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Research Paper

Failure to rescue following emergency general surgery: A national analysis

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ABSTRACT

Background: Failure to rescue (FTR) is increasingly recognized as a quality metric but remains understudied in emergency general surgery (EGS). We sought to identify patient and operative factors associated with FTR to better inform standardized metrics to mitigate this potentially preventable event.

Methods: All adult (≥18 years) non-elective hospitalizations for large bowel resection, small bowel resection, repair of perforated ulcer, laparotomy and lysis of adhesions were identified in the 2016–2020 National Readmissions Database. Patients undergoing trauma-related operations or procedures ≤2 days of admission were excluded. FTR was defined as in-hospital death following acute kidney injury requiring dialysis (AKI), myocardial infarction, pneumonia, respiratory failure, sepsis, stroke, or thromboembolism. Multilevel mixed-effect models were developed to assess factors linked with FTR.

Results: Among 826,548 EGS operations satisfying inclusion criteria, 298,062 (36.1 %) developed at least one MAE. Of those experiencing MAE, 43,477 (14.6 %) ultimately did not survive to discharge (FTR). Following adjustment for fixed hospital level effects, only 3.5 % of the variance in FTR was attributable to center-level differences. Relative to private insurance and the highest income quartile, Medicaid insurance (AOR 1.33; 95%CI, 1.23–1.43) and the lowest income quartile (AOR 1.22; 95%CI, 1.17–1.29) were linked with increased odds of FTR.

A subset analysis stratified complication-specific rates of FTR by insurance status. Relative to private insurance, Medicaid coverage and uninsured status were linked with greater odds of FTR following perioperative sepsis, pneumonia, and AKI.

Conclusion: Our findings underscore the need for increased screening and vigilance following perioperative complications to mitigate disparities in patient outcomes following high-risk EGS.

Introduction

With >500,000 cases performed each year in the US [1], emergency general surgery (EGS) assumes a crucial role in providing acute management for patients with significant hemodynamic disturbance and organ dysfunction [2]. Despite comprising approximately 11 % of total operations, EGS procedures are responsible for nearly 28 % of all surgical complications and half of all postoperative deaths [3]. In the contemporary landscape of value-based care, various surgical societies have increasingly emphasized the need for quality improvement initiatives aimed at optimizing outcomes for EGS patients [4]. Nevertheless, the evaluative paradigm surrounding quality benchmarking remains a nuanced and multifaceted challenge.

Variations in postoperative morality within the acute care setting have been widely documented [4,5]. However, previous reports have noted that rates of mortality alone may not be a suitable measure of quality, as they reflect case mix and severity of illness at presentation [6]. In this context, failure to rescue (FTR), defined as the inability to prevent mortality following a major complication, has emerged as a promising surrogate marker of quality [7]. Consequently, several groups have recently adopted FTR to assess care in cardiac, thoracic and trauma operations [8,9]. However, there exists a paucity of literature examining drivers of patient- and hospital-level variation in FTR among EGS patients in the recent decade.

The present study used a nationally representative cohort to examine the utility of FTR as a potential quality metric in emergency general surgery. Additionally, we identified patient- and hospital-level factors associated with FTR following EGS. We hypothesized increasing age,

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disadvantaged socioeconomic status, and a greater burden of comorbidities to be associated with higher risk adjusted odds of FTR. We further postulated the presence of significant interhospital variation in rates of FTR not otherwise explained by patient factors.

Methods

This was a retrospective study of the 2016–2020 Nationwide Readmissions Database (NRD). The NRD is the largest all-payer readmissions database and uses survey weights to provide accurate estimates for approximately 60 % of all United States hospitalizations [10].

All adult (≥18 years) hospitalizations entailing large bowel resection, small bowel resection, repair of a perforated ulcer, laparotomy and lysis of adhesions, were identified using relevant *International Classification of Diseases Tenth Revision* procedure codes (Supplementary Table 1). Appendectomy and cholecystectomy were excluded due to low rates of mortality and complications [11]. To reduce heterogeneity, patients with elective operations, admissions for trauma injury, or a hospital duration of stay <3 days, were excluded from the analysis. Records missing data for age, sex, costs, and in-hospital mortality, were further excluded (<1 %). Major adverse event (MAE) was defined as a composite of acute kidney injury requiring dialysis, myocardial infarction, pneumonia, respiratory failure, sepsis, stroke, or thromboembolism. FTR was defined as in-hospital mortality among patients who presented with at least 1 MAE. Patients were subsequently categorized into *FTR* and *non-FTR* cohorts (Fig. 1). The NRD data dictionary was used to define patient-level factors, including age, sex, insurance status, ZIP-code-adjusted income quartile, as well as hospital-level characteristics such as teaching status and bed size. To account for institutional experience, centers were categorized into low-, medium-, and high-volume tertiles based on the annual number of EGS hospitalizations. Briefly, unique hospital identifiers were used to tabulate institutional caseload of the reporting hospital, generating volume cutoffs at the 33rd and 67th percentiles. The modified Elixhauser Comorbidity Index, a previously validated composite score of 30 conditions, was used to capture the burden of chronic illness numerically [12]. For records entailing multiple operations, the procedure with the greatest probability of mortality was used for analysis [2].

