# Does delayed operation increase morbidity and mortality? An analysis of emergency general surgery procedures

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**BACKGROUND:** Early operation is assumed to improve outcomes after emergency general surgery (EGS) procedures; however, few data exist to inform this opinion. We aimed to (1) characterize time-to-operation patterns among EGS procedures and (2) test the association between timing and patient outcomes. We hypothesize that patients receiving later operations are at greater risk for mortality and morbidity.

**METHODS:** We performed a retrospective cohort study of the American College of Surgeons National Surgical Quality Improvement Program data for adults aged 18 to 89 years who underwent nonelective intra-abdominal operations (appendectomy, cholecystectomy, small bowel resection, lysis of adhesions, and colectomy) from 2015 to 2020. The primary outcome was 30-day postoperative mortality. Secondary outcomes were serious morbidity and all morbidity. Admission-to-operation timing was calculated and classified as early (≤48 hours) or late (>48 hours). A multivariable logistic regression model adjusted risk estimates for age, comorbidities, frailty (Modified Frailty Index, 5-item score), and other confounders.

**RESULTS:** Of 269,959 patients (mean age, 47.0 years; 48.0% male, 61.6% White), 88.7% underwent early operation, ranging from 70.36% (lysis of adhesions) to 98.67% (appendectomy). Unadjusted 30-day mortality was higher for late versus early operation (6.73% vs. 1.96%; $p < 0.0001$). After risk adjustment, late operation significantly increased risk for 30-day mortality (odds ratio [OR], 1.545; 95% confidence interval [CI], 1.451–1.644), serious morbidity (OR, 1.464; 95% CI, 1.416–1.514), and all morbidity (OR, 1.468; 95% CI, 1.417–1.520). This mortality risk persisted for all EGS procedures; risk of serious and any morbidity persisted for all procedures except cholecystectomy.

**CONCLUSION:** Late operation significantly increased risk for 30-day mortality, serious morbidity, and all morbidity across a variety of EGS procedures. We believe that these findings will inform decisions regarding timing of EGS operations and allocation of surgical resources. (*J Trauma Acute Care Surg.* 2024;97: 266–271. Copyright © 2024 Wolters Kluwer Health, Inc. All rights reserved.)

**LEVEL OF EVIDENCE:** Therapeutic/Care Management; Level III.

**KEY WORDS:** Emergency general surgery; outcomes; delay; time to operation.

Time to operation is accepted by expert consensus as a key measure of quality for emergency general surgery (EGS).[1,2] Timeliness of operation is included as a cornerstone metric of the EGS Quality Verification Program by the American College of Surgeons and the American Association for the Surgery of Trauma.[3] In practice, high performance on this measure relies on well-implemented diagnostic and triage systems, which best allocate limited physical and personnel resources. For centers with dedicated EGS services, surgeons must triage competing clinical priorities between the varied patients and pathologies on their services. High-quality data on how operative delays affect patients with different EGS pathologies are needed to inform these triage decisions and to inform time-dependent metrics in quality measurement.

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Our understanding of which EGS patients most need emergent operative treatment has evolved greatly in recent years. Appendicitis and small bowel obstructions, both formerly regarded as operative emergencies, now have accepted nonoperative therapies, and their surgical treatment is often delayed or foregone altogether.[4–6] Conversely, evidence is mounting that specific categories of EGS operations are more time sensitive than previously thought. Current sepsis management guidelines recommend source control, "as soon as is medically and logistically feasible"; however, recent work suggests that even more rapid operation within 6 hours of presentation demonstrated mortality benefit.[7,8] Given this evolving evidence, there is a need to integrate the nuances of specific procedure timing within the broad nature of EGS services in the modern practice environment.

To address this gap in knowledge, we aim to first characterize time-to-operation patterns among the most common EGS procedures. Second, we aim to test the association between timing and patient outcomes. We hypothesize that patients receiving later operations are at greater risk for mortality and morbidity.

