The Emergency Surgery Score accurately predicts the need for postdischarge respiratory and renal support after emergent laparotomies: A prospective EAST multicenter study

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BACKGROUND: The Emergency Surgery Score (ESS) was recently validated as an accurate mortality risk calculator for emergency general surgery. We sought to prospectively evaluate whether ESS can predict the need for respiratory and/or renal support (RRS) at discharge after emergent laparotomies (EL).

METHODS: This is a post hoc analysis of a 19-center prospective observational study. Between April 2018 and June 2019, all adult patients undergoing EL were enrolled. Preoperative, intraoperative, and postoperative variables were systematically collected. In this analysis, patients were excluded if they died during the index hospitalization, were discharged to hospice, or transferred to other hospitals. A composite variable, the need for RRS, was defined as the need for one or more of the following at hospital discharge: tracheostomy, ventilator dependence, or dialysis. Emergency Surgery Score was calculated for all patients, and the correlation between ESS and RRS was examined using the c-statistics method.

RESULTS: From a total of 1,649 patients, 1,347 were included. Median age was 60 years, 49.4% were men, and 70.9% were White. The most common diagnoses were hollow viscus organ perforation (28.1%) and small bowel obstruction (24.5%); 87 patients (6.5%) had a need for RRS (4.7% tracheostomy, 2.7% dialysis, and 1.3% ventilator dependence). Emergency Surgery Score predicted the need for RRS in a stepwise fashion; for example, 0.7%, 26.2%, and 85.7% of patients required RRS at an ESS of 2, 12, and 16, respectively. The c-statistics for the need for RRS, the need for tracheostomy, ventilator dependence, or dialysis at discharge were 0.84, 0.82, 0.79, and 0.88, respectively.

CONCLUSION: Emergency Surgery Score accurately predicts the need for RRS at discharge in EL patients and could be used for preoperative patient counseling and for quality of care benchmarking. (*J Trauma Acute Care Surg.* 2021;90: 557–564. Copyright © 2020 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Prognostic and epidemiological, level III.

KEY WORDS: Emergency Surgery Score; dialysis; ventilator; tracheostomy; discharge.

In the United States, emergency general surgery (EGS) accounts for 7.1% of all hospitalizations and contributes to a disproportionately large portion of postoperative mortality, morbidity, and decreased quality of life as compared with non-EGS patients.[1–4] Moreover, the financial burden of EGS patients is disproportionately high, amounting to an average adjusted cost of US $10,477 per hospitalization.[4–6] The cost figure is further amplified in the postdischarge setting for the subset of patients that require dialysis,[7] tracheostomy, and/or home mechanical ventilation.[8] Predicting EGS patient postdischarge outcomes is crucial in guiding patient and family preoperative discussions and better benchmarking the quality of care beyond mortality rates.

The Emergency Surgery Score (ESS) was developed and validated as a scoring system that can reliably predict postoperative outcomes of EGS patients.[9–14] Most recently, an Eastern Association for the Surgery of Trauma (EAST) multicenter study prospectively validated ESS as a strong predictor of mortality, morbidity, and the need for intensive care.[15] Nonetheless, the performance of ESS in predicting the need for respiratory and renal support (RRS) at discharge after EGS has not been assessed. In

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this analysis, we aimed to prospectively validate the ability of ESS to predict the need for RRS at discharge in the high-risk EGS population undergoing emergent laparotomy (EL).

METHODS

This is a post hoc analysis of a prospective, observational, 19-center study sponsored by EAST.[15] The EAST multicenter study was previously approved by institutional review board at each participating site.

Patient Selection

Between April 2018 and June 2019, centers enrolled and collected preoperative, intraoperative, and postoperative data for all adult patients (≥18 years) undergoing an EL. Diagnoses included, for example, mesenteric ischemia, complicated diverticulitis, hollow viscus organ perforation, and small bowel obstruction. Emergent laparotomy was defined as a laparotomy that needed to be performed as soon as possible following diagnosis or onset of related preoperative symptomatology, and where unnecessary delay could potentially jeopardize the patient's well-being and outcome.[16] Trauma, vascular, and gynecological laparotomies were excluded. In addition, patients were excluded from this post hoc analysis if they died during the index admission, were discharged to hospice care, or were transferred to other hospitals.