Categorical variables are reported as proportions (%), while continuous variables are described as medians with interquartile range (IQR). The Pearson's χ^2 and adjusted Wald tests were used to compare categorical and continuous variables, respectively. Multilevel regressions accounting for fixed hospital effects were developed to identify the independent association of covariates with the risk of FTR. The first level included patient characteristics selected using elastic net regularization, which minimizes overfitting and collinearity via a penalized least-squares methodology [13]. Random effects were represented in the second level through unique hospital identifiers provided by the NRD. Regression outcomes are shown as adjusted odds ratio (AOR) with 95 % confidence intervals (95%CI). Standard mean differences (SMD) were obtained to demonstrate effect size. Statistical significance was set at α <0.05 and SMD > 0.1. All statistical analysis was performed using Stata software version 16.1 (StataCorp, College Station, TX). This study was exempted from full review by the University of California, Los Angeles Institutional Review Board.

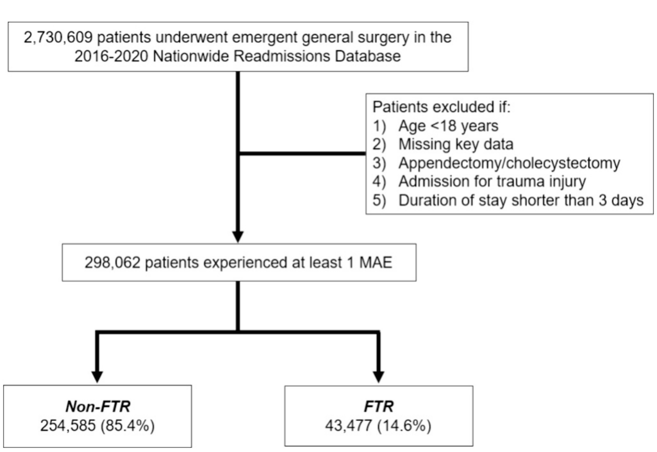

Fig. 1. Consort (Consolidated Standards of Reporting Trials) diagram of study cohort and survey-weighted sample size. *MAE*, major adverse event. *FTR*, failure to rescue.

Results

Among 826,548 EGS hospitalizations meeting inclusion criteria, 298,062 (36.1 %) had at least one MAE. Among patients experiencing MAE, 43,477 (14.6 %) ultimately did not survive to discharge (*FTR*) (Fig. 1). Compared with those who developed at least one complication but survived to discharge, the *FTR* cohort was older (73 [64–82] vs 68 [57–78] years, SMD = 0.41), had a higher median Elixhauser Comorbidity Index (4 [3–5] vs 3 [2–5], SMD = 0.36) (Table 1) and more frequently insured by Medicare (75.2 vs 62.1 %, SMD = 0.31). Additionally, *FTR* more often underwent large bowel resections (54.9 vs 49.9 %) and peptic ulcer repair (7.1 vs 5.5 %, SMD = 0.23), compared to others. Notably, *FTR* was similar at high-volume (77.3 vs 75.5 %, SMD = 0.06) and metropolitan teaching institutions (71.1 vs 68.0 %, SMD = 0.06)

Table 1
Demographic and clinical characteristics of patients who experience FTR after major complication relative to non-FTR. In addition to *p*-values, SMD was included to account for effect size of cohorts. *FTR*, failure to rescue. *SMD*, standard mean difference.

