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# Can the emergency surgery score (ESS) be used as a triage tool predicting the postoperative need for an ICU admission?

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ABSTRACT

*Background:* The emergency surgery score (ESS) is a preoperative risk calculator recently validated as a mortality predictor in emergency surgery (ES) patients. We sought to evaluate the utility of ESS as an ICU admission triage tool.

*Methods:* A four-step methodology was designed. First, the 2007–2015 ACS-NSQIP database was examined to identify all ES patients using the "emergent" variable and CPT codes for "digestive system". Second, we created a composite variable called ICUneed, defined as death or the development of one or more postoperative complication warranting critical care (e.g. unplanned intubation, ventilator dependent ≥48 h, cardiac arrest, septic shock and coma ≥24 h). Third, for each patient, ESS was calculated. Fourth, the correlation between ESS and ICUneed was assessed by calculating the model c-statistics (AUROC).

*Results:* Out of a total of 4,456,809 patients, 65,989 patients were included. The mean population age was 56 years; 51% were female, and 71% were white. The overall 30-day postoperative mortality and morbidity were 8.2% and 31.7%, respectively. ESS gradually and accurately predicted ICUneed, with 1%, 40% and 98% of patients with ESS of 2, 9 and 16 requiring critical care, respectively. Only 6.2% of patients with ESS ≤7 had an ICUneed, while 97.2% of patients with ESS ≥15 had an ICUneed. The c-statistic of the predictive model was 0.90.

*Conclusions:* ESS accurately predicts the need for postoperative critical care and ICU admission. In resource-limited settings, ESS may prove useful as an ICU triage tool ensuring a prompt rescue of the clinically deteriorating patient without unnecessary and burdensome ICU admissions.



## Introduction

In the past two decades, the field of acute care surgery evolved to include Emergency surgery (ES), trauma surgery and surgical critical care.[1] As importantly, the burden of emergency surgical disease is now widely recognized to be substantial and rapidly increasing. For example, between 2001 and 2010, there were more than 27 million ES admissions in the United States alone, accounting for 7.1% of all hospitalizations; 28.8% of the admitted patients required an operation.[2]

The correlation between ES and postoperative morbidity and mortality has been studied extensively.[3–5] Not surprisingly, when compared to similar elective surgery, ES has up to 8 times higher

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postoperative mortality.[6] In addition, Lissauer et al. demonstrated that ES patients had increased need for life- and organ-sustaining models of treatment and thus more likelihood of an intensive care unit (ICU) admission and stay.[7] In another controversial study, Symons et al. suggested that the mere availability in a hospital of ICU beds and resources is independently correlated with decreased perioperative mortality in high-risk patients undergoing ES, and that the failure to allocate high-risk ES patients to the ICU postoperatively is associated with worse patient outcomes.[6] While few surgeons would argue the latter statement, the challenge remains in our inability to preoperatively predict what ES patient will develop complications and thus need the ICU postoperatively for rescue.

The Emergency Surgery Score (ESS) is a preoperative risk scoring system that accounts for both the patients' demographics, comorbidities as well as the acuity of disease upon presentation. It includes 22 variables with a score ranging from 0 to 29[8] (Table 1). ESS has been previously validated as a high-fidelity model that accurately predicts 30-day postoperative mortality and morbidity in the ES patient.[8–10] In this study, we sought to evaluate whether ESS could be used as a tool to triage ES patients to the ICU by predicting their postoperative need for critical care.

## Material and methods

### *Patients and methods*

To test the ability of ESS to preoperatively predict the need to triage an ES patient to the ICU postoperatively, we used the 2007–2015 American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. The ACS-NSQIP is a prospective well-validated database for patients undergoing major surgical operations. The database includes more than 150 preoperative, intraoperative and postoperative variables.[11]

**Table 1**
The emergency surgery score (ESS).

| Variable | Points |
|---|---|
| Demographics | |
| Age >60 years | 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 months | 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 ration >1.5 | 1 |
| Platelets <150 × 10$^3$/μL | 1 |
| SGOT >40 U/L | 1 |
| Sodium >145 mg/dL | 1 |
| WBC, × 10$^3$/μL | |
| <4.5 | 1 |
| >15 and ≤ 25 | 1 |
| >25 | 2 |
| Maximum score | 29 |

BMI, body mass index; COPD, chronic obstructive pulmonary disease; WBC, white blood cell.

