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The Importance of the First Complication: Understanding Failure to Rescue After Emergent Surgery in the Elderly

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Abstract

Introduction—Perioperative mortality in the elderly is high following emergency surgery and varies significantly between hospitals– an observation partially explained by differences in failure to rescue. We hypothesize that failure to rescue following certain types of complications underlies the disproportionately poor outcomes observed in elderly patients.

Methods—We identified 23,217 patients undergoing emergent general or vascular surgery procedures at 41 hospitals within the Michigan Surgical Quality Collaborative between 2007 and 2012. Patients' first complications were identified and categorized by type. We compared failure to rescue rates at the patient-level between patients <75 and ≥75 years of age. We then compared failure to rescue rates after specific complications across hospitals grouped in tertiles by risk-adjusted 30-day mortality.

Results—Risk-adjusted failure to rescue rates were significantly higher in the elderly after a first infectious (21.7% vs. 10.3%; p<0.01) or pulmonary (38.2% vs. 20.4%; p<0.01) complication when compared to younger patients. At the hospital level, high morality centers failed to rescue elderly patients more frequently than low mortality centers after a first infectious (35.6% v. 22.2%; p<0.01) and pulmonary (24.3 v. 14.3; p<0.01) complication. Failure to rescue rates following cardiovascular complications did not differ significantly across patient ages or tertiles of hospital mortality.

Conclusion—Hospitals fail to rescue elderly patients at higher rates than younger patients after infectious and pulmonary complications. Efforts to recognize and manage these specific complications have the potential to improve emergency surgical care of the elderly in Michigan.

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Introduction

Addressing the challenges that come from providing surgical care to an aging population is a national priority. Elderly patients are complex, high-risk, and represent the largest growing demographic in surgical practice.(1, 2) These concerns are amplified for emergent surgeries, where elderly patients experience particularly poor outcomes.(3–5) In this context, recent evidence suggests that reducing failure to rescue events may be the most appropriate target for quality improvement within this demographic.(6)

Whether the risks of failure to rescue are higher following specific types of complications remains unclear. Previous findings indicate a relationship between cardiovascular or pulmonary complications and postoperative mortality in the elderly.(7, 8) However, these studies do not consider the time sequence of complications or how these observations may vary across hospitals. Preventing failure to rescue events requires both the recognition and subsequent management of complications.(9, 10) Given this, there may be particular utility in understanding the influence of patients' first complications on the hospital's ability to coordinate failure to rescue countermeasures.

In this context, we conducted a population-based study using data from the Michigan Surgical Quality Collaborative to investigate the impact of a patient's first complication on mortality after emergency surgery. In addition to comparing outcomes between the elderly and non-elderly, we assessed the relationship between specific complications and failure to rescue rates in elderly patients across hospitals stratified by mortality.

Methods

Data Source and Study Population

We studied data from the Michigan Surgical Quality Collaborative (MSQC) prospective clinical registry from 2007 through 2012 for patients undergoing emergent general or vascular surgery. The MSQC represents a partnership between two entities- Blue Cross and Blue Shield of Michigan and 52 Michigan hospitals. This project followed standard data definitions and collection protocols as we have previously described.(11) Data collection occurs at the hospital level by specific MSQC data-collection nurses. Accuracy of data collection and maintenance is ensured by rigorous training of staff and data audits performed at participating sites. We excluded all patients under the age of 18 or those with incomplete registry data. All available variables were collected for this analysis including patient demographics, preoperative risk factors, laboratory values, perioperative factors, and 30-day postoperative morbidity and mortality.

Outcomes

The primary outcomes for this study were 30-day in-hospital mortality, major complication, and failure to rescue. We determined various in-hospital postoperative complications such as surgical site infection (superficial, deep, and organ space), deep venous thrombosis, urinary tract infection, acute renal failure, postoperative bleeding requiring transfusion, stroke, unplanned intubation, fascial dehiscence, prolonged mechanical ventilation over 48 hours, myocardial infarction, pneumonia, pulmonary embolism, sepsis, vascular graft loss, and

renal insufficiency. We excluded urinary tract infection, deep venous thrombosis, renal insufficiency, and superficial surgical site infection in determining the incidence of major complications as has been previously described.(12) We grouped complications *a priori* by type in to three categories: cardiovascular (myocardial infarction, stroke, cardiac arrest), pulmonary (reintubation, prolonged ventilation, pneumonia), and infectious (deep and organ space surgical site infection, sepsis, septic shock). These complications have been previously identified as both common and correlated with mortality in elderly surgical patients.(8, 13) Complications were grouped by physiologic similarity, in addition to having similar management (recue) strategies. We defined failure to rescue as death following at least one major complication. For this study we were particularly interested in the sequence of patients' complications. The MSQC registry maintains data on the dates when each documented complication occurred, defined as the date the patient met standardized registry criteria (clinical, laboratory, and radiologic as applicable) for the complication. We calculated the time to development of an initial complication as the number of days between the index operation and the first documented postoperative complication.