Calculating ESS

Emergency Surgery Score was calculated using each patient's preoperative variables, including demographics, laboratory values, comorbidities, and acuity of disease (Table 1).[13] In this multicenter study, the authors focused on collecting primarily the data points required for the calculation of ESS and potential outcomes of interest. With regard to race, we did not collect granular information and we will report only if a patient was self-identified as White or not. If a patient had a missing variable, it was treated as the default (i.e., no additional points assigned). Missing values were assumed to be the null value, thus not resulting in additional ESS points. This assumption was based on previous findings suggesting that the predictive performance of ESS does not change if missing data points for its calculation are considered to be normal (i.e., the null value).[11]

Defining the Need for RRS at Discharge

Renal support was defined as the need for permanent or temporary peritoneal dialysis or hemodialysis at discharge. Respiratory support was defined as a composite of the need for tracheostomy or ventilator dependence at discharge.

The primary outcome was to determine the ability of ESS to predict the patient's need for RRS at discharge. Secondary outcomes included the ability of ESS to predict the same outcome in the geriatric patient population (age, ≥65 years).

Statistical Analysis

The association of ESS with each outcome of interest was evaluated using the area under the receiver operator characteristic curve or c-statistic metric. Univariate logistic regression analyses were used to assess the association between the individual risk factors included in the calculation of ESS and the outcomes of interest. All statistical analyses were performed by using Stata v15.1 (StataCorp 2017. Stata Statistical Software: Release 15; StataCorp LLC, College Station, TX).

TABLE 1. The ESS

Variables	Points
Demographics	
Age >60 y	2
White race	1
Transfer from outside emergency department	1
Transfer from an acute care hospital inpatient facility	1
Comorbidities	
Ascites	1
BMI <20 kg/m^2	1
Disseminated cancer	3
Dyspnea	1
Functional dependence	1
History of COPD	1
Hypertension	1
Steroid use	1
Ventilator requirement within 48 h preoperatively	3
Weight loss >10% in the preceding 6 mo	1
Laboratory values	
Albumin <3.0 U/L	1
Alkaline phosphatase >125 U/L	1
Blood urea nitrogen >40 mg/dL	1
Creatinine >1.2 mg/dL	2
International normalized ratio >1.5	1
Platelets <150 × 10^3/μL	1
SGOT >40 U/L	1
Sodium >145 mmol/L	1
WBC × 10^3/μL	
<4.5	1
>15 and ≤25	1
>25	2
Maximum score	29

BMI, body mass index; SGOT, serum glutamic-oxaloacetic transaminase; WBC, white blood cell.

Sensitivity Analysis

The exclusion of patients who were discharged to hospice care and patients that were transferred to another institution might have introduced a bias to our study. To address that, we conducted a sensitivity analysis including these patients. The association between ESS and each outcome of interest was assessed using the c-statistic method.

RESULTS

Out of a total of 1,649 patients, 1,347 (81.7%) were included. Missing information were 0.7% or less for the majority of the variables. Four percent of the patients had missing information for preoperative albumin, alkaline phosphatase, and serum glutamic-oxaloacetic transaminase, while 19.7% of the population had missing information regarding the preoperative international normalized ratio. The median age was 60 years, 49.4% were men, 70.9% were White, 31.0% were patients transferred from outside hospitals, and 16.6% were functionally

