, we identified 1007 patients in 19 hospitals undergoing pancreatic resections between 2008 and 2013 for analysis. The characteristics of the hospitals are shown in Table 1. The majority of the hospitals in our analysis fell into the lowest caseload (<10 cases/year) category. The majority of the hospitals were nonteaching institutions and not-for-profit hospitals as defined by the American Hospital Association. A mix of small (<99 beds), medium (100–399 beds), and large ($\geq$ 400 beds) hospitals was distributed among the three categories, except that the medium-caseload group had no small hospitals and the high-caseload group had no medium hospitals.

The patient and operative characteristics across the two periods are shown in Table 2. The majority of patients were white, and 48–61 % had a primary hepatopancreaticobiliary cancer depending on the period. Overall, the patients were similar in terms of gender, race, percentage of primary cancers, and comorbidity burden across periods. In general, the demographic, comorbidity, and operative characteristics were similar across the periods for all the hospitals. More patients with an ASA class higher than 2 were found in the later period for hospitals with medium case submission (79.7 vs. 70.1 %; $p < 0.05$), and more

extended lymphadenectomies were performed during the later period in the hospitals with high case submission (16.6 vs. 3.6 %, $p < 0.001$). Cases with prolonged operative duration (>75th percentile for each primary procedure type) were significantly more numerous in the later period for both the low (38.7 vs. 17.3 %; $p < 0.001$) and medium (28.8 vs. 17.2 %; $p < 0.05$) case submission hospitals.

Figure 1 shows the adjusted outcome rates across hospital groups in the early and late periods. The low-caseload hospitals had higher risk-adjusted major complication rates (Fig. 1a) than the high-caseload hospitals in 2008–2010 (27.8 vs. 17.8 %; $p = 0.02$), but these differences were attenuated in 2011–2013 (22.2 vs. 20.0 %; $p = 0.74$). The low-caseload hospitals had higher risk-adjusted mortality rates than the high-caseload hospitals in 2008–2010 (6.2 vs. 0.8 %; $p = 0.02$), but these differences were attenuated in 2011–2013 (3.3 vs. 1.1 %; $p = 0.18$) (Fig. 1b). Finally, the low-caseload hospitals had a trend of higher risk-adjusted FTR rates than the high-caseload hospitals in 2008–2010 (21.8 vs. 5.2 %; $p = 0.08$), with attenuation of these differences in 2011–2013 (14.9 vs. 4.7 %; $p = 0.14$) (Fig. 1c).

The overall hospital variation in selected outcomes between the two periods is shown in Fig. 2. The variation in major complication rates decreased (44 %, Fig. 2a) between the two periods, driven largely by decreasing variation in medical complications (cardiopulmonary problems, venous thromboembolism, acute renal failure, or stroke) across hospitals (33 %, Fig. 2b). In contrast, whereas surgical-site complication rates decreased in general, variation across hospitals decreased much less during the periods (6 %, Fig. 2c).

Discussion

We show that in the setting of a statewide surgical collaborative, variation in outcomes after pancreatic resection between high- and low-caseload centers in Michigan has decreased over time. This was observed for major complications and mortality after pancreatic resection, with a corresponding trend for rates of FTR. This occurred despite similar patient and procedure characteristics across the two periods for all hospitals. These results suggest the possibility that participating in a regional surgical collaborative may allow low-volume hospitals to achieve short-term outcomes comparable with those of higher-volume centers.

Previous research has demonstrated a volume–outcome relationship for pancreatectomy at state, regional, and national levels.^{2–9} However, the mechanisms behind this relationship are poorly understood. In our study, the lowest-volume hospitals and the traditionally poorest-performing hospitals showed the greatest improvement over time. It appears that hospitals with low caseloads can improve their pancreatectomy outcomes. Although it is unknown whether participation in a robust regional quality-improvement collaborative resulted in this improvement, there are theoretical reasons to believe that it might have contributed to the improvement.

The MSQC organization provides hospitals with a multifaceted intervention to improve quality in surgery. These facets include audit and feedback, a broader “community of practice” for surgeons (regular interactions with other surgeons from whom techniques and procedures can be learned), educational materials, and training in health care quality

improvement theory and practice.²⁰ It is well known that a single educational or feedback intervention is unlikely to improve health care quality. However, multifaceted interventions typically have larger effect sizes.²⁷

An alternative explanation for these findings, consistent with the volume–outcome mechanism, is that relationships between surgeons and hospitals fostered by this collaborative led to a referral of more difficult cases to higher-volume hospitals with a more extensive infrastructure to handle complex perioperative care. However, our case mix analysis shows that patients who underwent surgery at hospitals in the low-caseload category did not change significantly. Low-caseload hospitals continue to perform complex procedures with the same rates of additional organ resection and vascular reconstruction and increased rates of prolonged operative duration. Thus changes in referral patterns is unlikely to explain all the changes seen over time. Notably, patient age and comorbidity also were unchanged among patients who received care at lower-volume centers.

The decrease in the variation between high- and low-caseload hospitals was more pronounced with regard to medical complications than with respect to surgical complications. Other studies have shown a similar reduction in medical complications related to processes of perioperative care, such as venous thromboembolism after surgery with participation in a regional collaborative.^{16,21} Previous studies also have suggested that perioperative complication rates can improve over time with incorporation of practices such as adherence to perioperative care guidelines and standardized recovery pathways, which have been promoted by the MSQC for several years.^{28,29} It is possible that participation in a regional quality collaborative influenced how effectively hospitals managed patients perioperatively or how often they “rescued” them after postoperative complications.

Importantly, the incidence of surgical-site complications at these hospitals did not seem to improve over time, and this may be expected because improvements in technique may be more difficult to achieve through participation in a surgical collaborative alone. Investigation of other procedures has shown that technical skill is a very important contributor to adverse event rates after surgery.³⁰ It is likely that pancreatic resections are no different, although more directed study of this is needed.

