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The Importance of Improving the Quality of Emergency Surgery for a Regional Quality Collaborative

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Abstract

INTRODUCTION—Within a large, statewide collaborative, significant improvement in surgical quality have been appreciated (9.0% reduction in morbidity for elective general and vascular surgery). Our group has not noted such quality improvement in the care of patients who had emergency operations. With this work, we aim to describe the scope of emergency surgical care within the Michigan Surgical Quality Collaborative (MSQC), variations in outcomes among hospitals, and variations in adherence to evidence based process measures. Overall, these data will form a basis for a broad based quality improvement initiative within Michigan.

METHODS—We report morbidity, mortality, and costs of emergency and elective general and vascular surgery cases (n= 190,826) within 34 hospitals participating in the MSQC from 2005 to 2010. Adjusted hospital specific outcomes were calculated using a step-wise multivariable logistic regression model. Adjustment covariates included patient specific co-morbidities and case complexity. Hospitals were also compared based on their adherence to evidence based process measures (measures at the patient level for each case – SCIP 1 and 2 compliance).

RESULTS—Emergency procedures account for approximately 11% of total cases, yet they represented 47% of mortalities and 28% of surgical complications. The complication-specific cost to payers was \$126 million for emergency cases and \$329 million for elective cases. Adjusted patient outcomes varied widely within MSQC hospitals; morbidity and mortality rates ranged from 16.3% to 33.9% and 4.0% to 12.4%, respectively. The variation among hospitals was not correlated with volume of emergency cases and case complexity. Hospital performance in emergency surgery was found to not depend on its share of emergent cases, but rather was found to directly correlate with its performance in elective surgery. For emergency colectomies, there was wide variation in compliance with SCIP 1 and 2 measures, and overall compliance (42.0%) was markedly lower than elective colon surgery (81.7%).

CONCLUSION(S)—Emergency surgical procedures are an important target for future quality improvement efforts within Michigan. Future work will identify best practices within high-performing hospitals and disseminate these practices within the collaborative.

Introduction

An obvious target for healthcare reform involves reducing surgical complications, as such efforts not only improve patient care but also reduce costs.^{1–3} For example, a single postoperative respiratory complication costs payers over \$52,000.^{1–3} Clearly, payers are

aware of the cost-quality relationship and are willing to invest in broad-based quality improvement efforts. Blue Cross Blue Shield of Michigan Foundation fully funds the Michigan Surgical Quality Collaborative (MSQC). This collaborative is one of several to have demonstrated the effectiveness of regional collaboratives in improving the quality of surgical care.⁴⁻⁸ Within the MSQC, there has been an absolute morbidity reduction in elective general and vascular surgery operations of 9.0%.⁹

Despite this early success within the MSQC, more recently the collaborative has struggled to maintain the rapid pace of reductions in surgical complications. Potentially, there needs to be a shift in the focus of many of our quality improvement efforts. While the efforts of the MSQC have demonstrated quality improvement in surgical outcomes, they have been localized primarily in non-emergency cases, with emergency surgical outcomes remaining stable and unacceptably poor. Though emergency cases represent a relatively small proportion of all surgeries, others have reported that these cases are responsible for a large proportion of morbidity, mortality, and costs.^{10,11} If there is significant variation in outcomes among emergency surgical cases within the MSQC, novel quality improvement efforts should target this area.

In this study, we investigated morbidity and mortality rates of patients who underwent emergency surgery in the state of Michigan. Our retrospective analysis utilized a large patient population that allowed us to investigate variations in case mix, patient characteristics, and clinical process measures in an effort to identify potential targets for statewide surgical improvement. We hypothesized that there remains substantial variation in emergency outcomes that are not solely attributable to patient factors or case mix.

Methods

Data Acquisition

The MSQC is a surgical quality collaborative involving 52 Michigan hospitals (over the observation period there were 34 participating hospitals). The collaborative engages in data collection, center specific outcomes feedback, and frequent quality improvement themed collaborative meetings with a focus on best practices. A robust number of preoperative patient characteristics, intraoperative events, and postoperative outcomes are collected as previously described.^{3,9,12,13}

Patient Selection

All patients entered into the MSQC clinical database between 2005– 2010 were analyzed for this work. Cases included both general and vascular surgical procedures. Cases were then stratified as either emergency or elective, as defined by the American College of Surgeons - National Surgical Quality Improvement Program (ACS - NSQIP). The Surgical Clinical Reviewer (SCR) reviewed the anesthesiology note to verify that the surgery was emergent. Urgent cases were included as elective cases.