## PATIENTS AND METHODS

We compiled participant user files from the American College of Surgeons National Surgical Quality Improvement

Program (NSQIP) for the years 2015 to 2020 and performed a retrospective cohort study in line with NSQIP best practices.[9]

We identified all patients who underwent appendectomy, cholecystectomy, small bowel resection, lysis of adhesions, or colectomy (partial and total) as defined by Current Procedure Terminology. We excluded patients undergoing procedures labeled as nonemergent, those outside of the 18 to 89 years age range, and those missing time-to-operation data. The distribution of admission-to-operation timing was examined to define cutoff values. Operations beyond the 99th percentile (hospital day [HD] 11) were excluded. To account for variations in data reporting, the admission-to-operation variable was then standardized by rounding to the appropriate integer variable to form a categorical variable by HD of operation. Those within the 75th percentile (≤48 hours of admission) were defined as early operation. We quantified frailty by calculating each patient's Modified Frailty Index, a previously validated 5-item score, which includes nonindependent functional status, diabetes, history of chronic obstructive pulmonary disease or preoperative pneumonia, history of congestive heart failure, and hypertension requiring medication.[10] Race data were included for the purpose of identifying potential vulnerable populations for future support; this variable was coded into the NSQIP database from medical chart review. Our analysis adhered to STROBE guidelines[11] (Supplemental Digital Content, Supplementary Data 1, http://links.lww.com/TA/D731). Patients with missing data for key variables were excluded as described in Figure 1.

The primary outcome was 30-day postoperative mortality. Secondary outcomes were serious morbidity (deep incisional surgical site infection [SSI], organ space SSI, wound disruption, postoperative pneumonia, unplanned reintubation, ventilator dependence for >48 hours postoperatively, pulmonary embolism, progressive renal insufficiency, acute renal failure, stroke/cerebrovascular accident, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, bleeding requiring transfusion, deep vein thrombosis/thrombophlebitis, sepsis, and septic shock) and all morbidity (superficial incisional SSI, urinary tract infection, and those complications included in "serious morbidity").

Categorical variables are presented as frequencies and proportions. Continuous variables are reported as medians and interquartile ranges. $\chi^2$ Testing was used for determining difference in categorical data. A multivariable logistic regression model adjusted risk estimates for age, sex, race, frailty (Modified Frailty Index, 5-item score [mFI-5]), smoking status, preoperative dialysis, preoperative chronic steroid use, preoperative sepsis, hospital transfer status, laparoscopic procedure, and late operation. Model elements were identified by assessment of clinical relevance and significance on bivariate analysis. All

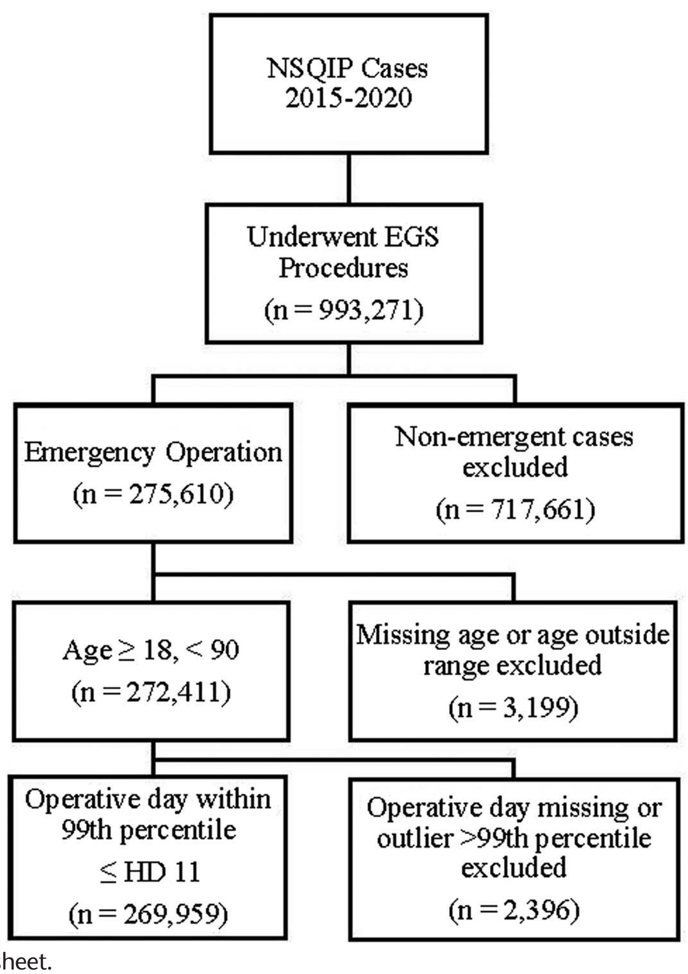


**Figure 1.** Subject inclusion flowsheet.

 

statistical analyses were performed in SAS 9.4 (Cary, NC) with two-sided significance of $p < 0.05$.

