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Evaluation of the relationship between score results of APACHE-IV scoring system and mortality rate of patients admitted to the Intensive Care Unit (ICU) of the burn section.

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Abstract

Introduction: The study aimed to evaluate APACHE-IV scoring system and functionality of this system in prognostic evaluation of burn patients admitted to the Intensive Care Unit (ICU) of the burn section of Shahid Motahari Hospital in Tehran.

Methods: First the scores for APACHE-IV scoring system have been calculated on specific software on the first day of admission of patients who have been hospitalized to the ICU for burns of Shahid Motahari hospital; other clinical information of the patient such as level of burn (TBSA%), depth or degree of burns, causes of burns, the location of anatomical condition of burns, presence or absence of airway burns and underlying disease have been recorded in specific form and scoring results for APACHE-IV scoring system have been compared with actual values of mortality.

Results: 210 patients have been studied. The average age of male patients was 39.9 ± 15.9 years and the average age of female patients was 39 ± 16.4 years. The average age of deceased patients was 37.9 ± 18.8 versus 39 ± 16.4 years (mean age of the survived patients). Comparing Average score of APACHE-IV in died and survived patients strongly have been reported to be statistically significant. Also studying the relationship of obtained scores from APACHE-IV scoring system in most of the studied variables showed that this correlation have been strongly significant in younger than 50 years old groups.

Conclusion: It can be concluded that APACHE-IV scoring system can be used as a risk evaluation method in burn patients; however, for obtaining the best results and extraction of clinically reliable scores, effective criteria associated with burns, especially the area of burns and burns of airway with calculating value and influence of each of these criteria should be considered in the mortality of patients.

Keywords: APACHE-IV scoring system, Mortality, Intensive care units (ICU), Burns, Total body surface area (TBSA).

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Introduction

Burn-related injuries accounted for a large share of world accidents and causes death, disability, pain, physical, psychological, economical problems and disability of patients [1]. In recent years, burn injuries reached a point that is now regarded as a serious problem and currently burn is the fifth leading cause of death in the United States [2].

Accidents are among the major epidemics of non-communicable diseases of the current century and it is not considered entirely coincidence, but it is part of the price that humans pay for the advancement of technology; and among these, the most common injuries are burns [3-7]. More than 95% of burns occur in developing and underdeveloped countries [8,9]. The statistics show that burns in Iran with a population of 75 million is about 150 thousand per year while this number is 500 thousand for the United States of America with a population of 320 million; this shows that burning rate due to fires in our country is very high. In addition, about three thousand people lose their lives in the country due to burns that in recent years this rate has risen to two thousand. According to 2000 World Health Organization, 8.4 to 10.4 people in every hundred thousand die of burn complications [2]. Burn is the

sixth leading cause of death in the country and official statistics also confirm this [10].

Assessing the outcome of medical treatment has been founded for the first time in 1863 by Florence Nightingale. First, estimating the result in serious diseases has been done based on a subjective judgment of doctors. The rapid expansion of ICUs required little clinical and alternative measurements methods to evaluate the effectiveness of interventions. Therefore, scoring systems have been developed and used for this purpose. The outcome of patients admitted to the ICU depends on a number of factors on the first day and subsequent days during periods of admission in ICU. A scoring system usually consists of two parts: a score (a number that indicates the severity of the disease) and a probability model (equation for obtaining the chances of death of patients in hospital). A model modifies the ability of scores or indicators for uses in different patient groups for the purpose of treatment, triage or comparative analysis and therefore assists in decision-making. These systems also create a high understanding of the impact of hospital treatment and optimizing the use of resources and thus are helpful in developing the standards of care.