TABLE 2. Patient Demographics, Comorbidities, Laboratory Values, and Diagnoses

	All Patients, N = 1,347	Need for Renal Support, n = 36	Need for Respiratory Support, n = 64
Sex, male	665 (49.4%)	24 (66.7%)	40 (62.5%)
Age: median (IQR)	60 (49, 71)	61 (50.5, 71)	63 (52, 73)
Race, White	955 (70.9%)	20 (55.6%)	42 (65.6%)
Transferred	418 (31.0%)	23 (63.9%)	37 (57.8%)
Comorbidities			
Ascites	273 (20.3%)	10 (27.8%)	18 (28.1%)
BMI <20	138 (10.2%)	3 (8.3%)	9 (14.1%)
Disseminated cancer	94 (7.0%)	0 (0.0%)	3 (4.7%)
Dyspnea	190 (14.1%)	8 (22.2%)	19 (29.7%)
Functionally dependent status prior to surgery	224 (16.6%)	10 (27.8%)	21 (32.8%)
History of severe COPD	170 (12.6%)	6 (16.7%)	13 (20.3%)
Steroid use	130 (9.7%)	7 (19.4%)	8 (12.5%)
Preoperative mechanical ventilation	101 (7.5%)	17 (47.2%)	34 (53.1%)
>10% loss in body weight in last 6 mo	138 (10.2%)	4 (11.1%)	9 (14.1%)
Hypertension requiring medication	743 (55.2%)	32 (88.9%)	44 (68.8%)
Laboratory values			
Albumin <3 g/dL	307 (22.8%)	24 (66.7%)	34 (53.1%)
Sodium >145 mmol/L	48 (3.6%)	3 (8.3%)	9 (14.1%)
Alkaline phosphatase >125 U/L	224 (16.6%)	11 (30.6%)	18 (28.1%)
Blood urea nitrogen >40 mg/dL	166 (12.3%)	24 (66.7%)	25 (39.1%)
Creatinine >1.2 mg/dL	412 (30.6%)	32 (88.9%)	38 (59.4%)
International normalized ratio >1.5	136 (10.1%)	15 (41.7%)	16 (25.0%)
Platelets <150/μL	153 (11.4%)	12 (33.3%)	17 (26.6%)
SGOT >40 U/L	261 (19.4%)	15 (41.7%)	37 (57.8%)
WBC count ($\times 10^9$ per L)			
≥4.5 and ≤15	870 (64.6%)	16 (44.4%)	28 (43.8%)
<4.5	90 (6.7%)	1 (2.8%)	4 (6.3%)
>15 and ≤25	317 (23.5%)	13 (36.1%)	21 (32.8%)
>25	70 (5.2%)	6 (16.7%)	11 (17.2%)
Diagnosis			
Abdominal compartment syndrome	22 (1.6%)	7 (19.4%)	9 (14.1%)
Bowel/mesenteric ischemia	193 (14.3%)	8 (22.2%)	20 (31.3%)
Colonic obstruction	60 (4.5%)	1 (2.8%)	3 (4.7%)
Complicated diverticulitis	94 (7.0%)	2 (5.6%)	1 (1.6%)
Endoscopic complication	11 (0.8%)	0 (0.0%)	0 (0.0%)
Foreign body/caustic ingestion	24 (1.8%)	0 (0.0%)	1 (1.6%)
Fulminant *Clostridium difficile* colitis	16 (1.2%)	3 (8.3%)	4 (6.3%)
Gastrointestinal bleeding	39 (2.9%)	3 (8.3%)	3 (4.7%)
Hollow viscus organ perforation	379 (28.1%)	11 (30.6%)	18 (28.1%)
Internal hernia or closed loop bowel	127 (9.4%)	0 (0.0%)	0 (0.0%)
Nonresolving small bowel obstruction	330 (24.5%)	0 (0.0%)	5 (7.8%)
Pancreatitis	14 (1.0%)	1 (2.8%)	2 (3.1%)
Strangulated or incarcerated hernia	199 (14.8%)	2 (5.6%)	3 (4.7%)
Volvulus	93 (6.9%)	3 (8.3%)	5 (7.8%)
Other	327 (24.3%)	6 (16.7%)	22 (34.4%)

Continued next page

TABLE 2. *(Continued)*

IQR, interquartile range.