Outcomes

The primary outcomes were 30-day postoperative morbidity and mortality. Morbidity was defined as at least one case of: acute renal failure, bleeding leading to transfusion, cardiac arrest, neurologic event (CVA, coma lasting more than 24 hours, or peripheral nerve injury), surgical site infection (superficial, deep, or organ space), deep venous thrombosis (DVT), prosthetic graft failure, myocardial infarction, renal insufficiency, pulmonary embolism, stroke, sepsis, septic shock, unplanned intubation, wound disruption, and ventilator dependence for more than 48 hours. Urinary tract infection was excluded as a morbid outcome for the analysis. Costs were calculated based on estimates made within our

previous work and reflect payer costs for a complication.¹⁻³ After adjusting for inflation, the average cost per postoperative surgical complication following general and vascular surgery was estimated to be \$9815 (2010 USD).

Process Measures

The Surgical Care Improvement Project (SCIP) is a national partnership of organizations committed to improving the safety of surgical care through the reduction of postoperative complications. SCIP has designated perioperative best practices to decrease occurrence of postoperative complications. In this study, we used prophylactic intravenous antibiotics administered within 60 minutes before surgical incision (SCIP-1) and appropriate selection of intravenous prophylactic antibiotic (SCIP-2) to measure hospital procedural compliance. SCIP compliance data was only available for colectomy cases within the MSQC database between 2007 – 2010. Colectomy cases were identified by four Current Procedural Terminology codes (1) open segmental colectomy (44140), (2) laparoscopic segmental colectomy (44204), (3) ileocolic resection (44160), and (4) laparoscopic ileocolic resection (44205).

Statistical Analysis

Descriptive statistics were computed for the study cohort. Continuous variables were summarized by the mean and standard deviation, while categorical variables were summarized with frequency tables. Continuous variables were compared using Student's t-test, while chi-square and Fisher's exact tests were used to compare categorical and dichotomous variables, respectively. Relationships between the proportion of emergent surgery and morbidity or mortality were assessed using linear regression techniques.

To further assess for site-specific variability, we used a logistic regression model to identify factors independently associated with morbidity and mortality. A morbid outcome was defined as the incidence of any of the outcomes previously listed. All candidate predictors were entered into the model, and stepwise backwards selection was used to select a subset of adjustment covariates. The 42 covariates available in the MSQC included: age, alcoholism, angina, ascites, Black race, bleeding diathesis, body mass index (BMI), cancer, chemotherapy, congestive heart failure (CHF), central nervous system (CNS) deficit, chronic obstructive pulmonary disease (COPD), cerebrovascular accident (CVA) resulting in residual neurological deficit, CVA resulting in no neurological deficit, diabetes, dialysis, dyspnea, esophageal varices, gangrene, gender, hemiplegia, hypertension, impaired sensorium, open wound, paraparesis, percutaneous transluminal coronary angioplasty (PTCA), preoperative myocardial infarction, preoperative sepsis, preoperative functional status, previous cardiac surgery, peripheral vascular disease (PVD), quadriparesis, radiotherapy, renal insufficiency, smoking, steroid use, transient ischemic attack (TIA), total operation time, transfer from home, transfusion, unintended weight loss, and ventilator dependence. The percent concordance was used to gauge the model's predictive accuracy.

The output from the logistic regression analysis was used to derive the adjusted morbidity and mortality ratios. These were calculated by dividing the predicted number of morbidity or mortality cases (sum of predicted frequencies per site) by the total number of observed cases per site. The 95% confidence intervals for these rates were calculated in an identical fashion, by dividing the upper and lower estimates by total cases per site.

A two-sided significance level of $\alpha = 0.001$ was used in all analyses. All statistical computations were performed in SAS v9.2 (SAS Institute; Cary, NC).

Results

Current outcomes in emergency surgery in Michigan

From 2005 to 2010, annual morbidity and mortality rates among patients undergoing emergency surgery in the MSQC database have remained relatively unchanged (Figure 1). More specifically, morbidity has ranged from 30.0% in 2005 to 21.3% in 2010, while mortality has ranged from 9.2% in 2005 to 7.0% in 2010.