## RESULTS

A total of 269,959 patients underwent EGS operations within 11 days of hospital admission (Fig. 1). The mean age was 47.0 years (SD, 19.2 years), and the mean body mass index was 29.0 kg/m$^2$ (SD, 2.07 kg/m$^2$). The majority of patients had low preoperative frailty (mFI-5, 0; 69.30%). Appendectomy was the most common EGS operation (n = 160,959 [59.62%]) followed by cholecystectomy (n = 42,256 [15.65%]) (Tables 1 and 2).

Over half of all patients underwent operation in the first 24 hours after hospital admission (n = 174,941 [64.80%]) with an additional 23.89% (n = 64,489) between 24 and 48 hours of admission (Fig. 2). By procedure, appendectomies were the most concentrated in the first 24 hours (n = 122,844 [76.32%]), followed by small bowel resections (n = 9,278 [55.55%]); all other procedures had approximately half or fewer operations in this period (Fig. 2).

Of all patients, 11.31% (n = 30,529) underwent late operation (>48 hours); cholecystectomies and colectomies had the greatest proportion of patients in this category (Table 1). Patients undergoing late operation were older (mean age, 59.45 years; SD, 18.12 years), more likely to be frail (mFI-5 >2 in 21.58% of late operation patients vs. 7.98% in early operation), and smokers (n = 5,543 [18.157%]) compared with those undergoing early operation (Table 1). Late operation patients were less likely to be septic preoperatively (34.11% late vs. 35.25% early, $p < 0.0001$), although this margin was relatively small.

Postoperative mortality was uncommon, with only 2.50% of patients experiencing death within 30 days of the operation. Of all patients, 16.28% experienced postoperative morbidity, 18.13% experienced serious morbidity, and 8.18% were not discharged to home (Table 3). When compared with operations performed within 24 hours of admission (HD 1), risk of 30-day mortality was not significantly different on HD 2 across all operations (odds ratio [OR], 1.060; 95% confidence interval [CI], 0.986–1.139) but steadily increased by each subsequent HD until HD 10 (Table 4). Risk of any morbidity and serious morbidity was decreased on HD 2 compared with HD 1 and then followed a similar pattern of increase until HD 10. Unadjusted rates of in-hospital and 30-day mortality were greater for patients undergoing late versus early operation (5.52% vs. 1.61% and 6.73% vs. 1.96%, respectively; $p < 0.0001$). These