	Non-FTR (*n* = 254,585)	*FTR* (*n* = 43,777)	*P-value*	*SMD*
Age (y), median [IQR]	68 [57–78]	73 [64–82]	<0.001	0.41
Female, %	52.2	53.4	0.01	0.03
Elixhauser Index, median [IQR]	3 [2–5]	4 [3–5]	<0.001	0.36
Operative type, %			<0.001	0.23
Large Bowel Resection	49.9	54.9		
Lysis of Adhesion	17.0	10.0		
Small Bowel Resection	26.2	25.5		
Peptic Ulcer Repair	5.5	7.1		
Laparotomy	1.4	2.5		
Income quartile, %			<0.001	0.05
76th–100th	18.1	16.8		
51st-75th	24.4	23.4		
26th–50th	28.3	28.6		
0-25th	29.3	31.2		
Insurance coverage, %			<0.001	0.31
Private	22.1	12.2		
Medicare	62.1	75.2		
Medicaid	10.4	7.3		
Uninsured	5.4	5.3		
Comorbidities, %				
Congestive heart failure	16.5	26.0	<0.001	0.23
Pulmonary Circulatory Disorder	4.7	5.1	0.01	0.03
Peripheral vascular disease	12.0	22.2	<0.001	0.27
Late-stage kidney disease	2.6	6.5	<0.001	0.18
Liver disease	5.8	19.7	<0.001	0.42
Cancer	17.8	18.1	0.17	0.01
Coagulopathy	9.0	23.2	<0.001	0.40
Hospital volume, %			0.001	0.06
Low tertile	2.0	1.6		
Medium tertile	22.5	21.1		
Highest tertile	75.5	77.3		
Hospital teaching status, %			<0.001	0.06
Non-Metropolitan	8.5	7.6		
Metropolitan Non-Teaching	23.5	21.3		
Metropolitan Teaching	68.0	71.1		

To examine whether the present disparity was attributable to fixed hospital effects and clustering, a hierarchical mixed effects model was employed. An examination of the intraclass correlation coefficient revealed merely 3.5 % of the risk-adjusted variation in FTR to be attributable to hospital-level differences (Fig. 2). However, several patient factors including increasing age (AOR 1.03 per year; 95%CI, 1.03–1.04) and higher Elixhauser comorbidity index (AOR 1.02 per unit; 95%CI, 1.01–1.03) remained linked with increased odds of FTR (Fig. 3). Relative to large bowel resection, peptic ulcer repair (AOR 1.17; 95%CI, 1.10–1.25) demonstrated an increased risk of FTR. Notably, the lowest income quartile (AOR 1.22; 95%CI, 1.17–1.29) and Medicaid coverage (AOR 1.33; 95%CI, 1.23–1.43) were associated with increased risk of FTR, with the highest income quartile and private insurance as reference, respectively.

A secondary analysis was performed to examine complication-specific variation in FTR, stratified by insurance status. Relative to private insurance, Medicaid coverage was linked with increased odds of mortality following perioperative sepsis (AOR 1.28, 95%CI, 1.18–1.37), acute kidney injury (AOR 1.26, 95%CI, 1.12–1.39) and pneumonia (AOR 1.32, 95%CI, 1.12–1.53) (Fig. 4). However, similar odds of mortality following other complications were noted between private and public insurance status (Supplementary Fig. 1). Lack of insurance coverage was linked with increased odds of FTR following all complications, aside from intraoperative hemorrhage.

Discussion

While FTR has been increasingly adopted to assess hospital quality in various operations, the examination of this metric within EGS remains inadequately defined. The present study utilized a nationally representative cohort of EGS to identify hospital-level variation in FTR to evaluate its utility as a quality metric. Following a mixed-effects analysis, only 3.5 % of the variation in FTR was found to be attributable to the institution where the procedure was performed. However, we found several patient factors, including increased age, Medicaid insurance coverage and low income, to be associated with greater odds of FTR. Additionally, we noted variation in FTR among insurance status was driven by mortality following perioperative sepsis, acute kidney injury and pneumonia. Several of these findings warrant further discussion.

Over the past two decades, FTR has garnered significant attention in surgical practice as a quality metric [14]. Indeed, surgical groups including the Society of Thoracic Surgeons have endorsed low rates of FTR as a surrogate of institutional expertise [9]. In assessing the relevance of this metric in EGS, the present analysis revealed a low proportion of the total variation in FTR was explained by center-level differences. Congruent with this finding, Zangbar et al. demonstrated a lack of association between EGS mortality and hospital factors, including bed size and teaching status [15]. It is plausible that the poor correlation of FTR rates and hospital-level factors may reflect a degree of unmodifiable clinical complexity and severity of disease at the patient-level. Due to emergent presentation, EGS patients carry a significant baseline risk of mortality, which may not be mitigated by surgical interventions received in the hospital [16]. Consequently, the risk of FTR for individual patients may be a product of chronic comorbidities and sociodemographic risk factors which are not altered by hospital quality. Indeed, the lack of hospital-level variation in FTR demonstrates this metric to be a poor discriminator among centers performing EGS. Taken together, our findings highlight that FTR may not be an ideal benchmark of hospital quality for EGS operations and thus may not be suitable for inclusion in risk models.