In most scoring systems such as APACHE (Acute Physiology and Chronic Health Evaluation), scores are calculated from obtained data on the first day of hospitalization in ICU. APACHE II have been described in 1985 using data from patients admitted to the ICUs of North America which is a classification system for the severity of disease. This system uses a 12 point physiological scoring such as age and previous health conditions that is obtained in the first 24 hours of hospitalization of the patients for obtaining the severity of the disease. The major limitation of this scoring system is that many patients have multiple conditions and diseases, and selecting only one major area of diagnosis may be difficult. Prognostic scoring of APACHE III consists of two parts:

APACHE III score which provides a risk classification for severely ill hospitalized patients defined independent groups.

APACHE III predictive equation that uses APACHE III score and referenced data in large batches of diseases and treatment positions immediately before being admitted to the ICU for determining the risk of hospital mortality in patients admitted to the ICU.

APACHE III system uses mostly the same variables of APACHE II, but it uses a different way to sum up Neurologic data by GCS. This system, particularly adds two important variables: where the patient has been referred from and induced error; acute and early diagnosis is considered in the calculation and it should be considered as a diagnosis. APACHE III scores (which are calculated from a cluttered data obtained from the first 24 hours of hospitalization in the ICU) are varied in a range of zero to 299 points; and consist of 252 points for 18 physiological variables, 24 points for age and 23 points for previous health conditions. All variables have been selected in order to increase the clarity and transparency of the model.

APACHE IV system has been developed gradually and uses the same variable of APACHE III. The new variables that have been added are: mechanical ventilation, thrombolysis, sedation effect on GCS, GCS re-evaluation and the ratio of PaO_2/FiO_2 (arterial oxygen pressure and oxygen concentration of inhale) [5].

Apache system by determining the prognosis of patients during hospitalization provides the ability to classify patients and selecting the neediest groups of patients to be hospitalized in the intensive care units. It also provides the duration of hospitalization and determines daily APACHE score so that treating team would be able to make changes to treatment plans in case of need. the effectiveness of APACHE system in selecting the most suitable and neediest patient for referral to ICU have been confirmed recently by Tanaka et al. in two separate reports that have examined the evaluation of the status of APACHE in determining the risk of the death in burn patients [11,12]. Validity and reliability of this system have been reported in many studies [13].

Due to the severity and high frequency, disabling and sever complications of burns, and also the lack of such research in Iran, the researches aimed to compare and estimate the effects and mortality rate by using classification systems for determining severity and prognosis in burn patients.

Methods

This study is a cross-sectional and prospective study that have been conducted on patients who have been hospitalized at least 24 hours in ICU for burns in Shahid Motahari Hospital between September 2014 and August 2015; sampling have been done using convenience sampling method. The classification items of APACHE-IV for patients have been recorded and they have been scored based on this system and patients have been fallowed for a year after the hospitalization in ICU, and finally the mortality rate of patients have been calculated based on obtained scores from APACHE-IV scoring system. For each patient who have been hospitalized in the ICU for Burns, a form containing relevant information base on APACHE-IV scoring system have been completed in the first 24 hours of hospitalization and specifications associated with burns that includes age, sex, cause of burn, the time between burning and hospitalized in the ICU, anatomic area of burns, degree of burn (depth), percentage of burn (TBSA) base on law 9, existence of any airway burns and any underlying disease also have been completed; the mortality of patients have been determined by entering the data related to APACHE-IV system. Since the purpose of this research was to study the mortality in patients who have been hospitalized in ICU for burns, therefore the related criteria have been considered until the hospitalization of the patients and cases that have been released from ICU have been considered as healthy ones. At the end, determined values have been compared with the real world values and therefore, the use of scoring system in ICU for burns have been evaluated to determine prognosis and mortality.

Inclusion criteria for the study was hospitalization in ICU for burns at least 24 hours, patients being 16 years old or older, and exclusion criteria was hospitalization for any other reasons than burns, chronic burns, hospitalization for plastic reconstructive surgery due to complications resulting from burns. The data from this study have been entered into SPSS 16 software, and after statistical analysis of the data, the relationship between studied variables have been analysed.