dependent at baseline. The most common diagnoses were hollow viscus organ perforation (28.1%), followed by small bowel obstruction (24.5%), and strangulated hernia (14.8%) (Table 2). The median hospital length of stay was 11 days (7–19 days), with approximately half (48.6%) of the patients requiring intensive care unit admission. Most patients were discharged home (48.5%) or home with nursing service (19.2%). On the contrary, the majority of the patients requiring renal or respiratory support at discharge were discharged to long-term acute care facilities (52.8% and 51.6%, respectively) and rehabilitation centers (19.4% and 29.7%, respectively) (Table 3). The median ESS was 5 (3–8) (Fig. 1).

ESS and the Need for Renal Support at Discharge

Among the 1,347 patients included in the analysis, 412 (30.6%) patients had a preoperative creatinine level above 1.2 mg/dL. A total of 36 (2.7%) patients still needed renal support at discharge. The observed need for renal support gradually increased from 0% to 7.4% to 28.6% at ESS levels of 1, 10, and 16 points, respectively. Emergency Surgery Score was associated extremely well with the need for renal support with a c-statistic of 0.88 (95% confidence interval [CI], 0.84–0.92) (Fig. 2*A*). Among patients 65 years or older, the performance of ESS was preserved with a c-statistic of 0.84 (95% CI, 0.73–0.95) (Table 4).

ESS and the Need for Respiratory Support at Discharge

A total of 64 (4.8%) patients needed respiratory support at discharge, 46 (71.9%) required tracheostomy, 1 (1.6%) patient required mechanical ventilation, and 17 (26.5%) required both of these modalities of respiratory support. Among the cohort of patients requiring respiratory support at discharge, 34 (53.1%) patients were on mechanical ventilation preoperatively, and 13 (20.3%) had a history of severe chronic obstructive pulmonary disease (COPD). The observed need for respiratory support gradually increased from 0% to 16.7% to 71.4% at ESS levels of 1, 12, and 16 points, respectively. Emergency Surgery Score associated well with the need for respiratory support with a c-statistic of 0.82 (95% CI, 0.77–0.87) (Fig. 2*B*). Individual c-statistic were as follows: tracheostomy, 0.82 (95% CI, 0.77–0.87); ventilator dependence, 0.79 (95% CI, 0.64–0.94).

Among patients 65 years or older, the performance of ESS in predicting the need for respiratory support at discharge was

TABLE 3. Patient Hospital Course, Lengths of Stay, Discharge Status, and 30-Day Mortality

	All Patients, N = 1347	Need for Renal Support, n = 36	Need for Respiratory Support, n = 64
Unplanned reoperation	154 (11.4%)	9 (25.0%)	25 (39.1%)
ICU admission	655 (48.6%)	35 (97.2%)	61 (95.3%)
Length of ICU, median (IQR)	5 (3–10)	15 (9–28)	27 (18–41)
Postoperative length of stay, median (IQR)	9 (6–16)	32.5 (19.5–42)	42 (26–53.5)
Total hospital length of stay, median (IQR)	11 (7–19)	39.5 (22–50.5)	49.5 (31–69.5)
Discharge destination			
Home	653 (48.5%)	3 (8.3%)	3 (4.7%)
Home with nursing service	258 (19.2%)	2 (5.6%)	2 (3.1%)
Long term acute care facility	94 (7.0%)	19 (52.8%)	33 (51.6%)
Nursing home	128 (9.5%)	5 (13.9%)	7 (10.9%)
Rehabilitation	213 (15.8%)	7 (19.4%)	19 (29.7%)
30-d Mortality	10 (0.7%)	2 (5.6%)	1 (1.6%)

ICU, intensive care unit.

equally high with a c-statistic of 0.80 (95% CI, 0.71–0.88). Individually, the c-statistics were slightly lower at the following values: tracheostomy, 0.80 (95% CI, 0.71–0.88); ventilator dependence, 0.75 (95% CI, 0.56–0.94) (Table 4).