Statistical Analysis

We compared demographic, comorbidity, and operative differences between patients using Student's *t*-test, Pearson Chi-squared (χ^2) and analysis of variance (ANOVA) as appropriate. For this study, we performed two distinct analyses stratifying subjects at the (1) patient-level and the (2) hospital-level. For our patient-level analysis, we stratified subjects by age – deeming those greater than or equal to 75 years of age elderly. The remaining patients were regarded as non-elderly. We used multilevel mixed-effects regression modeling to risk-adjust all outcomes. Models were assembled using backwards-stepwise selection. We adjusted the incidence of each outcome at the patient level for variables such as age, sex, race, BMI, diabetes, smoking status, alcohol use, dyspnea, do-not-resuscitate (DNR) status, preoperative functional status, chronic obstructive pulmonary disease (COPD), pneumonia, ascites, congestive heart failure, need for dialysis, hemiplegia, transient ischemic attack (TIA), disseminated cancer, steroid use, bleeding disorders, chemotherapy, radiotherapy, sepsis, esophageal varices, prior myocardial infarction, angina, hypertension requiring medication, peripheral vascular disease, prior operations, American Society of Anesthesiologists (ASA) class, operative duration (minutes), surgeon specialty, work Relative Value Units (RVU), and the need for intraoperative transfusion. The c-statistic for all models ranged between 0.77 and 0.84 with good calibration across deciles of risk on the basis of Hosmer-Lemeshow test.

We performed a similar analysis at the hospital-level using the same covariates listed above for risk-adjustment of 30-day mortality. However, for this analysis, we adjusted for reliability using empirical Bayes techniques.(14) This was done in order to minimize the effects of random variation in mortality differences between hospitals that can result from small sample size. We then used the risk- and reliability-adjusted mortality rates to rank hospitals and group them in to tertiles- low, middle, and high mortality. We then calculated the incidence of complications and failure to rescue for each group of hospitals. Our hospital analysis focused solely on the elderly cohort of patients in order to elucidate the possible mechanism of high mortality in this demographic.

All statistical analyses were performed using Stata statistical software version12.1 (College Station, Texas). This study was approved by the University of Michigan Institutional Review Board.

Results

Patient Characteristics

Patients' demographics and comorbid disease profile are detailed in Table 1. The median age for the non-elderly cohort was 49 (IQR=27) and 81 (IQR=6) for elderly patients. The non-elderly cohort of patients contained a higher percentage of patients of non-white race (30.3% vs. 20.9%; $p<0.01$). Overall, elderly patients had a higher comorbid disease burden when compared to non-elderly patients. However, a greater number of non-elderly patients were active smokers at the time of surgery (33.3% v. 9.4%; $p<0.01$). The most common operation for both elderly (23.9%) and non-elderly (11.1%) was colectomy. When assessing overall case distribution between cohorts.

Comparing Outcomes Between the Non-Elderly and Elderly

Elderly patients had higher overall (46.2% v. 22.9%) and major complication (40.6% v. 19.3%) rates when compared to younger patients ($p<0.01$ for both). (Table 2) Of those patients with complications, elderly patients experienced a first cardiovascular (4.6% v. 2.7%; $p<0.01$) or pulmonary (25.6% v. 20.3%; $p<0.01$) complication more often than non-elderly patients. Elderly patients experienced a first infectious complication less frequently than non-elderly patients (17.2% v. 23.4%; $p<0.01$). Mortality was significantly higher in elderly patients (19.7% v. 4.6%; $p<0.01$). Failure to rescue rates were significantly higher in elderly patients who experienced a first pulmonary (38.2% v. 20.4%; $p<0.01$) or infectious (21.7% v. 10.3%; $p<0.01$) complications. (Figure 1) Failure to rescue rates were not significantly different following a first cardiovascular complication (43.1% v. 41.5%; $p=0.15$).

Outcomes in Elderly Patients at Low, Middle, and High Mortality Hospitals

The incidence of any and specific postoperative complications were not significantly different across low, middle, and high mortality hospitals. (Table 3) Failure to rescue rates increased in a stepwise fashion from low, middle, and high mortality hospitals in elderly patients who experienced a first pulmonary (22.2%, 29.8%, 35.6%) or infectious (14.3%, 18.5%, 24.3%) complication ($p<0.01$ between low and high mortality for both). (Figure 2) Failure to rescue rates following a first cardiovascular complication were not significantly different across low, middle, and high mortality hospitals (41.2%, 38.3%, 44.1%; $p=0.32$).