**TABLE 1.** Patient and Operative Characteristics

| | Overall | | Early Operation | | Late Operation | | |
|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | ***p*** |
| Age, y | 46.954 | 19.19 | 45.360 | 18.73 | 59.454 | 18.12 | <0.0001 |
| BMI, kg/m$^2$ | 29.00 | 7.07 | 28.97 | 6.99 | 29.23 | 7.67 | <0.0001 |
| | **n** | **(%)** | **n** | **(%)** | **n** | **(%)** | |
| All | 269,959 | 100.00 | 239,430 | 88.69 | 30,529 | 11.31 | <0.0001 |
| Race | | | | | | | <0.0001 |
| Asian | 12,258 | 4.54 | 11,074 | 4.63 | 1,184 | 3.88 | |
| Black | 20,668 | 7.66 | 17,651 | 7.37 | 3,017 | 9.88 | |
| Other (including Native American and Pacific Islander) | 2,968 | 1.10 | 2,733 | 1.14 | 235 | 0.77 | |
| White | 166,226 | 61.57 | 149,454 | 62.42 | 16,772 | 54.94 | |
| Unknown | 67,839 | 25.13 | 58,518 | 24.44 | 9,321 | 30.53 | |
| Hispanic ethnicity | 35,571 | 13.18 | 32,344 | 13.51 | 3,227 | 10.57 | <0.0001 |
| Sex, male | 129,691 | 48.04 | 116,092 | 48.49 | 13,599 | 44.54 | <0.0001 |
| Smoker, current | 46,884 | 17.37 | 41,341 | 17.27 | 5,543 | 18.157 | 0.0001 |
| Frailty (mFI-5) | | | | | | | |
| 0 | 187,080 | 69.30 | 172,950 | 72.23 | 14,130 | 46.28 | <0.0001 |
| 1 | 55,073 | 20.40 | 45,424 | 18.97 | 9,649 | 31.61 | |
| ≥2 | 25,490 | 9.44 | 18,945 | 7.91 | 6,545 | 21.44 | |
| Dialysis, preoperative | 2,368 | 0.88 | 1,540 | 0.64 | 828 | 2.71 | <0.0001 |
| Chronic steroid use | 8,941 | 3.31 | 6,831 | 2.85 | 2,110 | 6.91 | <0.0001 |
| Sepsis or SIRS, preoperative | 94,803 | 35.12 | 84,389 | 35.25 | 10,414 | 34.11 | <0.0001 |
| Transferred from outside facility | 34,822 | 12.90 | 29,493 | 12.32 | 5,329 | 17.46 | <0.0001 |
| Laparoscopic procedure | 202,112 | 74.87 | 187,503 | 78.31 | 14,609 | 47.85 | <0.0001 |
| Procedure type | | | | | | | <0.0001 |
| Appendectomy | 160,959 | 59.62 | 158,820 | 66.33 | 2,139 | 7.01 | |
| Cholecystectomy | 42,256 | 15.65 | 31,450 | 13.14 | 10,806 | 35.40 | |
| Lysis of adhesions | 11,261 | 4.17 | 7,923 | 3.31 | 3,338 | 10.93 | |
| Small bowel resection | 16,702 | 6.19 | 13,206 | 5.52 | 3,496 | 11.45 | |
| Colectomy | 38,781 | 14.37 | 28,031 | 11.71 | 10,750 | 35.21 | |

BMI, body mass index; SIRS, systemic inflammatory response syndrome.

**TABLE 2.** Unadjusted Odds of Adverse Outcomes

| | Overall | Early Operation | | Late Operation | | |
|---|---|---|---|---|---|---|
| | % | n | % | n | % | *p* |
| Any postoperative complication | 18.13 | 38,454 | 16.06 | 10,480 | 34.33 | <0.0001 |
| Serious postoperative complication | 16.28 | 34,403 | 14.37 | 9,536 | 31.24 | <0.0001 |
| Death during hospital stay | 2.05 | 3,846 | 1.61 | 1,686 | 5.52 | <0.0001 |
| Death within 30 d of primary operation | 2.50 | 4,702 | 1.96 | 2,055 | 6.73 | <0.0001 |
| Discharge destination other than home | 8.18 | 15,625 | 6.53 | 6,463 | 21.17 | <0.0001 |

differences were persistent for any morbidity and serious morbidity (34.33% vs. 16.06% and 31.24% vs. 14.37%, respectively; $p < 0.0001$).

After risk adjustment in our multivariable model, late operation remained significant for 30-day mortality (OR, 1.545; 95% CI, 1.451–1.644), any morbidity (OR, 1.464; 95% CI, 1.416–1.514), and serious morbidity (OR, 1.468; 95% CI, 1.417–1.520). This significant difference persisted within all procedural subgroups for 30-day mortality. For any morbidity and serious morbidity, the cholecystectomy subgroup did not