This study had several limitations. First, the retrospective nature of the study cohort limited our ability to know which aspects of participation in MSQC influenced improvement in outcomes. Rates of morbidity and mortality after pancreatic resection have improved over time across all settings, so the possibility exists that our findings are only a reflection of national trends as opposed to participation in a regional collaborative.^{31,32} However, the changes seen in our study reflect relatively better outcomes than national data would predict. Nevertheless, further study is needed to compare MSQC results with those nationwide.

Second, although the current study demonstrated a decrease in variation in complications over time, these changes cannot with certainty be attributed to participation in a regional collaborative. Furthermore, a distinct and measurable intervention for pancreatectomy procedures was lacking between the two time groups. Although the dissemination of more generalized “best practices” offers direct benefits, some of the observed improvement is

possibly attributable to the Hawthorne effect created by participation in this group.³³ Either way, these results remain an important finding because they support the possibility that engagement in quality improvement efforts may lead to improved outcomes.

Third, we were limited by an inability to account for laparoscopic cases, unmeasured intraoperative technique differences, very specific tumor characteristics, and anesthesia-related variables such as fluid balance, which have been shown previously to influence outcomes.^{34–37} Our data did not provide us with the ability to understand individual case decision making, nor could we control for operations performed. Consequently, we could not provide explanations for such things as why extended lymphadenectomy increased in high-volume hospitals or why rates of additional organ resections, including liver resections, were higher than might be expected on the average in pancreatic resections. Procedure-specific complications such as incidence of pancreatic fistula or delayed gastric emptying also are not available, although there is ongoing consideration for collection of such data and more proactive focused interventions.

In conclusion, this study shows that pancreatectomy outcomes improved over time in lower-volume hospitals participating in a statewide surgical collaborative. These findings suggest the possibility that variation in pancreatectomy outcomes between high- and low-volume centers may be mitigated by participation in regional surgical quality improvement collaboration. Most of the improvements were realized with decreases in medical complications, so our findings also highlight the need to focus more on intraoperative and technical aspects of surgical procedures.

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Fig. 1. Adjusted rates for a major complications, b mortality, and c FTR across hospital groups for the early 2008–2010 period versus the late 2011–2013 period

Fig. 2.

Change in variation (ΔV) in **a** major complications, **b** medical complications, and **c** surgical-site complications between the early 2008–2010 period and the late 2011–2013 period. The connected dots represent individual hospitals over time. The variation in major complications across all the hospitals decreased by 44 %. The variation in medical complications decreased by 33 %, and the variation in surgical-site complications decreased by 6 %

Table 1
Characteristics of the 19 Michigan hospitals in this study divided empirically into three groups based on caseload for pancreatic resection

	Cases submitted per year		
	<10	10–20	>20
Hospitals	12	4	3
Teaching ^a	4	1	1
Not for profit ^a	10	4	3
Hospital size ^a			
Small (< 99 beds)	2	0	1
Medium (100–399 beds)	4	2	0
Large (≥ 400 beds)	5	2	2

^a Categories as defined by the American Hospital Association Annual Survey, 2007. Category data were not specified for 1 hospital in the analysis

Table 2
Patient and procedure characteristics for open pancreatic resections across periods, January 2008–August 2013

	<10 Cases/year			10–20 Cases/year			>20 Cases/year			Total cohort
	2008–2010 (n = 133)	2011–2013 (n = 124)	2008–2010 (n = 174)	2011–2013 (n = 153)	2008–2010 (n = 224)	2011–2013 (n = 199)				
Patient characteristics (%)										
Mean age (years)	64.4 ± 12.3	62.3 ± 12.0	62.1 ± 12.8	61.1 ± 12.6	62.4 ± 13.0	63.3 ± 13.6	62.6 ± 12.8			
Female sex	51.9	46.0	55.2	47.1	51.8	57.8	52.1			
White race	76.7	78.2	69.5	77.1	76.3	72.4	74.8			
3 Comorbidities ^a	13.5	12.1	12.1	14.4	13.4	11.6	12.8			
ASA class 3 or 4	76.7	75.0	70.1	79.7 ^b	65.2	69.9	71.9			
Primary HPB cancer	54.9	61.3	52.3	51.0	53.1	48.2	52.9			
Procedure characteristics (%)										
Whipple	48.1	48.4	52.3	47.1	46.4	46.2	48.1			
Pylorus-preserving Whipple	6.8	12.9	12.6	19.6	14.3	16.1	14.0			
Distal or near-total	42.1	34.7	31.0	31.4	35.3	31.7	34.1			
Total pancreatectomy	1.5	1.6	0.6	0.0	2.2	4.0	1.8			
Prolonged operative duration	17.3	38.7 ^b	17.2	28.8 ^b	25.9	21.1	24.3			
Concomitant procedures (%)										
Extended lymphadenectomy	0.0	1.6	0.0	4.6 ^b	3.6	16.6 ^b	5.0			
Additional organ resection	23.3	19.4	11.5	15.0	12.5	14.6	15.4			
Liver resection	6.0	4.0	6.3	5.9	3.6	4.5	5.0			
Colon resection	4.5	6.5	1.7	5.2	1.8	1.5	3.2			
Splenectomy	14.3	7.3	3.5	3.9	5.8	7.5	6.8			
Vascular reconstruction	3.0	4.8	1.2	3.9	4.0	4.5	3.6			

^aComorbidities from registry data include hypertension, preoperative dialysis requirement, peripheral vascular disease, diabetes, and preoperative ascites

^b $p < 0.05$ across time periods for univariate t-test, χ^2 analysis, or Fisher's exact test, as appropriate