### *Patient population*

To identify ES patients, we used the ACS-NSQIP "EMERGNCY" variable. ACS-NSQIP defines an "emergency case" as one that is "performed as soon as possible and no later than 12 h after the patient has been admitted to the hospital or after the onset of

**Table 2**
The demographics, comorbidities and postoperative complications.

| Variable | Patients, n, (%) |
|---|---|
| Total N | 65,989 |
| **Preoperative complications** | |
| **Demographics** | |
| Age ≥ 60 y | 28,835 (43.74) |
| White race | 46,542 (70.53) |
| Female | 33,469 (50.72) |
| Transfer from outside emergency department | 7390 (11.20) |
| Transfer from an acute care hospital inpatient facility | 2763 (4.19) |
| **Comorbidities** | |
| Current smoker within 1 y | 13,978 (21.18) |
| Ascites | 3215 (4.87) |
| History of congestive heart failure in 30 days before surgery | 1789 (2.71) |
| Diabetes | 9161 (13.88) |
| Dyspnea | 7279 (11.03) |
| Functional dependence | 9486 (14.38) |
| Ventilator dependence | 4870 (7.38) |
| COPD | 4868 (7.38) |
| Hypertension | 29,094 (44.09) |
| Acute renal failure (pre-op) | 1839 (2.79) |
| Currently on dialysis | 2074 (3.14) |
| Disseminated cancer | 2415 (3.66) |
| Weight loss > 10% in the preceding 6 months | 2429 (3.68) |
| Steroid use | 4151 (6.29) |
| Bleeding disorder | 8362 (12.67) |
| No sign of systemic sepsis | 37,945 (57.65) |
| SIRS | 14,053 (21.35) |
| Sepsis | 8471 (12.87) |
| Septic shock | 5352 (8.13) |
| **Laboratory values** | |
| Albumin <3.0 | 15,630 (23.69) |
| Alkaline phosphatase > 125 | 8863 (13.43) |
| Bilirubin >1 | 5990 (9.08) |
| Creatinine > 1.2 | 6056 (9.18) |
| Platelets < 150 | 8906 (13.50) |
| SGOT > 40 | 11,872 (17.49) |
| Sodium > 145 | 1931 (2.93) |
| WBC < 4.5 | 3467 (5.29) |
| WBC > 11 and ≤ 15 | 16,777 (25.59) |
| WBC 15-25 | 14,185 (21.63) |
| WBC > 25 | 2293 (3.50) |
| **Postoperative Complication** | |
| Mortality | 5403 (8.19%) |
| Unplanned reintubation | 3076 (4.66%) |
| On ventilator > 48 h | 8135 (12.33%) |
| Cardiac arrest | 1071 (1.6%) |
| Septic shock | 3818 (5.79%) |
| Coma >24 h | 155 (0.23%) |
| DVT | 1387 (2.1%) |
| Superficial SSI | 2612 (3.96%) |
| Deep SSI | 899 (1.36%) |
| Organ/space SSI | 2510 (3.8%) |
| Wound dehiscence | 1052 (1.59%) |
| Pneumonia | 3646 (5.53%) |
| Pulmonary embolism | 555 (0.84%) |
| Progressive renal insufficiency | 649 (0.98%) |
| Acute renal failure, requiring dialysis | 1315 (1.99%) |
| Urinary tract infection | 1865 (2.83%) |
| CVA/stroke with neurological deficit | 317 (0.48%) |
| Acute myocardial infarction | 639 (0.97%) |
| Bleeding Transfusions | 6876 (10.42%) |
| Sepsis | 3579 (5.42%) |

COPD, chronic obstructive pulmonary disease; SGOT, aspartate aminotransferase; WBC, white blood cell; DVT, deep vein thrombosis; SSI, surgical site infection; CVA, cardiovascular accident.

**Table 3**
Types of procedures performed, categorized by organ and approach.

| Organ | Open, n (%) | Laparoscopic, n (%) | Total, n (%) |
|---|---|---|---|
| Esophagus | 170 (0.19%) | 61 (0.07%) | 231 (0.26%) |
| Stomach | 4140 (4.67%) | 454 (0.51%) | 4594 (5.18%) |
| Small bowel | 12,141 (13.70%) | 1322 (1.49%) | 13,463 (15.19%) |
| Colon and rectum | 14,875 (16.78%) | 1569 (1.77%) | 16,444 (18.55%) |
| Appendix | 4294 (4.84%) | 23,940 (27.00%) | 28,234 (31.85%) |
| Hepato-biliary-pancreas | 2615 (2.95%) | 8331 (9.40%) | 10,946 (12.35%) |
| Hernia | 7162 (8.08%) | 821 (0.93%) | 7983 (9.01%) |
| Other intraperitoneal | 5253 (5.93%) | 327 (0.37%) | 5580 (6.30%) |
| Others | 1003 (1.13%) | 160 (0.18%) | 1163 (1.31%) |
| Total | 51,653 (58.27%) | 36,985 (41.73%) | 88,638 (100%) |