ESS and the Need for RRS at Discharge

Overall, ESS was associated extremely well with the need for RRS at discharge with a c-statistic of 0.84 (95% CI, 0.80–0.88) (Fig. 2*C*). Among patients aged 65 years or older, the high performance of ESS was maintained with a c-statistic of 0.81 (95% CI, 0.73–0.88) (Table 4). The results of the univariate regression analyses for the association of individual risk factors included in the ESS calculation with the requirement of RRS at discharge are shown in Supplementary Digital Content Appendix A (http://links.lww.com/TA/B838). Supplemental Digital Content Figure A (http://links.lww.com/TA/B837) shows the sensitivity and specificity graph for ESS's ability to predict the need for either renal and/or respiratory support at discharge. Patients with an ESS of 8 or greater should be considered high risk for the subsequent requirement of RRS after discharge. The positive predictive value (PPV) and negative predictive value (NPV) of using 8 as the cutoff for the high-risk population was 17.6% and 98.7%, respectively.

Similar to the above, the optimal cutoffs for the requirement of renal support at discharge is ESS of 9 or greater (PPV, 9.2%; NPV, 99.2%) and for the need of respiratory support at discharge ESS of 8 or greater (PPV, 12.4%; NPV, 98.8%).

Sensitivity Analysis

To account for the bias introduced to our study from exclusion of patients that were discharged to hospice care and those transferred to other hospitals, we conducted a sensitivity analysis including the above patients. Of note, ESS preserved its ability as a powerful predictor of the outcomes of interest at discharge with the following c-statistics: RRS (c-statistic, 0.84; 95% CI, 0.80–0.88), renal support (c-statistic, 0.88; 95% CI, 0.84–0.92), respiratory support (c-statistic, 0.82; 95% CI, 0.77–0.87), tracheostomy (c-statistic, 0.82; 95% CI, 0.77–0.87), and ventilator dependency (c-statistic, 0.79; 95% CI, 0.66–0.92).

DISCUSSION

Emergency Surgery Score was associated extremely well with the need for RRS at discharge in our patient cohort and preserved its high-performing association with the need for RRS in the geriatric population as well. To the best of our knowledge, this is the first study to evaluate a scoring system to accurately predict the need for RRS at discharge for EGS patients. Based on the results of our analysis, we recommend the use of ESS ≥ 8 as the cutoff for patients at high-risk for the requirement of RRS at discharge (Supplemental Digital Content Figure A, http://links.lww.com/TA/B837). In this population, preoperative and postoperative counseling not only of the patients but also of their families can set the expectation regarding the postdischarge recovery early in their hospital course.

Moreover, it has been shown that one commonly overlooked factor that prolongs hospital length of stay in EGS patients is the time-consuming discharge planning and arranging.[17] Based on the above, we also recommend the use of ESS of 8 or greater as the cutoff for early initiation of discharge planning, which can lead to shorter lengths of hospital stay and decreased health care costs. These findings support the use of ESS as a bedside risk assessment tool, a tool for benchmarking the quality of care of EGS patients across different hospital settings, and a quality improvement tool that can proactively help postdischarge planning and thus decrease hospital length of stay of EGS patients.[17] With improved survival of EGS patients undergoing EL, the incidence of acute kidney injury requiring outpatient dialysis is expected to rise.[18–20] Acute kidney injury requiring dialysis currently complicates 1% of all hospital admissions.[20] While no study has focused exclusively on EL patients, between 5% and 20% of all critically ill patients who

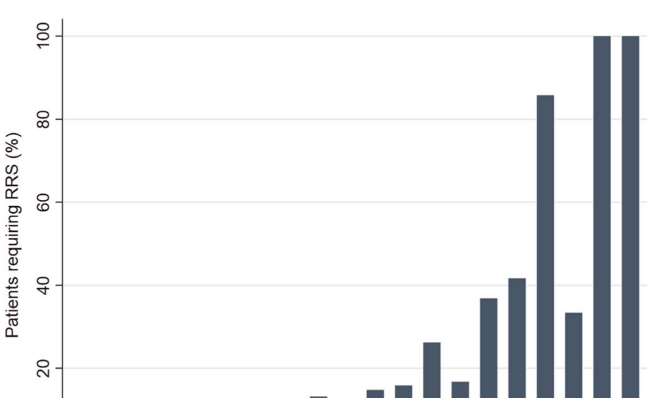

Figure 1. ESS versus percentage of patients requiring Renal and Respiratory Support (any of need for dialysis, tracheostomy, or ventilator dependence).