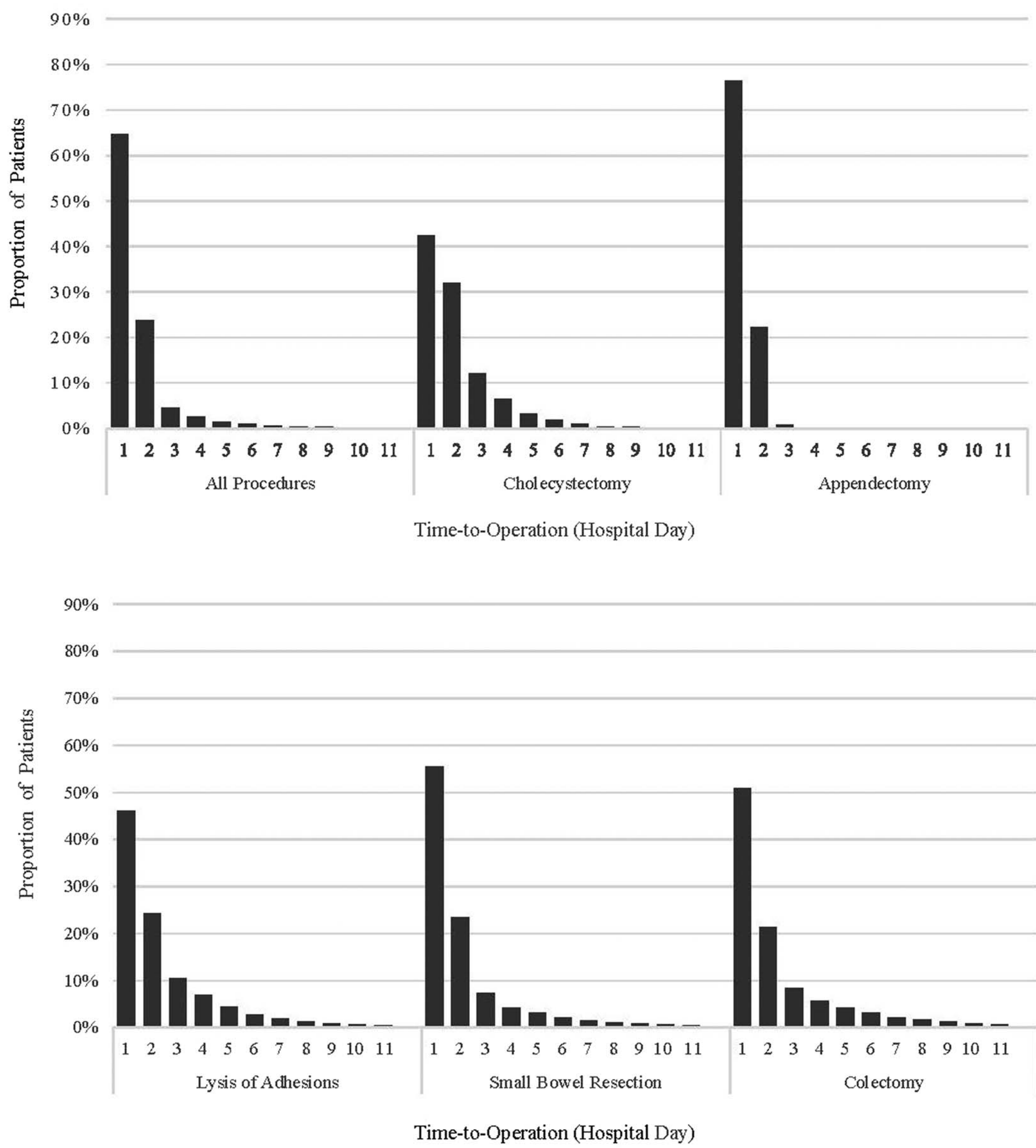


**Figure 2.** Distribution of time to operation by procedure type.

**TABLE 3.** Adjusted Odds of Adverse Outcomes (Multivariable Logistic Regression)

| | 30-d Mortality | | | | Any Morbidity | | | | Serious Morbidity | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CI | | | | CI | | | | CI | | |
| Procedure | OR | Lower 95% | Upper 95% | p | OR | Lower 95% | Upper 95% | p | OR | Lower 95% | Upper 95% | p |
| Overall | | | | <0.0001 | | | | <0.0001 | | | | <0.0001 |
| Late vs. early operation | 1.545 | 1.451 | 1.644 | 1.464 | 1.416 | 1.514 | 1.468 | 1.417 | 1.520 | | | |
| Appendectomy | | | | 0.0144 | | | | <0.0001 | | | | <0.0001 |
| Late vs. early operation | 2.251 | 1.175 | 4.312 | 1.869 | 2.136 | 1.863 | 1.917 | 1.666 | 2.209 | | | |
| Cholecystectomy | | | | 0.0010 | | | | 0.1894 | | | | 0.6199 |
| Late vs. early operation | 1.668 | 1.231 | 2.259 | 1.063 | 0.970 | 1.164 | 1.026 | 0.928 | 1.133 | | | |
| Lysis of adhesions | | | | <0.0001 | | | | <0.0001 | | | | <0.0001 |
| Late vs. early operation | 1.442 | 1.186 | 1.754 | 1.511 | 1.360 | 1.678 | 1.527 | 1.364 | 1.709 | | | |
| Small bowel resection | | | | <0.0001 | | | | <0.0001 | | | | <0.0001 |
| Late vs. early operation | 1.826 | 1.608 | 2.074 | 1.673 | 1.535 | 1.823 | 1.637 | 1.500 | 1.787 | | | |
| Colectomy | | | | <0.0001 | | | | <0.0001 | | | | <0.0001 |
| Late vs. early operation | 1.286 | 1.187 | 1.393 | 1.370 | 1.300 | 1.444 | 1.373 | 1.302 | 1.447 | | | |

Model adjusted risk estimates for age, sex, race, frailty (mFI-5), smoking status, preoperative dialysis, preoperative chronic steroid use, preoperative sepsis, hospital transfer status, laparoscopic procedure, and late operation.

show a significant difference between late and early groups (Table 3).

## DISCUSSION

This study outlined the distribution of time to operation and analyzed the relationship between late operation and patient outcomes for 269,959 adults in the American College of Surgeons NSQIP database who underwent nonelective EGS procedures from 2015 to 2020. Most patients undergoing appendectomy or small bowel resection did so within 24 hours of admission and all procedures within 48 hours. When all procedures were analyzed in aggregate, an inflection point of increased risk for all adverse outcomes occurred at this 48-hour time point. Operation beyond 48 hours (late operation) was a significant risk factor for postoperative mortality; this effect persisted throughout all operative subtypes. For overall and serious morbidity, the cholecystectomy subgroup alone did not demonstrate a significant difference with late operation.

These findings are concordant with the clinical intuition that delays from emergency department presentation to the operating room negatively impact patient care. Wood et al.[12] investigated a similar question by analyzing a smaller population of EGS patients at two Canadian hospitals, finding that time from emergency department presentation to operation was predictive of overall mortality and morbidity. Similar to our findings, cholecystectomy was the only procedural subtype in which operative timing was not predictive of morbidity.

This work expands upon previous examinations of time-to-operation effects by including patients in the days following