related preoperative symptomatology". Only patients who underwent abdominal surgery (CPT codes for digestive system 43020–49999) were included. Patients with any missing ESS variables were excluded.

*Defining "need for ICU"*

A panel of 6 surgical critical care experts, all board certified and with years of clinical and research experience in surgical critical care, systematically evaluated all the ACS-NSQIP defined *postoperative* complications and determined which of them would most-likely require an ICU level of care. Based on their assessment, we created a composite variable called "ICUneed", which we defined as death or the development of one or more of the following: unplanned intubation, postoperative ventilator requirement for more than 48 h, cardiac arrest requiring CPR, septic shock and coma more than 24 h.

*ESS versus ICUneed*

Each patient's ESS was calculated, and the relationship between ESS and ICUneed was evaluated. The receiver operating characteristic curve was computed to find the c-statistic as a measure of the strength of the relationship between ESS and ICUneed.

*Statistical analysis*

All data analysis was performed using STATA version 13.1.

*Ethical oversight*

The study was approved by our Institutional Review Board Committee.

## Results

Out of a total of 4,456,809 patients, 65,989 patients who underwent emergency abdominal surgery were included. The mean age of the population was 56 years, 51% were female and 71% were white; 42% of the patients presented with sepsis or septic shock. The 30-day mortality rate was 8.2% and more than 32% of the patients experienced at least one complication within 30-days from their operation. Table 2 summarizes the demographic, preoperative, and postoperative characteristics of our patient cohort. Table 3 describes the type of surgery performed, categorized by organ and surgical approach (laparoscopic vs. open).

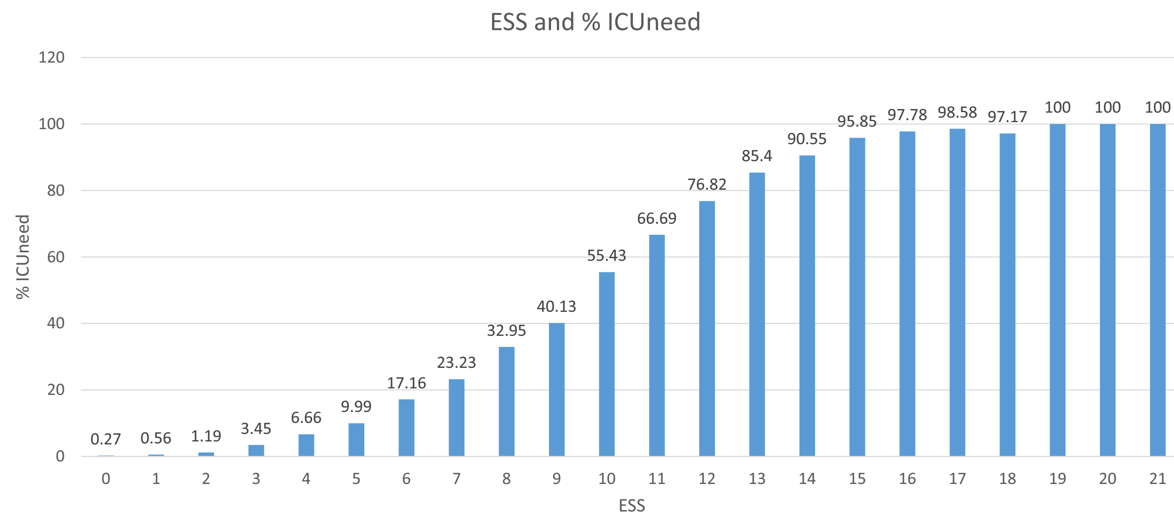
*ESS versus ICUneed*

A total of 11,264 patients (17.07%) met the definition of an ICUneed. ESS gradually and accurately predicted ICUneed, with 1%, 40% and 98% of patients with ESS of 2, 9 and 16 requiring critical care, respectively [Fig. 1]. The cumulative number of patients showed that only 6.2% of patients with ESS of 7 or lower had an ICUneed, while 58.2% of patients with an ESS higher than 7 had an ICUneed. The c-statistic of the predictive model was at a high of 0.9040 [Fig. 2].