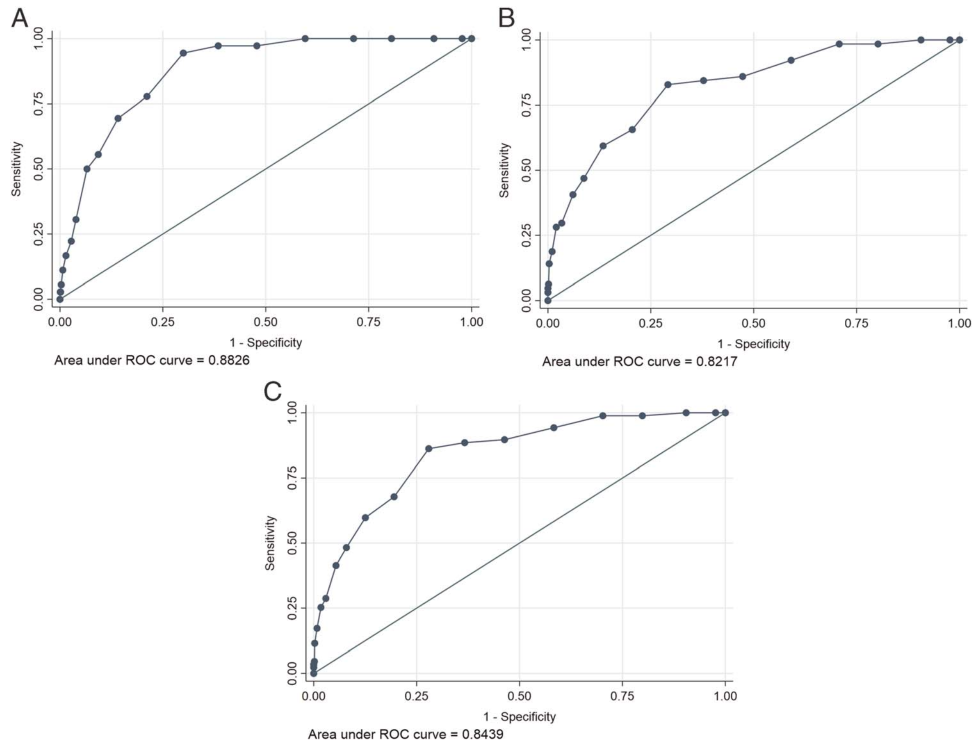

Figure 2. Area under the receiver operating characteristic curve (c-statistic) of the ESS predicting: (*A*) renal support, and (*B*) respiratory support, and (*C*) renal or respiratory support.

survive remain dialysis dependent at hospital discharge.[21–23] Among those, approximately 43% are able to discontinue dialysis by 90 days, with 16% returning to prior baseline renal function.[20] However, during this recovery period, and indefinitely for patients who do not recover, day-to-day challenges imposed by dialysis are taxing. Strict adherence to fluid intake and diet, a significant pill burden, and socioeconomic constraints for transportation to dialysis treatment sessions[24] all lead to poor patient-perceived quality of life.[25] A poor quality of life can lead to depression, which has been repeatedly tied to nonadherence to therapy,[26–28] such as missing treatment sessions, terminating treatment, or noncompliance with medication and diet. The reduced delivery of care subsequently results in significant morbidity, readmission, or death,[24] particularly in the elderly patient.[29] The ESS can help mitigate these risks by starting discussions with the family and involving social work services early in the admission.

