(range of LR, 0.06-0.21). The NT-proBNP level is useful in about 36% of patients.

The authors concluded that their review suggests that cardiac syncope can be accurately identified using clinical examination. There are some limitations to the review, including the risk of misclassification bias in some studies which may overestimate sensitivities and specificities. Additionally, exclusion of patients with unexplained syncope in some studies may have also increased sensitivities and specificities reported. Additionally, the findings from these studies are not generalizable to all clinicians. Some studies have shown promise for the use of multivariable clinical prediction rules, but further research is needed. Features such as palpitations, pallor, diaphoresis, absence of prodromal symptoms and injury are classically associated with cardiac syncope but may be unreliable based on the studies reviewed. The reviewers conclude that cardiac markers should not be used routinely but may be beneficial in some populations, which is consistent with recommendations by European Society of Cardiology and American College of Cardiology/American Heart Association.

[Ryan Matthews, MD
Amanda Young, MD
University of Arkansas for Medical Sciences, Little Rock, AR]

Comment: This review provides further support that clinicians can use the history and physical examination to determine an appropriate workup in patients presenting with syncope. The combination of low risk features with a normal EKG confers low overall risk of cardiac syncope. The patient populations studied were not all emergency department patients which could affect generalizability. However, an understanding of evidence-based high- and low-risk features allows physicians to pursue patient specific workups and dispositions.

☐ EMERGENCY DEPARTMENT TRIAGE PREDICTION OF CLINICAL OUTCOMES USING MACHINE LEARNING MODELS.

Yoshihiko R, Tadahiro G, Mohammad KF, et al.
Critical Care 2019;23(1):64

The practice of emergency medicine relies on the application of a triage system to determine which patients are most ill and require evaluation and treatment more urgently than others. The most widely used conventional model is the Emergency Severity Index (ESI). The authors of this study used machine learning models and compared their predictive performance to that of the conventional ESI method in order to determine which may more accurately predict clinical outcomes flowing triage in the ED.

The study used emergency department data from the 2007-2015 National Hospital and Ambulatory Medical Care Survey (NHAMCS). This survey collects data from general and short stay hospitals, and excludes federal, military, and Veterans Affairs (VA) hospitals. The study identified all ED visits in the data set from 2007-2015. Exclusion criteria included those who were deceased on arrival, patients who left without being seen, patients who left against medical advice (AMA), and patients with missing information or data inconsistencies. Routine ED triage information were used as predictors for the learning models, including age, sex, method of arrival, vital signs, chief complaint(s), and comorbidities. The primary outcome was a critical care outcome, defined as either direct admission to a critical care unit or in-hospital death. The secondary outcome was hospitalization, either at the original hospital or transfer to an acute care hospital. The authors used 70% randomly selected samples of the data set for a training model. The reference model utilized ESI as a predictor of clinical outcomes. For comparison, four machine learning models were developed: Lasso regression, random forest, gradient boosted decision tree, and deep neural network. The remaining 30% of samples were used in a test set to predict the performance of each model using area under receiver-operating characteristics curve (AUC), net reclassification improvement, and confusion matrix results (i.e sensitivity, specificity, positive predictive value, and negative predictive value).

During the 2007-2015 time period, 209,800 adult ED visits were recorded in the NHAMCS. A total of 74,330 patients were excluded due to the previously listed exclusion criteria, leaving a total of 135,470 visits to be analyzed. Characteristics between the analyzed and non-analyzed cohorts were similar. Regarding prediction of a critical care outcome, all four machine learning models demonstrated a significantly higher AUC) (all $p<0.001$). The reference model resulted in an AUC of 0.74 [95% CJ 0.72-0.75], , while the AUC for the machine learning models ranged from 0.84-086. All machine learning models had a higher sensitivity (0.75-0.86) for a critical care outcome than the reference model (0.50). The reference model did have a higher specificity than the machine learning models for a critical care outcome (0.86 vs 0.68-.077). The ESI model correctly predicted critical care outcomes in ESI level 1 and 2 patients (49.6% of all critical care outcomes), but also over-triaged a large number of patients into these two categories, as well as under-triaged critical care patients in levels 3-5 (under triaging 50.4% of critical care patients). In contrast, the machine learning models correctly identified 71.3-81.6% of critical care outcomes in ESI levels 3-5. In regards to hospitalization, all machine learning models had a significantly higher AUC ($p<0.001$). Regarding hospitalization, the reference model had a higher sensitivity (0.87 [95% CI 0.86-0.87]) than the highest computer learning model, 0.71 [95% CI 0.70-0.72]. However, machine learning models had a higher specificity (0.71-0.76) as compared to the reference model (0.42) with regards to hospitalization. The reference model over-triaged many patients and failed to predict hospitalization for patients with a lower ESI level (3-5), ultimately under-triaging 13.4% of patients. The machine learning models successfully predicted hospitalization outcomes in 64.2-72.4% of patients triaged to a lower ESI.

The authors conclude that the machine learning methods were statistically superior to the conventional ESI method in their ability to predict critical care and hospitalization outcomes. The authors highlight that in particular the machine learning models have a higher sensitivity for critical care outcomes with less under-triaging of patients with regard to a critical care outcome, and a higher specificity for hospitalization outcomes with less over-triaging. The authors note limitations that include similar possible selection bias, ascertainment bias

of the data set, certain information not included in the NHAMCS data (e.g., chronic medications, etc),and differences in critical care admission criteria, hospitalization, and transfers between facilities. The authors note that although they believe their predictive model is superior to the conventional ESI model, the performance is not without flaws, which they attribute to limited predictors, clinical factors, physician practice patterns, resources, etc.

