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Editorial

Scoring Systems for the Patients of Intensive Care Unit

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The patients being treated in intensive care unit (ICU) have considerably unstable clinical status and physiological capacity. Therefore, care services, backed by accurate clinical judgement, have a great impact on their recovery. Accurate clinical assessment can facilitate not only prognostic prediction and therapeutic decision-making, but also assessment and comparison of ICU performance or quality of critical care services. Among the measures of illness severity, mortality rate or survival rate is widely used because it is an easy to use, simple, and powerful tool. However, this measure cannot be used as performance indicator of ICU for comparison because it cannot be adjusted for patient severity in each ICU.

Severity scoring systems that are commonly used in critical care settings include Acute Physiology and Chronic Health Evaluation (APACHE), which was developed in 1980s for predicting mortality, Simplified Acute Physiology Score (SAPS) and Mortality Probability Model (MPM). Although these scoring systems use different variables and weights for classification of disease severity, they commonly monitor parameters such as heart rate, blood pressure, neurological state, and clinical data as these factors are significantly deviated from physiological normality in progression of critical disease. Old age and chronic disease are also captured by the scoring systems. Sequential Organ Failure Assessment (SOFA) score, which is based on organ failure over time to evaluate morbidity and multiple organ dysfunction are also used.

The APACHE model was first presented by Knaus et al. [1] in 1981. This model is used to classify patients according to their physiological severity using medical records to measure the severity of illness. The APACHE II, which was published by Knaus et al. [2] in 1985 as the updated version of APACHE I, excluded the patients aged 16 years or less, those with burn injuries and coronary artery disease and those with an ICU stay of less than 8 hours. It quantifies illness severity based on 12 basic physiologic parameters, including body temperature, central arterial pressure, heart rate, respiratory rate, $AaDO_2$ or PaO_2, arterial pH, serum Na^+, serum

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K^+, creatinine, hematocrit, white blood cell count, and Glasgow Coma Scale (GCS), along with age and previous health status. These physiologic variables indicate the worst values recorded during the initial 24 hours of ICU admission and are combined with the degree of risk factors associated with increased age and chronic health evaluation outcomes (recent surgery, history of severe organ failure, and weakened immune system) to produce the severity score. That is, APACHE II score is a sum of basic physiologic measurements, age and chronic health evaluation score. The APACHE III, published in 1991, is similar in structure to its earlier version APACHE II, which is based on acute physiological changes, age and chronic health evaluation [3]. APACHE III score (range, 0 to 299) is based on 17 physiologic variables including 12 basic variables, urine output in first 24 hours, blood urea nitrogen, albumin, bilirubin, and glucose. It also assesses age and seven chronic diseases (acquired immunodeficiency, liver failure, lymphoma, metastasis, leukemia, immune injury, and liver cirrhosis). Unlike its earlier versions, the APACHE III can be applied at any time during the course of the ICU stay to produce an equation predicting hospital mortality. It has been reported that a 5-point increase in APACHE III score correlates with an increase in mortality, and the correlation was statistically significant. In addition to its common use for measuring illness severity, APACHE III score can be used to compare treatment outcomes between patients with low-risk disease and patients with high mortality risk and to diagnose or set criteria for ICU admission. The APACHE IV, published in 2006, had better accuracy as the problems of the previous systems had been modified and fixed [4]. This scoring system includes patients who had coronary artery reconstruction for the first time. The APACHE IV score is calculated for patients who did not have coronary artery construction through statistical analysis of acute physiological changes on the first day of ICU admission (APACHE III score), age, chronic health status, admission diagnosis, patient location before ICU, length of hospital stay before ICU, emergency surgery, GCS score calculation (yes/no), remeasure of the GCS score, PaO_2/FiO_2, and so forth. APACHE IV variables for the patients who had coronary artery reconstruction are further segmented and include emergency surgery, history of coronary artery reconstruction, gender (female), the number of blood vessels in transplant, internal breast artery, hospital myocardial infarction, length of hospital stay before ICU and diabetes for statistical analysis. However, the use of APACHE IV is limited due to the following reasons: first, the increased complexity of the model requires designated software to apply it. Second, as the system was developed in ICU settings in the United States, there can be differences in the areas of ICU resources, classification systems and ICU bed availability, compared with other countries.

SAPS II, since developed in 1993, has been used as one of ICU scoring systems quantifying disease severity and predicting mortality and verified among surgical and internal medicine patients in large scale studies [5]. Like APACHE II, it excludes the patients aged 16 years or less, those with burn injuries and coronary artery disease and those with a past history of cardiac surgery. This scoring system consists of 17 variables including 12 physiological variables, age, admission type (elective surgery, emergency surgery, and internal medicine) and three underlying diseases (acquired immunodeficiency, metastasis, and blood cancer). All measurements are completed within 24 hours after ICU admission and the resultant score can range from 0 to 163. A logistic regression equation is used, and a different score is assigned to each variable, based on their strength of predictability. The SAPS III, developed in 2005, is reportedly better at predicting mortality than SAPS II [6]. SAPS III score is calculated through statistical analysis of information available during the first 3 days of ICU admission and before discharge, chronic underlying disease, diagnosis data, physiologic variable during ICU stay, severity of organ dysfunction, length of stay in ICU and hospital, vital signs on ICU admission and discharge, and so forth.

MPM, which was developed on the basis of 755 patients at a single hospital in 1985, uses multiple logistic regression to assign weights to variables selected for

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prediction of hospital mortality [7]. It selects predictive variables using a computer-based survey and offers probability level as a result, instead of an absolute score, making it different from other scoring systems. The MPM II, developed in 1993 [8], excludes children, burn injuries, coronary artery, and patients who had cardiac surgery as APACHE II does. It is used to predict hospital mortality based on partial physiological disorders, requiring fewer variables. MPM places more weight on chronic illness, concurrent illness, and age and less weight on acute physiological disorders, when compared with the APACHE. The MPM III was developed using the sample of 124,855 patients from 135 ICUs of 98 hospitals between 2001 and 2004 [9]. In 2009, the data initially presented were revised using logistic regression models [10].

This review introduces relative functions of the three classification and prediction systems in critical care that are most frequently addressed in the literature. However, no scoring system is fully capable of predicting patient outcome. Therefore, the use of scoring system may not be appropriate for selecting a treatment option. However, APACHE, MPM, and SAPS are highly advanced and prospectively verified tools, thereby making them useful for the comparison of ICU performance, which is required for the management of patients with different characteristics.

Critical care physicians can also use the SOFA developed to quantify organ dysfunction in respiratory, cardiovascular, hepatic, coagulation, renal, and neurological systems and the Multiple Organ Dysfunction Score, which facilitates functional assessment of each organ.

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