Discussion

In this study, we report on differences in failure to rescue following specific complications in an elderly emergent surgical population. We found that failure to rescue rates are markedly different between elderly and non-elderly patients following an initial pulmonary or infectious complication. In contrast, there were no significant differences observed after cardiovascular complications. This observation persisted at the hospital-level, where high

mortality centers failed to rescue elderly patients from pulmonary or infectious complications at significantly higher rates than low mortality centers. These findings offer more granular data for hospitals as they address failure to rescue in elderly surgical patients.

Managing the risks of surgical care in elderly patients is complex. Opportunities to improve outcomes exist both before and after the operation. Recent evidence suggests that addressing issues such as nutritional status and polypharmacy can enhance risk-stratification and reduce morbidity in the elderly population.(15, 16) However, the acuity of elderly patients presenting for emergent surgical care renders many preoperative care practices impractical. Shifting the focus to postoperative care can identify tangible quality improvement targets for surgeons and hospitals.(6, 17) Intuitively, certain complications are more serious than others – specifically those associated with cardiopulmonary compromise.(7, 8, 13, 18) Others have shown that advanced age also predisposes patients to more serious renal and wound complications.(19) How these complications are managed may be a crucial determinant in how elderly patients fare after emergent operations.

Here we have shown that a patient's first complication is important. Recognition of a patient's first complication initiates the rescue effort. Despite similar outcomes following cardiovascular complications, elderly patients died more frequently than the non-elderly after an initial pulmonary or infectious complication. Clearly, cardiovascular complications are important for all patients and failure to rescue rates were universally high. For these complications, age may be less of a determinant of mortality than the physiologic insult itself. We also posit that diagnosis and management of a myocardial infarction, for example, is a highly protocolled endeavor.(20) Rescue practices may not vary significantly between patients or hospitals. Conversely, the diagnosis and management of postoperative pneumonia may be more subjective.(21, 22) How hospitals rescue patients from pulmonary and infectious complications underscores differences surgical mortality for elderly patients. This observation is substantiated by the fact that our results did not differ after accounting for the development of subsequent complications. Clinical management protocols have been shown to improve outcomes in patients with sepsis or ventilator associated pneumonia.(23, 24) However, few studies systematically examine these interventions for surgical patients. Further, the timeliness with which protocols are initiated may be particularly important for following surgery – as complications must first be recognized and diagnosed by care teams. Surgeons must also consider whether management protocols differ in efficacy between medical and surgical patients. Nonetheless, protocolled practices have improved the management of pulmonary and infectious disease processes and may represent a novel avenue for surgical quality improvement.

This study should be interpreted with consideration of several limitations. This is a retrospective study and as a result we are unable to assert causation. As with any large data registry, there are issues with data reliability and accuracy. However, the MSQC performs data audits and educates abstractors to ensure accuracy.(11) Complications are identified through specific clinical criteria. Nonetheless, we are unable to account for severity of complications. While abstractors report the date of diagnosis for each complication, this information is contingent on care teams documenting these findings in the medical record. Although this is a limitation, we do not believe that this would confound our data

differentially for patients of different ages. Further, we do not have information on specific care practices that may influence outcomes at these hospitals. Despite this, we believe this data provides the necessary context to study these critical issues.

In the emergent setting, surgeons rely on their postoperative management to mitigate the high risks ascribed to elderly patients. This study substantiates growing sentiments that appropriate surgical care is age-specific. Efforts to improve the coordination of care for pulmonary and infectious complications may attenuate the large mortality differences between elderly and non-elderly patients. Our Statewide surgical collaborative will use this information to augment existing quality improvement initiatives for Michigan's elderly surgical patients.

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Abbreviations

MSQC	Michigan Surgical Quality Collaborative
ASA	American Society of Anesthesiologists
RVU	Relative value units

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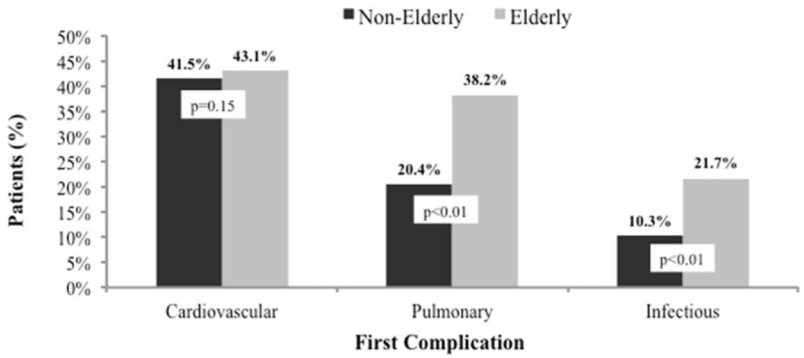

Figure 1.