Regarding respiratory support, patients who receive tracheostomy prior to discharge also face a range of daily physical challenges, from adjusting to swallowing and speaking,[30–32] to psychological aspects of their altered physical appearance.[33] Furthermore, a number of complications can present after discharge such as hemorrhage, tube dislodgement, infection, stenosis, and fistulizations.[34,35] To best prevent these issues, the care process of these patients should include adequate communication with the caregiver regarding cannula and cuff management, as well as stoma care and dressings. This can be a challenging process, especially for elderly patients and their caregivers,[30,36] who frequently report that they needed guidance and skills training to provide tracheostomy care, particularly during an emergency at home.[37,38]

As such, the ability to detect the need for tracheostomy early in a patient's admission has important implications for targeted interventions. With sufficient resources, high-fidelity simulation training can allow for realistic exposure to tracheostomy-related cases and emergencies. Simulation will allow the caregiver to gain important insight and allow for the identification of knowledge gaps prior to discharge, which can be targeted for education.[39]

TABLE 4. Frequencies of Patients With Need for Renal and Respiratory Support and the Corresponding c-Statistic of ESS Predictions

	All Patients, N = 1,347	ESS c-Statistic	95% CI	Patients ≥ 65, n = 533	ESS c-Statistic	95% CI
Renal support (dialysis)	36 (2.7%)	0.88	0.84–0.92	15 (2.8%)	0.84	0.73–0.95
Respiratory support	64 (4.8%)	0.82	0.77–0.87	31 (5.8%)	0.80	0.71–0.88
Tracheostomy	63 (4.7%)	0.82	0.77–0.87	31 (5.8%)	0.80	0.71–0.88
Ventilator dependence	18 (1.3%)	0.79	0.64–0.94	11 (2.1%)	0.75	0.56–0.94
RRS	87 (6.5%)	0.84	0.80–0.88	39 (7.3%)	0.81	0.73–0.88

In addition, patients are increasingly being discharged with a tracheostomy and invasive home mechanical ventilation, if weaning from ventilation proves unsuccessful during hospital stay.[40] While we were unable to identify studies tackling new oxygen dependence after EGS, landmark studies from the Nocturnal Oxygen Therapy Trial Group[41] and the British Medical Research Council Working Party[42] have demonstrated a 12% and 40% 1- and 3-year mortality rates, respectively, in COPD patients receiving home oxygen. Emergency Surgery Score can also be of aid in this scenario, by highlighting high-risk patients and thus encouraging early involvement of respiratory specialists and preparations for transfer to long term acute care.

Our study has a number of limitations. First, the long-term outcomes of patients were not recorded, and thus we were unable to ascertain if the need for RRS was temporary or permanent. Second, ESS applies only to patients who underwent surgery. The performance of ESS on patients managed nonoperatively was not assessed. Third, we did not directly assess patient-reported outcomes that reflect quality of life (e.g., SF-36), but we used RRS as a proxy to evaluate quality of life indirectly. Fourth, information regarding the socioeconomic status of the patients that may affect the outcomes of interest were not available and could not be accounted for. Finally, exclusion of patients that died during index hospitalization may have introduced a survival bias in our results.

CONCLUSION

Emergency Surgery Score accurately predicts the need for RRS at discharge in EL patients. Emergency Surgery Score can thus not only serve as a predictor of postoperative mortality and morbidity but also will allow providers to counsel patients on matters related to the quality of life postdischarge, specifically the burden related to renal or respiratory dependence. In addition, ESS can be used for benchmarking quality of care beyond the classical mortality and morbidity quality indicators.

AUTHORSHIP

M.E.H., N.K., H.M.A.K. participated in the conception and design of the study. All authors contributed patients to this multicenter study for data collection. M.E.H., N.K., L.N. participated in the data analysis. M.E.H., L.N., H.M.A.K. participated in the data interpretation. M.E.H., L.N., H.M. A.K. participated in the drafting of the article. All authors critically revised the article. All authors approved of the submitted article.

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DISCLOSURE

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