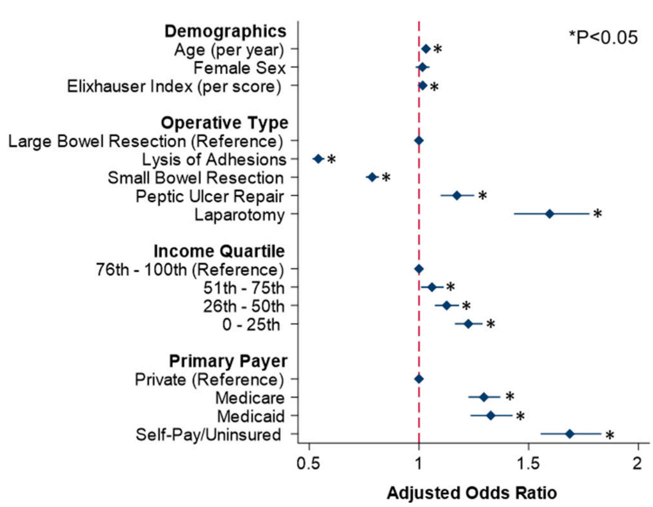

Fig. 2. Factors associated with failure to rescue following emergency general surgery after adjustment for fixed hospital effects. *Indicates statistical significance ($P < 0.05$). Error bars represent 95 % Confidence Intervals.

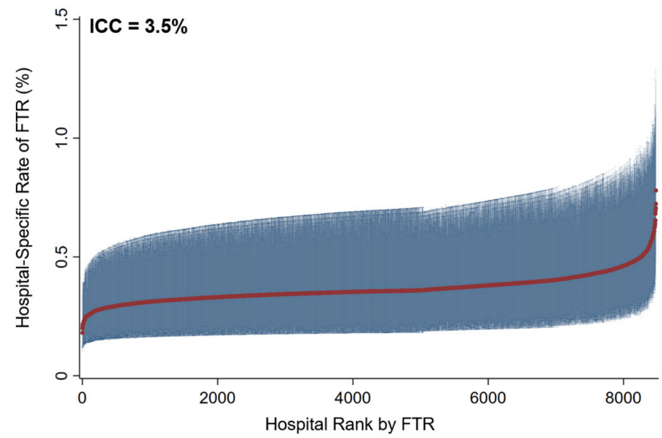

Fig. 3. Interhospital variation in failure to rescue rates after emergency general surgery procedures. Hospitals ranked by hospital-attributable risk-adjusted rate of failure to rescue (FTR). Overall, 3.5 % of the variation was attributable to hospital factors across the study period. Error bars represent 95 % CIs. FTR, failure to rescue; ICC, intraclass correlation coefficient.

Several studies have identified socioeconomic disparities in FTR following EGS procedures [17–19]. In a single-year cohort, Metcalfe and colleagues identified uninsured status to be a determinant of FTR among a cohort of nearly 200,000 EGS patients [17]. Similarly, we found patients with Medicaid and uninsured status, as well as those of lower income, to have a greater incidence of FTR following high-risk EGS operations. Previous literature has proposed that socioeconomically disadvantaged patients may have inadequate access to high-quality care for conditions necessitating acute surgery [20]. In particular, Khubchandi et al. demonstrated that centers that provide EGS services were distributed disproportionately outside of socioeconomically disadvantaged communities [21]. Even after adjustment for hospital-level effects, multi-level models demonstrated a significant association between low-income and Medicaid on risk of FTR following EGS. The persistence of such associations after adjustment for center-level clustering, suggest economic disparities extend beyond the hospitals at which disadvantaged patients seek emergency care. The development of targeted care pathways and risk mitigation strategies may improve outcomes for vulnerable patients. Additionally, an algorithmic assessment of socioeconomic vulnerability derived from the current mixed effects model could be incorporated into electronic records to enhance provider decision making. Future work is necessary to evaluate actionable strategies aimed to reduce the observed disparities in EGS care.