[Seth Bartholomew, MD
Amanda Young, MD
University of Arkansas for Medical Sciences, Little Rock, AR]

Comment: This study introduces the possibility of computerized modeling to predict high acuity ED patients rather than the traditional ESI model. While these models do show improved accuracy for identifying patients who will need admission or critical care, further study and validation will be needed before computerized modeling could be incorporated into ED operations.

☐ EXTRACORPOREAL MEMBRANE OXYGENATION FOR SEPTIC SHOCK.

Falk L, Hultman J, Broman LM. *Crit Care Med.* 2019;47(8):1097-1105

Septic shock has a very high mortality rate despite early aggressive resuscitation with antibiotics, fluids, and vasopressors. Extracorporeal membrane oxygenation (ECMO) has become the standard of care for refractory neonatal and pediatric septic shock, however it is not as common in adults. The current data is scarce in regards to the mortality benefit of ECMO in adult septic shock.

The goal of this retrospective observational study was to estimate the mortality benefit of ECMO in adult refractory septic shock patients. This study evaluated adult patients in a high volume ECMO center in Sweden who presented between January 2012 and December 2017. Patients were diagnosed with septic shock meeting the Sepsis-3 criteria with suspected end-organ hypoperfusion; objectively they required vasoactive medications to maintain a mean arterial pressure (MAP) of >65 mmHg with a vasoactive inotropic score (VIS) >50 despite adequate fluid resuscitation at time of ECMO initiation. Patients excluded from the study were those who had CPR during ECMO initiation as well as those who had their entire ECMO treatment done outside the ECMO center. Patients were either placed on venovenous or venoarterial ECMO. Venovenous ECMO was used for PaO2:FiO2 ratio of 60-80 mmHg when conventional respiratory therapy had failed. Venoarterial ECMO was used in cardiocirculatory failure defined as one of the following: persistent lactate >5mmol/L, mixed venous saturation (SVO) <55%, cardiac index <2L/min/m2 (>1 hour), rapidly deteriorating ventricular dysfunction, refractory arrhythmia, VIS>50 (<1 hour), VIS >45 (>8 hours), or VIS>40 if myocarditis was present. All patients received an echocardiogram prior to ECMO initiation. The primary outcomes measured were ECMO unit mortality, hospital mortality and 6-month mortality. The secondary outcomes were ECMO related complications and days on ECMO.

Thirty-seven patients were included in the study with 27 patients placed on venoarterial ECMO and 10 patients placed on venovenous ECMO. Twenty of the patients had left ventricular failure (LVF). The overall survival rates for all patients on ECMO were 81.1% at discharge from the ECMO unit, 78.4% at hospital discharge, and 59.5% at 6-month follow up. Patients with LVF had a 90% survival rate at time of leaving the ECMO unit as well as at time of hospital discharge, but 75% survival at 6-months. The survival in patients with LVF was better with venoarterial ECMO (94.4%, 94.4%, 83.3% for ECMO unit discharge, hospital discharge and 6 month respectively) compared to venovenous ECMO (50%, 50%, 50%, respectively). The survival in patients with non-LVF was 70.6% for ECMO unit discharge, 64.7% for hospital discharge, and 47.1% for 6-months. It was similar for venovenous and venoarterial ECMO in the non-LVF group (62.5% vs 66.7% for ECMO unit discharge, 62.5% vs 66.7% for hospital discharge, 37.5% vs 55.6% for 6-month). The mortality difference between patients with LVF vs non-LVF was significant at hospital discharge (p=0.044) and at 6-months (p=0.081). ECMO complications included higher risk of in hospital death (50% vs 11%, p=0.011) and all cause mortality at 6-month follow up (70.0% vs 29.6%, p=0.026) in the venovenous ECMO group compared to the venoarterial group. Thirty eight percent of the patients experienced ventilator associated pneumonia, two experienced bleeding, and two experienced limb ischemia in the cannulated limb. The patients who expired on ECMO were those who had care withdrawn secondary to futility of care after intracranial complications (bleeding, ischemia, or herniation).

The authors concluded that venoarterial ECMO could improve the mortality rate of septic shock adult patients when used by an experience physician at a high use ECMO center. They concluded this benefit may be even more dramatic in those septic shock patients with cardiac failure. Limitations of the study included the small number of patients within the study itself as well as the overall small number of adult septic patients that ECMO has been utilized on which limits the generalizability of the results. The use of a single center in this study also further limits this generalizability. Finally, physicians decided which ECMO setting to use (venovenous or venoarterial) which may introduce selection bias.

[Meredith K. Von Dohlen, MD
Jerrilyn Jones, MD, MPH
University of Arkansan Medical Sciences, Little Rock, AR]

Comment: There are currently no randomized control trials comparing ECMO in adult septic shock patients with the current standard of care. This retrospective study is the first step in establishing ECMO as an potential treatment for adult refractory septic shock, however there needs to be further studies to better elucidate the benefits versus risks of ECMO treatment in these types of patients prior to a change in current practice.