Of the 190,826 total cases, 11.05% were designated as emergent (Figure 2a). Emergency cases accounted for 47.12% of all mortalities (Figure 2b) and 27.75% of all surgical complications (Figure 2c) within the study group. Estimates of payer costs for these complications are \$329,085,078 million for patients having elective surgery and \$126,411,116 million for patients having emergency surgery (Figure 2d).

Variation in outcomes among hospitals

Statistically significant risk factors for morbidity included: functional status (odds ratio [OR] = 2.03, 95% confidence interval [CI] 1.73 – 2.38), operation time (OR = 1.01, 95% CI 1.007 – 1.008), sepsis (OR = 2.25, 95% CI 2.08 – 2.43), age (OR = 1.03, 95% CI 1.02 – 1.03), dyspnea (OR = 1.74, 95% CI 1.57 – 1.92), ventilator dependence (OR = 3.35, 95% CI 2.77 – 4.05), CHF (OR = 2.18, 95% CI 1.78 – 2.66), ascites (OR = 1.90, 95% CI 1.60 – 2.26), steroid use (OR = 1.83, 95% CI 1.56 – 2.14), and renal insufficiency (OR = 2.44, 95% CI 1.94 – 3.07). The percent concordance for this model was 82.4%. These statistically significant risk factors were used to calculate adjusted morbidity rate for each hospital. As demonstrated in Figure 3a, there is wide variation in hospital specific adjusted morbidity rates, ranging from 16.3% to 33.9%. This variation can be partially explained with the designation of a hospital's American College of Surgeons Level I or Level II trauma center designation (OR = 1.20, 95% CI 1.10, 1.30), however when considered in the context of the entire model (controlling for case complexity and patient comorbidities), trauma designation is not a significant predictor of morbidity.

Statistically significant risk factors for 30-day mortality included: functional status (OR = 2.82, 95% CI 2.36 – 3.38), age (OR = 1.06, 95% CI 1.05 – 1.06), sepsis (OR = 2.05, 95% CI 1.81 – 2.32), cancer (OR = 5.35, 95% CI 4.24 – 6.76), operation time (OR = 1.00, 95% CI 1.003 – 1.004), ascites (OR = 2.72, 95% CI 2.21 – 3.35), ventilator dependence (OR = 2.88, 95% CI 2.36 – 3.52), dyspnea (OR = 1.72, 95% CI 1.51 – 1.96), dialysis (OR = 2.34, 95% CI 1.87 – 2.91), and transfer from home (OR = 0.60, 95% CI 0.51 – 0.70). The percent concordance for this model was 89.4%. These statistically significant risk factors were used to calculate adjusted mortality rate for each hospital. As demonstrated in Figure 3b, there is wide variation in hospital specific adjusted mortality rates, ranging from 4.0% to 12.4%. American College of Surgeons Level I or Level II trauma center designation was not a significant predictor of mortality ($p=0.18$, OR = 0.91, 95% CI 0.80, 1.04).

Case mix and hospital specific outcomes

There was a wide variation in the proportion of total cases that were emergent among hospitals, ranging from 3.9% to 16.0%. As shown in Figure 4, there was a trend towards better emergency surgery outcomes among hospitals with a higher proportion of cases that were emergent, though these correlations were modest (for morbidity, $r^2 = 0.22$; for mortality, $r^2 = 0.13$).

To assess the relationship between case complexity and emergency surgical outcomes, we examined the relationship between work RVU (as a measure of case complexity) and outcomes. Once again, we note a trend towards higher morbidity ($r^2 = 0.44$; $y = -0.6293x +$

28.983) and mortality ($r^2 = 0.31$; $y = -0.2194x + 9.9098$) in more complex cases. In an effort to better control for hospital specific variations in case mix, we limited analysis to the 5 most common emergency surgical procedures (laparoscopic appendectomy, open appendectomy, small bowel resection, laparoscopic cholecystectomy, and exploratory laparotomy). Even among these operations, there was wide variation in outcomes ranging from 3.1% to 28.0% for morbidity (Figure 5a) and 0.0% to 13.6% for 30-day mortality (Figure 5b).

Process measures and emergency surgical outcomes

To assess the relationship between outcomes of elective and emergency surgery, we compared the rates of morbidity (and mortality) among hospitals stratified by performance levels in elective surgery. Hospitals were stratified into quartiles based on their unadjusted morbidity rates and mortality rates for elective general and vascular surgery cases. Using the adjusted morbidity and mortality rates from the aforementioned logistic regression analysis, we computed the overall adjusted morbidity (Figure 6a) and mortality (Figure 6b) rates for each performance quartile.

