Estimation of the mortality rate using the APACHE II standard disease severity scoring system in intensive care unit patients

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Abstract
Aims: Identification of priorities in intensive care units is a matter of high complexity due to dysfunction in patients' vital organs such as circulatory, lung and kidney which often undergo rapid changes in the mentioned wards. Nurses should therefore be able to make decisions with respect to priorities to resolve this problem. In this regard, the present study was undertaken to investigate the efficacy of APACHE II instrument.

Methods: In the present study in 2010, 70 patients of intensive care units with congestive heart failure and chronic obstructive pulmonary disease were evaluated, for whom the APACHE II scores were calculated. The research was conducted in a cross-sectional approach, in which patients' death or survival was recorded. SPSS15 statistical software was applied for statistical analysis, and clinical parameters were investigated using descriptive-statistical tests.

Results: The study findings showed significant difference between survivors and non-survivors with respectively 13.6 (±3.5) and 17 (±2.5) as the mean (±SD) APACHE II scores. Fifteen percent mortality rate was observed in patients with scores under 15, while it was 36% in those with scores ranging from 16 to 19, and almost 100% in participants obtaining 20 to 30 scores.

Conclusion: The APACHE II scoring system has been successful in predicting the mortality rate in intensive care unit patients and it has been found to be higher than the standard level in all patients.

Key words: APACHE II scoring system, Intensive Care Unit, Mortality

Introduction
Today, intensive care unit (ICU) has undergone a transition from a general ward to a specialized unit for providing care to patients with common disorder. However, in all critical care units, nursing aims have remained the same and include providing an ongoing care at the highest possible level to patients with life threatening diseases. Decision-making in intensive care units is actually the arts and the ability to work in emergency and urgent situations, raising the need for the knowledge in scientific fields such as physiology and pathology. Within the decision-making frame, priorities should be taken into consideration by nurses. Identification of priorities is a complex and immediate issue in these wards; in particular, due to dysfunction in patients' vital organs such as the circulatory, respiratory and renal systems and their rapid alterations in the mentioned wards, nurses should be able to make decision with respect to priorities to resolve these problems [1]. It should be noted that intensive care unit is a costly ward with functional approach for patients with reversible conditions and, hence, requires mechanical ventilation and other special services [2].

ICU is a place in which patients are hospitalized with urgent need to receive medical and nursing services in the first place, and benefit from it when admitted in the second, and undergo serious problems such as organ defects, increased hospital stay, increased costs and mortality in cases of untimely services [3]. Studies have shown that some patients in critical care units do not require special care and are mostly in need of continuous monitoring of vital signs or nursing care more than those of general sector [4]. In a study on 706 patients admitted to the ICU, it has been observed that 22 percent of total beds have been allocated to the above-mentioned group of patients per day in this ward. In a recent study, it has been found that less than ten percent of 6180 patients, out of 17440 subjects, admitted to ICU were in need of special care. It is ideal that only those patients be admitted to intensive care units that benefit from ICU care to reduce the risk of death. Patients in extremely good condition or dying are not candidates for admission in the ICU. Unfortunately, the indications for ICU admission have been generally defined,
and it is really difficult to diagnose whether the patients will take advantage of the special care or not. This issue has led to non-appropriate and non-optimized use of facilities and beds in critical care units [5, 6]. Estimation of the number of beds required for intensive care unit depends on criteria such as admission, triage, discharge, and length of ICU stay. Some studies have been conducted to define these criteria, however, the strategies proposed are rarely implemented [7, 8].

Using the disease severity scoring system can be a guide for nurses to evaluate patients' outcome or estimate their physiologic stability. These prognosis-determining systems can also be of help for the estimation of patient's physiological instability at the time of admission. Moreover, the severity classification and mortality prediction can be undertaken along with patients' clinical examination in the ICU to more accurately determine the chance of survival [9].

According to international estimates, mortality rate is reported to be between 6 to 40 percent in different ICUs while special medical care has also been performed. The mortality rate is always defined as cases of biological deaths recorded in intensive care units. Mortality rate in the ICU has high dependency on the disease severity and deterioration of patient's condition [10].

Mortality rate and disease severity-measuring tools are the information-giving instruments for the therapist group in terms of patient's prioritization and care optimization. The tools also cause a standard for care to be taken into consideration and patients with more serious condition be paid special attention. Application of critical care-measuring tools has begun since 30 years ago and has been gradually developed. These instruments are used to evaluate the severity of patients' condition as well as the hospital mortality rate. Such estimations are made based on patients' daily tests. Several factors such as age, acute onset of disease, certain medical condition (malignancy, immunosuppression, and the need to kidney transplant) and emergency admissions to the ICU increase the risk of mortality among ICU patients. Before 1980, no instrument was used for measuring the seriousness of patients' condition in the ICU, and critical care units were not therefore comparable to each other. ICU measuring systems are essentially consisting of two parts; the first part is the severity of critical condition and includes a number which shows the severity of disease (the greater number indicates more severity), and the second part is the percent of mortality rate; the measured amount is only indicative of the mortality risk in hospital [11].