Importantly, we identified a subgroup of complications that may drive the association of failure to rescue among those with public or lack of insurance. Notably, we found increased odds of FTR among uninsured

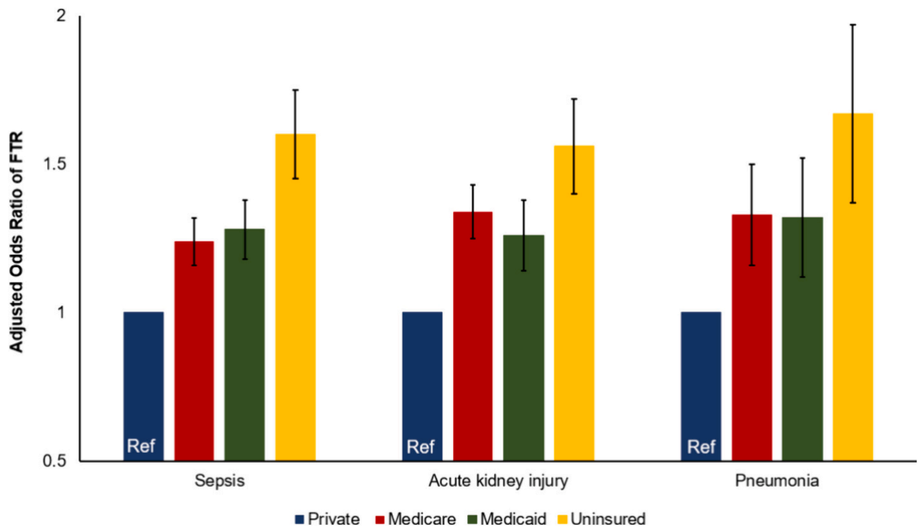

Fig. 4. Adjusted odds of failure to rescue following perioperative complications, stratified by insurance status with private insurance as reference. Error bars represent 95 % Confidence Intervals.

and Medicaid patients with perioperative sepsis, pneumonia, and acute kidney injury. Similarly, Kumar et al. identified uninsured status as a risk factor for FTR after admission for sepsis [22]. The underlying malnutrition, lack of longitudinal follow-up, and resultant medication non-adherence associated with socioeconomic disadvantage may exacerbate the acuity of illness following infections [23,24]. Furthermore, prospectively enrolled studies by Kidney Early Evaluation Program have identified reduced physiological reserve among patients considered socioeconomically deprived [25]. Increased perioperative efforts to prevent infectious and renal complications may reduce disparities in survival following EGS. Standardized system-wide protocols to improve screening, timely detection, and medical management of infection and kidney injury could yield improved survival benefits in this cohort. Furthermore, targeting specific risk factors associated with adverse outcomes, such as inadequate nutrition and underlying comorbidities, may foster the future evidence-based interventions tailored towards socially disadvantaged individuals.

The present study has several limitations. Due to the administrative nature of the NRD, the data is subject to errors and differential regional, hospital, and provider coding practices. Clinical data, including laboratory values, imaging findings, and measures of the disease severity, could not be captured in the NRD, preventing the adjustment of our models to these features. Future studies could consider the impact of such information on the variation of EGS outcomes among patients and centers. Additionally, the sequence of postoperative complications, granular details regarding surgical decision-making, and surgeon identifiers were not available for analysis. While the definition of FTR utilized in the present study has been validated in several operations [26,27], the complications comprising FTR following EGS remains poorly standardized across the literature. Despite these limitations, our study used statistically validated methodologies in a nationally representative cohort to reduce the risk of bias.

In conclusion, FTR poorly captures hospital variation in postoperative mortality following EGS. Rather, FTR appears to be more closely related to important patient factors, indicating the poor performance of this metric as a benchmark of hospital quality. Improved screening upon admission, targeted postoperative care pathways, and increased vigilance of infectious and renal complication management in socially vulnerable patients is warranted. Altogether, our findings underscore an important facet for quality improvement in outcomes following EGS.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sopen.2024.05.013.

Study type

Retrospective cohort study.

Funding

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Ethics approval statement

The data that support the findings of this study are available from the Healthcare Cost and Utilization Project (HCUP). Restrictions apply to the availability of these data, which were used with permission for this study. Data are available from the authors with the permission of the Healthcare Cost and Utilization Project. This study was deemed exempt from full review by the Institutional Review Board at the University of California, Los Angeles, due to the de-identified nature of the data.

CRediT authorship contribution statement

Jeffrey Balian: Conceptualization, Data curation, Methodology, Writing – original draft. **Nam Yong Cho:** Methodology, Validation, Writing – original draft, Writing – review & editing. **Amulya Vadlakonda:** Conceptualization, Validation. **Oh. Jin Kwon:** Methodology, Validation, Writing – review & editing. **Giselle Porter:** Validation. **Saad Mallick:** Writing – review & editing. **Peyman Benharash:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors have no related conflicts of interest or disclosures to report.

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