We further studied process measure by assessing compliance with SCIP 1 and 2 among colectomy cases. There were a total of 4,739 colectomy cases and 7.7% of cases were emergent. SCIP 1 and SCIP 2 compliance significantly varied between elective and emergency cases. (Figure 7) SCIP 1 compliance was significantly lower among the emergency colectomy operations (68.4% vs. 93.1%, $p < 0.0001$) compared to the elective colectomy operations. SCIP 2 compliance was significantly lower among the emergency colectomy operations (55.3% vs. 85.3%, $p < 0.0001$) compared to the elective colectomy operations. Finally, concomitant SCIP 1 and SCIP 2 compliance was significantly lower among the emergency colectomy operations (42.0% vs. 81.7%, $p < 0.0001$) compared to elective colectomy operations.

Discussion

The MSQC has resulted in improved surgical outcomes and reduced costs for patients in Michigan, though these improvements have been appreciated primarily among elective surgical procedures.⁹ As a result, we studied outcomes following emergency general and vascular surgery within the MSQC. We hypothesized that there was wide variation in emergency surgical outcomes and process measure compliance among MSQC hospitals. Our results do indeed report wide variation in morbidity and mortality rates. These data suggest that this variation in outcomes is not simply related to differences in patient and case mix factors. Overall, this work highlights the need to refocus quality improvement efforts on the emergency patient population. Within this context, we make several specific plans to initiate broad-based quality improvement initiatives within the state, focusing on improving the care of emergency surgery patients.

Most broad-based quality improvement efforts, including the MSQC, have focused on elective surgical procedures.^{3,9,12,14} In part, this is related to concerns with comparing hospitals with wide variations in case mix and patient characteristics among emergent procedures, assuming that hospitals cannot remediate these issues. Additionally, best practices and quality improvement initiatives are easiest to implement in an elective surgical setting, as our data regarding SCIP compliance seems to suggest.

Considering the relative lack of attention on emergency surgery within our collaborative, it is not surprising that the pace of quality improvement has been slow in emergency surgical care within Michigan. Certainly, others have noted the importance and opportunities of focusing on emergency surgery cases.^{10,11,15} Also important, there are significant concerns

within the surgical community regarding workforce shortage, credentialing, and sub-specialization in acute care surgery and surgical critical care.^{16,17} Considering these current policy considerations within the surgical community, in addition to the clear need for more focused quality improvement efforts, we plan to invest significant time and resources to optimizing the care of emergency surgical patients within Michigan.

There are several important issues regarding our findings that require additional explanation. Though it is not surprising that there remains broad variation in surgical morbidity and mortality following emergency surgery, the degree of variation is greater than we expected, even after controlling for case mix by focusing on the five most common procedures and examining trauma level designation. The degree of variation is even more pronounced than previously reported using a national sample.¹¹ It is also surprising that within Michigan, emergency surgical procedures account for such a large percentage of the morbidity, mortality, and costs of surgical care; previous work had not detailed the implications of emergency surgery within a similar context. It is also notable that hospital performance in emergency surgery was found to weakly correlate with the percent of emergent cases, but rather was found to directly correlate with its performance in elective surgery. Consistent with other multicenter studies¹⁸, hospital performance related to ACS Trauma designation Level I & Level II demonstrated a higher rate of morbidity without a corresponding association with mortality. Additional post hoc analysis revealed the higher rate of morbidity had little impact on the models overall predictive ability increasing only from 82.4% to 83.2%. This reinforces the importance of examining the unique process measures related to emergency surgery in isolation from both trauma and elective operations.

Armed with this important information, we have planned site visits and surveys to investigate institutional characteristics and culture related to emergency surgical care. As we have done before, we used this data to identify the best performing centers and ask them to help the remainder of the collaborative improve.^{13,19} Future work will investigate the relationships between large hospitals with significant resources and designated acute care surgical teams, and smaller hospitals that lack these resources. In addition, we will explore the feasibility of regionalizing emergency care within the collaborative hospitals. Finally, we will investigate variations and reimbursement structures for surgeons throughout the state who take care of emergency surgical patients.