APACHE instrument (Acute Physiology and Chronic health Evaluation) was refined by William Knaus in 1985 and defined by twelve physiological characteristics which covered most physiologic systems and was called "APACHE II". The system is still the most widely used system for the evaluation of ICU patients due to its simplicity in gathering information through regular tests and examinations and reproducibility. The APACHE II system consists of three basic elements:

1. Patients' acute physiological symptoms such as rectal temperature based on Celsius, respiratory rate, heart rate, serum potassium level, serum creatinine level, mean arterial pressure, oxygenation rate with respect to the percent of oxygen uptake and oxygen alveolar-arterial gradient, hematocrit, white blood cells, blood bicarbonate level, level of consciousness using the GCS and arterial PH
2. Patients' age
3. Previous chronic disorder [13, 12]

The APACHE score is obtained by summing up the above items. The worst sign and test in the first 24 hours of ICU admission is recorded and calculated in the scoring system. Each variable has a value between zero to four which are respectively the lowest and the worst scores. The APACHE II instrument is commonly used to predict the mortality rate in intensive care units in the first 24 hours of admission. Several studies have encouraged the application of the mentioned tool for patients' triage in the ICU [14].

In studies conducted by Gupta and Aurora in 2003 on respiratory patients admitted to ICU, out of 330 patients evaluated by APACHE II instrument, 43 patients had died and 287 survived, and the mean (±SD) was 23.09
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In COPD group, 12 (14%) out of 81 patients had died, and the mean (±SD) was 17.83 (±5.48) in this group [13].

In a study carried out in Hazrat Rasoul Akram hospital of Tehran, it has been shown that the mortality rate has been comparable to the international standard range in scores below fifteen; however, the mortality rate was higher than the standard level in scores over sixteen, and there has also been a significant gap between the scores achieved and the standard mentioned. In an investigation in this hospital, it has been observed that the system has been able to accurately predict patients' outcome in almost most cases.

In the overall result, the APACHE II system has been successful in predicting the mortality rate; nonetheless, it revealed a remarkable gap with international standard values in scores over sixteen, so as the difference was approximately 39% more than the standard level in patients with scores between 20-30 and 25 % in those with scores over 30.

The discrepancy noted in the Medical Center of Rasoul Akram hospital was higher and more remarkable in patients with scores between 20-30, because those with borderline scores at the time of ICU admission displayed a high rate of mortality at the end which could be indicative of a gap between the level of care and the treatment performed in mentioned center. The mean (±SD) APACHE II score was 11.75 (±6.9) and 22.06 (±7.9) in survivor and non-survivor groups, between which the difference was statistically significant [9, 10].

In a study by Safavi et al. in Isfahan in 2007, a comparison has been pointed out between APACHE II and two other instruments, among which the APACHE II has been successful in predicting the mortality rate in the ICU with 90% sensitivity, 32% specificity and 81% accuracy [14].

In the present study, a comparison has also been made between the instruments as well as the correlation coefficients for more accuracy in the results. In a study by Chen et al. in Singapore, 301 patients have been evaluated and the actual mortality rate has been estimated to be 17.2% in intensive care unit of this country; the mean (±SD) was 12.49 (±7.43) in survivors and 28.19 (10.43) in non-survivors [15].

However, the present study aims to find a relationship between APACHE II scores and mortality rate in ICU patients of Baqiyatallah hospital and to determine its ability to estimate the mortality rate while comparing the mortality rate recorded in this hospital with that expected according to APACHE II international standards. Performing such an investigation in each intensive care unit is a measuring criterion for the level of standardization in that unit and comparing it with international standards; in this line, this study was conducted to evaluate the efficacy of APACHE II instrument.

Methods
The study population included patients admitted to critical care units of Baqiyatallah hospital of Tehran. The study was performed in a cross-sectional approach and sampling was done through consecutive and non-random available sampling method from April to June 2010. Sample size was determined to be 70 and inclusion criteria consisted of developing COPD or CHF, as well as consent for study participation. Exclusion criteria were as follows;

1. Trauma surgery problems
2. Mental health problems
3. Psychiatric drugs consumption
4. Coma (GCS <7)
5. Memory and speech impairments due to mental problems

APACHE II was considered to be the data-collecting instrument in the present study, validity of which has been previously investigated on 5815 patients in 13 ICUs of different hospitals in America, and an acceptable correlation has been found in showing the predictive value and the disease outcome. In these studies, the instrument's correlation, which has been measured by the computer, was reported to be extremely good (p<0.01, r=.97). The intraclass correlation coefficient (ICC) was measured to be 0.848 for this instrument. The measured values in the three parts, physiology, age, and chronic...
disorders, were respectively 0.860, 0.987, and 0.645 for this tool [17]. APACHE II scoring table, including rectal temperature based on Celsius, respiratory rate, heart rate, serum level of potassium, serum creatinine level, the mean arterial blood pressure, oxygenation rate considering the percent of oxygen uptake and oxygen alveolar-arterial gradient, hematocrit, white blood cell, blood bicarbonate level, level of consciousness using the Glasgow scores, and arterial PH, was incorporated in the form. In APACHE II table, the first 24 hours of patients’ admission to the ICU was recorded; the worst item, from what has been mentioned herein above, was recorded in the first 24 hours of admission to the ICU and was calculated in the final summation. All the above items have a standard scoring range in Table. After recording the items, the scores were summed up and the final score was recorded. Patients were eventually divided into two groups based on the disease outcome; patients who were discharged from ICU and those who died in this ward. The APACHE score was calculated for both groups and compared mutually, and SPSS15 software was used for statistical analysis. Clinical parameters were reported as the mean ± SD or the percent. Parametric tests such as independent and paired t-test and non-parametric chi-square test were used for variables evaluation.