## Discussion

We have thus demonstrated the ability of ESS to *preoperatively* predict the need for *postoperative* critical care in ES patients. Such accurate and stepwise performance strongly suggests that ESS could be used preoperatively as a tool helping the surgeon and the anesthesiologist triage and admit ES patients to the ICU, stepdown units or the regular floors postoperatively. Allocating these patients to the appropriate level of care not only decreases the rates of failure to rescue, but also preserves hospital resources, and potentially decreases healthcare costs, especially in healthcare settings where critical care abilities are limited. The potential risks associated with failing to send a high-risk ES patient to the ICU was elegantly demonstrated by a study from Vester-Andersen et al. suggesting that the ES patient who was admitted postoperatively to the regular ward before getting transferred to the ICU for clinical deterioration has a significantly higher mortality risk compared to a similar patient that was admitted directly to ICU.[12] To the best of our knowledge, ESS, previously validated as a highly accurate predictor of outcome in ES, is the first tool to demonstrate a promising ability to specifically identify the ES patient that should be admitted to the ICU instead of the standard regular ward. Our team is currently conducting a 2-year multicenter study to prospectively study ESS and its correlation with outcome including ICUneed.

In general, we recommend ESS $\geq$7 as a cut-off point to admit patient to intensive care unit after ES because a score of 7 or higher simultaneously maximizes and balances sensitivity (80%) and specificity (85%) [Fig. 3], and therefore is the most accurate score per the ROC curve graph to detect the patient that will require critical care.[13] Nevertheless, we simultaneously recommend that each hospital, center or healthcare facility evaluates our results carefully and decide its own cutoff for triage, depending on their existent resources and infrastructure and their current level of tolerance of undertriage. For example, a humanitarian surgeon, anesthesiologist or intensivist operating in a conflict area hospital might have only one or 2 true critical care beds despite the clinical needs, and as such might opt to use ESS of 15 or higher to triage a patient to the ICU. More than 95% of patients with ESS $\geq$15 in our study required critical care. On the other hand, a small community hospital with adequate ICU resources but limited standard floor physician/nursing coverage at night might opt to send all patients with ESS of 5 or higher to the ICU or transfer them to a tertiary care hospital to avoid failing to identify and rescue the deteriorating patient in time.




**ESS Points:**
Age>60 years...**2** Albumin<3.0...**1** Alkaline phosphatase>125...**1** Ascites...**1** Body mass index<20...**1** BUN>40...**1** History of COPD...**1** Creatinine>1.2...**2** Disseminated cancer...**3** Dyspnea...**1** Functional dependence...**1** Hypertension...**1** INR>1.5...**1** Platelets<150...**1** SGOT>40...**1** Sodium>145...**1** Steroid use...**1** Transfer from outside ED or acute care hospital...**1** Ventilator requirement 48 hours pre-operatively...**3** WBC<4,500 or 15,000 -25,000...**1** WBC>25,000...**2** White race...**1** >10% weight loss in last 6 months...**1**

**Fig. 1.** ESS vs percentage of patients requiring postoperative crictical care.

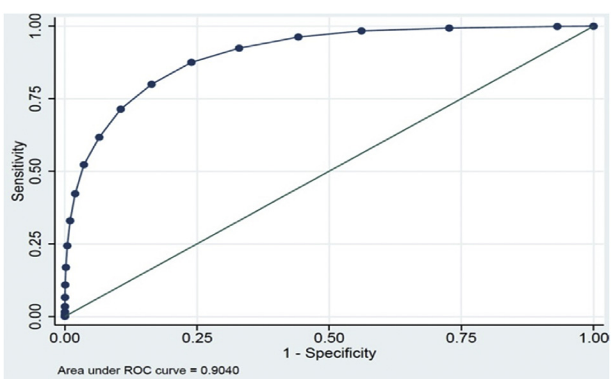



**Fig. 2.** ROC curves using data from the Model.

Several studies have previously attempted to predict which patients undergoing elective or emergency surgery will require the ICU.[14–16] Sobol et al. for example studied the Surgical Apgar Score as a tool to predict ICU admission after high-risk intraabdominal surgery. Despite the premise of that study, the correlation between the Apgar score (mostly for elective rather than ES) and the need for an ICU was relatively low, with a c-statistic of 0.763[14]. In addition, the Apgar score is derived intraoperatively, not preoperatively like ESS, which limits its usability as a triage tool because of the short time interval between its derivation and the readiness of the patient to leave the operating room.