Results

In the current study a total of 210 patients were studied which 161 patients (76.7%) were males and 49 patients (13.3%) were females. The average age of all patients were 38.9 ± 16.1 years, the average age of males were 39.3 ± 15.2 years and the average age of females were 37.9 ± 18.8 years. There was no statistically significant (P=0.1) difference between these two groups. Also, in this study, the average age of patients who died was 18.9 ± 15.9 years and the average age of patients who survived was 39 ± 16.4 years that these values have not been statistically significant (P=0.9).

The overall obtained average of APACHE-IV from the patients who survived and died from different age groups have been compared (Table 1). In this comparison, there was a significant difference of mortality rate between survived and deceased patients in the obtained scores for age groups of 16 to 30 years and 31 to 50 years; this difference was not significant for two groups of 51 to 65 years and above 65 years. Also, the relationship between obtained score of APACHE-IV have been studied with the mortality of burn patient based on the extent of burned body surface (%) in all patients (Table 1); which this relationship have been significant for all levels of burn except for burn level of "up to 10%", and this might be due to little difference between obtained scores of survived and died patients in the burned group of "up to 10". The relationship between overall average score obtained from APACHE-IV with mortality on all burn patients have been studied (Table 1); which in this study, there was a significant difference between obtained scores from survived and died patients.

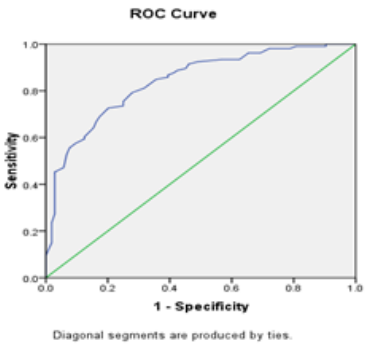

Figure 1. *Area under the curve. The sensitivity and specificity of the APACHE4 score.*

Based on the results of the relationship between scores of APACHE-IV with the studied variables through the logistic regression test (Table 2) it is understood that this relationship is significant for the cumulative percentage of burn, burn percentage of head and neck, trunk, extremities and perineum and depth (degree) of burns, perineal body burns and airway burns; in other cases, including age, sex, cause of burns, depth of burn (degree) to the head and neck and limbs, elapsed time from burning, current diseases, and hospitalization days in ICU there was no significant relationship through this test.

Table 1. *Affecting APACHE-IV scoring factors.*

Affective factors	APACHE-IV Scoring (Mean ± SD)				P-value
	Alive	Amount	Death	Amount	
Age group					
16-30	32.70 (13.81)	37	52.69 (13.19)	39	0.000
31-50	31.45 (8.75)	51	53.07 (17.12)	42	0.000
51-65	45.27 (16.00)	11	58.53 (18.22)	15	0.066
Over 65	51.71 (8.32)	7	65.38 (20.01)	8	0.117
Surface of burnt area (Percentage)					
Up to 10%	56.00 (21.27)	4	69.00 (32.07)	3	0.544
11-30%	35.62 (1239)	40	57.67 (10.67)	6	0.000
50-31%	33.50(12.19)	50	51.05 (14.27)	22	0.000
51-70%	26.50 (8.22)	8	51.85 (14.89)	40	0.000
Over 70%	34.50 (4.43)	4	58.64 (17.79)	33	0.011
Outcome	34.66 (12.95)	106	54.66 (16.33)	104	0.000

Table 2. *Relationship between scores of APACHE-IV with the studied variables (Step 0).*

Variables	Score	df	Sig
Age	0.091	1	0.763
Sex	0.796	1	0.372
Agent	0.217	1	0.641
PH.N	10.496	1	0.001
P_{Body}	41.589	1	0
P_{Limb}	51.903	1	0
$P_{Perineum}$	11.942	1	0.001
Cumulative per cent	63.675	1	0
DH.N	0.738	1	0.39
D_{Body}	15.769	1	0
D_{Limb}	1.237	1	0.266
$D_{Perineum}$	12.066	1	0.001
Airway	24.69	1	0
Passed days 1	0.047	1	0.829
Disease	0.009	1	0.926
ICU days	2.598	1	0.107

Overall statistics	91.623	16	0

Also, the analysis carried out by mapping curve ROC (Receiver Operating Characteristic) have been recorded in the comparison of obtained scores from the APACHE-IV and mortality rate of patients (Figure 1 and Table 3); it shows that the area under the curve (Area=0.841) represents the high value of this test in predicting mortality and the cut-off point of APACHE Score=47.5 has a sensitivity equivalent to 84.9% and Specificity equivalent to 64.4%.