**Results**

The study participants included 39 males (55.7%) and 31 females (44.3%); 34 patients (48.6%) were suffering from COPD and 36 (51.4%) from CHF. In terms of marital status, 65 subjects (92%) were married and the rest (8%) were single. During the study period, 50 participants (71.4%) survived and 20 subjects (28.6%) died, between which no statistical

| Table 1: The relationship between SOFA, APACHE II, and SAPS II scores |
|-------------|-------------|-------------|
| Variables   | SOFA        | APACHE II   | SAPS II    |
| SOFA        | 1           | r=0.53      | p<0.001    |
| APACHE II   | r=0.62      | p<0.001     | 1          |

![Figure1](Figure1.png): Frequency distribution of the mortality rate in intensive care units of Baqiyatallah and Rasoul Akram hospitals of Tehran and the international standards. The figure shows higher rate of mortality in relative ICUs than the global standards.
relationship has been shown by Chi-square and Fisher exact tests.
The mean APACHE II score was 14.3 (±3.7) in total participants, 13.16 (±3.5) in survivors and 17.15 (±2.5) in non-survivors, and the difference was statistically significant between the two groups (P<0.001). Therefore, as evident from the results, increase in scores is accompanied by increased risk of mortality (Figure 1).

In the research conducted in Baqiyatallah hospital, the correlation of the two instruments, SOFA and SAPS II, was measured along with APACHE II, and an acceptable correlation has been found in line with the above findings (Table 1). Out of 40 participants with APACHE II score less than 15, 34(85%) patients survived and 6(15%) subjects died; out of 25 participants with scores ranging from 16 to 19, 16(64%) subjects survived and 9(36%) patients died, and in scores between 20-30, all the five subjects died. International standardized mortality rate was 10%, 15%, and 35% for the three groups respectively, and the difference was statistically significant by chi-square analysis (p<0.001). Mortality rate was also lower than the standard level in Rasoul Akram hospital in scores below 15(8%). In other cases, it was in consistence with Baqiyatallah hospital and more than the international standards.

Discussion
Prediction of mortality rate using the APACHE II scoring system has begun since 1996. In this study in Baqiyatallah hospital, it has been observed that the mentioned system has been able to correctly predict patients' outcome in most cases, which is in consistent with the results obtained in Gupta study [13]. Comparison between the results of the present study and Safavi et al. investigation in 2007 demonstrated a seven-percent difference in APACHE II scores less than 15; in terms of intermediate and high APACHE II scores, the two studies are also in accordance with each other, affirming findings of this research [14]. Application of APACHE II instrument in the United States, Canada, New Zealand and Singapore has confirmed the correlation between the mortality rate predicted and the real rate of death. However, contradictory results have been brought about by researches in Britain and Ireland [15]. Comparison between the results of the present study and those obtained by Chen et al. study in Singapore exhibited lower rate of mortality in intensive care unit of this country; nonetheless, patients had higher APACHE II scores [15].

In this research in Baqiyatallah hospital, correlation of the two instruments, SOFA and SAPS II, was measured along with APACHE II which presented a good correlation. Congruent with our findings, in studies conducted in Portugal, China and America, APACHE II showed higher predictive ability in estimating the mortality rate [18, 20]. In general outlook, it seems that APACHE II scoring system has been successful in predicting the mortality rate in patients admitted to the relative ICUs, since regarding the results of previous studies and their conformity with the present research, a remarkable difference has been found in terms of mortality rate between three levels of APACHE II scores and international standards; so as 5%, 21% and 65% difference have been observed in scores below 15, ranging from 16 to 19 and 20 to 30 respectively. The difference is highly remarkable in scores between 20-30, as patients with intermediate scores at the time of ICU admission showed higher rate of mortality at the end, indicating a gap between the level of care and the treatment performed in mentioned center and those of international standards.

Such a discrepancy in patients' outcome, especially patients with intermediate risk, demonstrates more accuracy in treatment to decrease the risk of readmission to the ICU.

Conclusion
Given the limited number of beds in critical care units of the country hospitals, routine application of APACHE II instrument can be of benefit in prioritizing patients who are in more need of care and determining those with lower scores, and definitely lower risk, to put them in second priority for the allocation of
ICU beds; thereby, ICU patients with higher scores will be paid special attention and a better outcome will be brought about for the reduction of ICU mortality. Moreover, considering the results of the center studied, care and therapeutic measures can be evaluated in the relative ICU to assess the level of difference with international standards and try to minimize the gaps and bring them closer to the standard values.

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