**TABLE 4.** Adjusted Odds of Adverse Outcomes by Day to Operation (Multivariable Logistic Regression)

| | 30-d Mortality | | | | Any Morbidity | | | | Serious Morbidity | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CI | | | | CI | | | | CI | | |
| | OR | Lower 95% | Upper 95% | p | OR | Lower 95% | Upper 95% | p | OR | Lower 95% | Upper 95% | p |
| Risk by each HD from admission to operation | 1.118 | 1.104 | 1.132 | <0.0001 | 1.114 | 1.105 | 1.123 | <0.0001 | 1.116 | 1.107 | 1.125 | <0.0001 |
| Risk by HD (compared with HD 1) | | | | | | | | | | | | |
| HD 2 | 1.060 | 0.986 | 1.139 | 0.1160 | 0.941 | 0.913 | 0.970 | 0.0001 | 0.925 | 0.896 | 0.955 | <0.0001 |
| HD 3 | 1.221 | 1.098 | 1.356 | 0.0002 | 1.108 | 1.051 | 1.169 | <0.0001 | 1.073 | 1.015 | 1.133 | 0.013 |
| HD 4 | 1.295 | 1.139 | 1.473 | <0.0001 | 1.298 | 1.215 | 1.387 | <0.0001 | 1.287 | 1.201 | 1.378 | <0.0001 |
| HD 5 | 1.578 | 1.367 | 1.821 | <0.0001 | 1.607 | 1.483 | 1.742 | <0.0001 | 1.635 | 1.504 | 1.777 | <0.0001 |
| HD 6 | 1.900 | 1.618 | 2.232 | <0.0001 | 1.679 | 1.522 | 1.852 | <0.0001 | 1.685 | 1.523 | 1.865 | <0.0001 |
| HD 7 | 2.136 | 1.787 | 2.554 | <0.0001 | 2.208 | 1.961 | 2.486 | <0.0001 | 2.243 | 1.988 | 2.532 | <0.0001 |
| HD 8 | 2.440 | 1.990 | 2.992 | <0.0001 | 2.289 | 1.979 | 2.646 | <0.0001 | 2.403 | 2.073 | 2.785 | <0.0001 |
| HD 9 | 2.481 | 1.970 | 3.123 | <0.0001 | 2.499 | 2.110 | 2.960 | <0.0001 | 2.565 | 2.162 | 3.044 | <0.0001 |
| HD 10 | 2.116 | 1.615 | 2.772 | <0.0001 | 2.494 | 2.043 | 3.044 | <0.0001 | 2.478 | 2.026 | 3.030 | <0.0001 |
| HD 11 | 2.682 | 2.011 | 3.577 | <0.0001 | 3.458 | 2.735 | 4.372 | <0.0001 | 3.482 | 2.756 | 4.398 | <0.0001 |

Model adjusted risk estimates for age, sex, race, frailty (mFI-5), smoking status, preoperative dialysis, preoperative chronic steroid use, preoperative sepsis, hospital transfer status, laparoscopic procedure, and late operation.

admission, reflective of real-world surgical decision making. Previous studies have either been very early, targeting surgical emergencies, or very late, targeting conditions where nonoperative management has failed or patients admitted for reasons other than known surgical pathology.[13] This study brings data to an understudied decision point of EGS services in which providers must prioritize competing surgical urgencies, which have been admitted to the hospital and are awaiting operation. In addition, this analysis includes a diverse sample of procedures managed on EGS services, thus providing outcomes data in its appropriate clinical context. Finally, this study includes a large number of patients sampled from diverse clinical sites; small sample size and the use of single-institution data have been limiting factors in prior analyses of operative timing.

We acknowledge that this analysis is limited by several factors, many of which are inherent limitations of the data set. The "time to operation" variable is most consistently reported in 24-hour blocks, which limits granularity regarding operative timing. The NSQIP database does not capture detailed data on the cause of preoperative delays, such as timing of surgical consultation, descriptors of preoperative decision making, or additional testing performed. We were unable to adjust for center-specific factors, as data describing hospital characteristics are not publicly available. We acknowledge that residual confounding could be present because of these or other unmeasured factors. As with any large data set, we can identify associations but cannot determine a causal relationship.

Our identification of the association between delayed operation and adverse patient outcomes offers an opportunity to improve the well-being of nonelective surgical populations by mitigating the potential impact of delays to surgery. We hope that future interventions to minimize such delays will decrease morbidity and mortality, as well as streamlining preoperative workflows for providers and hospital staff. Such efficiency offers potential hospital system and payer-level cost savings.

## CONCLUSION

Operation beyond 48 hours of admission is an independent risk factor for mortality and morbidity among EGS patients. This is a concerning finding for patient safety, which warrants further investigation.

### AUTHORSHIP

K.N.F., M.N., and A.M. contributed in the study design. K.N.F. and A.M. contributed in the literature search. B.Z. contributed in the data acquisition. J.R.B. and B.Z. contributed in the project management and mentorship. K.N.F. and B.Z. contributed in the data analysis. K.N.F., M.N., A.M., J.R.B., and B.Z. contributed in the data interpretation. K.N.F. contributed in the writing. M.N., A.M., J.R.B., and B.Z. contributed in the critical revision.
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### DISCLOSURE

Conflicts of Interest: Author Disclosure forms have been supplied and are provided as Supplemental Digital Content (http://links.lww.com/TA/D732).

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