Moreover, in many studies, ICU admission as an outcome was subjectively defined, and the decision for ICU admission was mostly based on physician's preference. In our study, the conditions chosen for ICUneed were objective and defined as the patient's actual

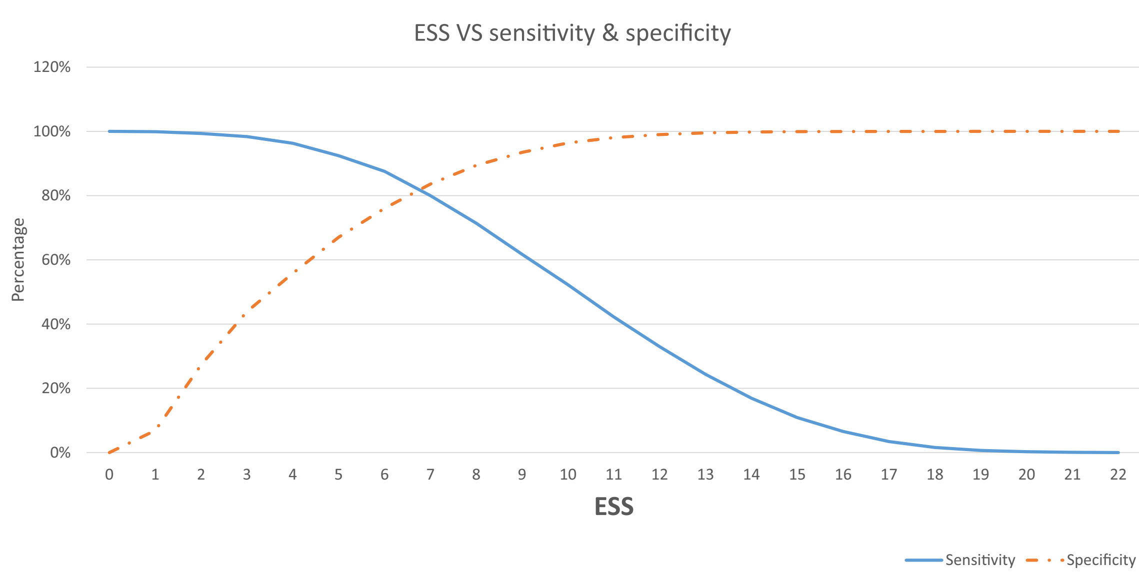



**Fig. 3.** The Emergency Surgery Score (ESS) versus sensitivity and specificity.

postoperative need for life-supportive therapies that could only be administered in the ICU. The current ICU admission guidelines by the Society of Critical Care Medicine state that patients needing life-sustaining interventions or invasive mechanical ventilation or complex life-threatening conditions, including those with sepsis, should be treated in an ICU.[17]

Our study has several limitations. First, this is a retrospective study (using prospectively collected data), and we did not assess whether the patients did or did not in fact get admitted to an ICU level of care. Second, the conditions included in the ICUneed variable were based on critical care surgeons' consensus and limited by what is available in the ACS-NSQIP database; other conditions such as severe electrolyte imbalances for example might warrant ICU admission, but were simply not available in our database and therefore not included in the ICUneed variable. Third, ESS is calculated preoperatively, and as such, the occurrence of intra-operative surgical or anesthesia complications may increase the chance of a patient needing the ICU as compared to their preoperative status. Finally, we did use the ACS-NSQIP definition of ES in our study; slightly different results might have been observed if we used the American Association for the Surgery of Trauma emergency general surgery definitions instead.

## Conclusion

We have thus demonstrated that ESS, a well-validated tool to predict outcomes in ES, could also be used as an effective predictive tool to preoperatively triage the ES patient to the appropriate level of care postoperatively. In general, a patient with an ESS score of 7 or higher warrants a postoperative ICU admission to ensure the ability to promptly rescue upon any clinical deterioration. In resource-limited settings, ESS may prove useful as an ICU triage tool ensuring a prompt rescue of the clinically deteriorating patient without unnecessary and burdensome ICU admissions.

## Conflicts of interest

We have no conflicts of interest to report.

## Disclosures

We have no disclosures.

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