Although the MSQC data used in our analysis was comprehensive, our study must be interpreted in light of several limitations. Most importantly, our determination of “emergency” status must be carefully considered. Though formally defined by ACS-NSQIP, determination of “emergency” status is inherently subjective, and certainly can be influenced by non-clinical and institutional interpretation. However, previous work has suggested that, upon audit, less than 5% of these cases were misclassified by the abstractor.²⁰ Secondly, as policy, we have not investigated the important issue of provider-specific variation in outcomes within the MSQC, even though such considerations would likely be hampered by lack of sample size. Despite advanced multi-variable modeling and a robust dataset, clearly unmeasured parameters may have potentially contributed to the variation observed in site-specific morbidity. This issue is likely most relevant regarding case mix. To address this, we refocused the analysis on only the most common surgeries, and the results showed an even more pronounced variation in hospital specific performance. Another important consideration is that we only had granular “process measure” data on colectomy operations. Considering the important information gleaned from these data, we are changing our data collection variables to include more robust process measures. Finally, the conclusions from this work are not necessarily relevant to all hospitals within the state, however, this dataset represents a large proportion of emergency surgical care within our 34 hospital collaborative.

Within this work, we have demonstrated that a significant proportion of poor surgical outcomes within Michigan occur among patients who undergo emergency surgery and that there is wide variation in the quality of emergency surgical care among Michigan hospitals. We now plan to implement a broad-based program to improve the care of emergency surgery patients. This plan includes the following steps:

In all, our goal is a 10% reduction in both morbidity and mortality within one year of initiating the MSQC emergency surgery improvement project.

1. Disseminate these findings at a MSQC quarterly meeting.
2. Identify and visit the three best performing centers for site visits and best practice assessment. Conduct a statewide best practices survey focusing on emergency surgery.
3. Disseminate emergency surgery best practices and expert panel discussion at the following quarterly meeting.
4. Survey of all surgeons and nurses within the MSQC regarding major obstacles for implementing best practices.
5. Engage national leaders in acute care surgery regarding policy issues relevant to acute care surgery.
6. Measure best practices compliance and outcomes for one year
7. Discuss the financial aspects of improving the quality of emergency surgical care for clinicians, hospitals, and payers.

In all, our goal is a 10% reduction in both morbidity and mortality within one year of initiating the MSQC emergency surgery improvement project.

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FIGURE 1.

Absolute rates of 30-day postsurgical morbidity and mortality outcomes after emergency general and vascular surgery operations from 2005 to 2010. Emergency cases were stratified as per ACS-NSQIP definitions of emergency operations

Figure 2A

Case Breakdown

■ Emergent Cases ■ Elective Cases

n = 190826

Figure 2B

Mortality

■ Emergent Cases ■ Elective Cases

n = 3330

Figure 2C

Figure 2D

Complications and Associated Costs

FIGURE 2.

A, Case breakdown: 11% (n=21,077) of cases in the MSQC from 2005 to 2010 were emergent cases, whereas 89% (n=169,749) were elective cases. Elective cases represent the vastmajority of cases. B, Mortality. Emergency cases represent almost one half of mortality, representing only 11% of the cases. C, Complications: 27.75% (n = 12,818) of complications were in emergency operations. Complications are tabulated by adding each independent event from each cohort. D, Costs from complications: Complications from elective procedures represents \$329,085,078, whereas emergent costs represent \$126,411,116 added costs.

FIGURE 3.

A, Adjusted morbidity rates per hospital site. B, Adjusted mortality rates per hospital site.

FIGURE 4.

trend towards better emergency surgery outcomes among hospitals with a higher proportion of cases that were emergent, though these correlations were modest (for morbidity, $r^2 = 0.22$; for mortality, $r^2 = 0.13$).

FIGURE 5.

FIGURE 5A-B. Among these operations, there was wide variation in outcomes ranging from 3.1% to 28.0% for morbidity (Figure 5a) and 0.0% to 13.6% for 30-day mortality (Figure 5b).

FIGURE 6.
FIGURE 6A-B. Using the adjusted morbidity and mortality rates from the aforementioned logistic regression analysis, we computed the overall adjusted morbidity (Figure 6a) and mortality (Figure 6b) rates for each performance quartile.

FIGURE 7.

The studied process measure by assessing compliance with SCIP 1 and 2 among colectomy cases. There were a total of 4,739 colectomy cases and 7.7% of cases were emergent. SCIP 1 and SCIP 2 compliance significantly varied between elective and emergency cases.