Risk-adjusted failure to rescue rates for elderly and non-elderly patients stratified by type of first documented complication.

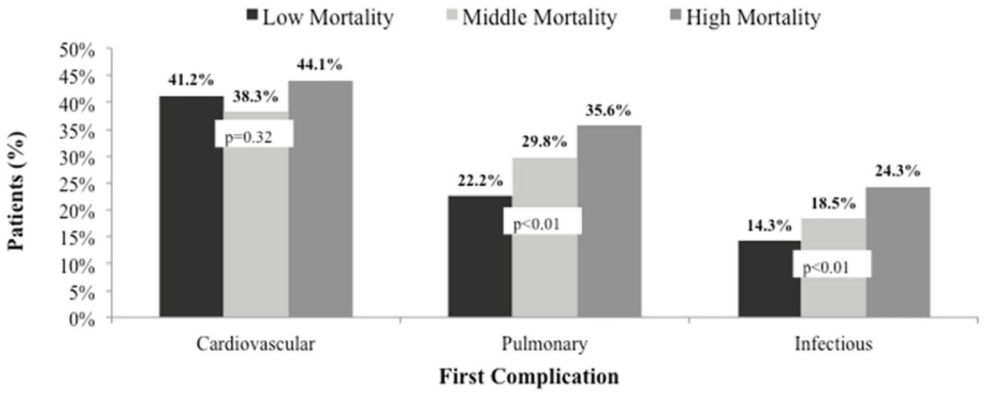

Figure 2.

Failure to rescue rates for elderly patients treated at low, middle, and high mortality hospitals. Patients are stratified by the type of first documented complication. P-values represent the comparison between low and high mortality hospitals.

Table 1

Patient demographics and clinical characteristics stratified by patient age.

Demographics	Non-Elderly (n=18,897)	Elderly (n=4,320)	P-value
Median age, y (IQR)	49 (27)	81 (6)	<0.01
Male sex, %	49.1%	40.8%	<0.01
Non-white race, %	30.3%	20.9%	<0.01
Mean BMI, (Kg/m2)	29.1	26.3	<0.01
Comorbidities, %			
Diabetes mellitus	13.2%	20.4%	<0.01
Smoking in past year	33.3%	9.4%	<0.01
Acute renal failure	1.8%	3.8%	<0.01
Preoperative sepsis	15.5%	21.2%	<0.01
Chronic obstructive pulmonary disease	6.1%	15.4%	<0.01
Dialysis	2.8%	3.8%	<0.01
Disseminated cancer	1.8%	3.1%	<0.01
Steroid use	3.5%	6.1%	<0.01
Albumin <3.5 g/dl	25.4%	53.1%	<0.01
Dependent functional status	11.4%	33.8%	<0.01
Hypertension requiring medication	36.2%	78.4%	<0.01
DNR	0.5%	5.5%	<0.01
Procedure Mix, %			
Colectomy	11.1%	23.9%	
Small bowel resection	4.2%	9.8%	
Laparoscopic cholecystectomy	5.9%	3.1%	<0.01
Ventral hernia repair	2.6%	2.6%	
Lower extremity amputation	1.1%	1.3%	

Table 2

Rates of morbidity and mortality stratified by patient age.

Outcomes	Non-Elderly	Elderly	P-value
Any Complication	22.9%	46.2%	<0.01
Major Complication	19.3%	40.6%	<0.01
Cardiovascular[1]	2.7%	4.6%	<0.01
Pulmonary[1]	20.3%	25.6%	<0.01
Infectious[1]	23.4%	17.2%	<0.01
Mortality	4.6%	19.7%	<0.01

[1]Type of patients' first documented complication in those patients with complications.

Table 3

Distribution of overall and first complications in elderly patients across hospitals stratified by mortality.

	Hospital Mortality			
Outcomes	**Low**	**Middle**	**High**	**p-value[2]**
Any Complication	48.5%	44.5%	44.2%	0.91
Major Complication	42.4%	39.5%	38.6%	0.84
Cardiovascular[1]	4.6%	5.7%	3.7%	0.44
Pulmonary[1]	26.0%	25.9%	23.9%	0.36
Infectious[1]	17.0%	21.5%	14.4%	0.18

[1]Type of patients' first documented complication in those patients with complications.

[2]P-value represents comparison of means across three tertiles.