Table 3. *Test result variable(s): APACHE 4 score.*

Area	Std. error[a]	Asymptotic Sig.[b]	Asymptotic 95% confidence interval	
			Lower bound	Upper bound
0.841	0.027	0.000	0.788	0.893

The test result variable(s): APACHE4 score has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased. [a]Under the nonparametric assumption; [b]Null hypothesis: true area=0.5.

Discussion

Burn is incident is an irreparable accident that have many physical, psychological, social and economic problems; however, half of these accidents and accompanied issues are preventable [13,14].

In the current study, the average age of male patients was 39.3 ± 15.2 years and the average age of female patients was 37.9 ± 18.8 years. The average age of the 274 hospitalized patients in the study was 15.7 ± 19.7 years [15]; in a study by Hashemian et al. this average ages were 49.1 ± 18.3 years [16], in the study of Tang et al. this average age was 70.9 years [17], in the study of Patel et al. [18] this average age was 62.5 years and in the study of Vasiloski this amount was 48.18 ± 19 years [19].

In the current study, about half of patients (44.3%) were classified in the age group of 31 to 50 years and 7.1% of patients have been in the age group of above 65 years. In similar studies, hospitalization of elderly patients in Italy and America has been reported to be 14 and 16 per cent respectively [20,21]. However, striking points in these studies, in the comparison of obtained scored was that the deceased people above 65 years of age, both in male and female groups had higher scores in terms of body surface burn percentage (TBSA) comparing to other age groups as well as survived patients in the same age group. Also, deceased patients in the age group of above 65 years, more scores have been obtained for 3rd degree burns and second- degree for head and neck and trunk limbs burns comparing to other age groups, and comparing to survived patients of the same group. Studying the results shows that aging plays an important role in the mortality rate. The higher mortality risk in older people has been also confirmed by other scores obtained from studies [22-24].

Examining the results from individuals older than 65 years of age shows in some cases, the scores and mortality are higher even for burns under 10% comparing to other groups. Other studies have also obtained similar results that mortality is higher in older age groups even for burns with lower percentage of burns comparing to younger age groups [25,26]. Examining the results have explained that mortality for a young adult individual with a burn of 80% is 50% while for a patient between ages 60-70 years with a burn of 35%, the mortality rate is also 50% and this number for a patient above the age of 70 with a burn of 30% is also 50% [27]. Among the reasons cited for the increased mortality in elderly burns can be associated with risk factors such as chronic disease, cardiovascular disease, reduced lean body mass, nutrition disorders, reduce of lung capacity with age, unintentional weight loss, lowering of anabolic hormones and aging of the skin (thinning skin, loss of collagen synthesis) can be mentioned. A combination of these risk factors from burns, hormonal and metabolic stress put elderly more at the risk of mortality, high risk of infection, pulmonary insufficiency and lack of wound healing comparing to younger adults [28,29]. Also in this study, the age average of patients who died was 39.9 ± 15.9 versus 39 ± 6.4 years (Average age of survived patients). In the meantime, in a study by Druji et al. it have been stated that age is one of the most influencing factors in the prediction of mortality and the outcome of intensive care of patients [30]. He also pointed out to the differences in average age of patients who had died and those who have survived.

Also in this study, the number of deaths observed in men was 80 (38.1%) and the number of deaths observed in women was 24 (11.4%). In a similar observation, researchers have reported mortality of 34.6% for female patients and 65.4% for male patients [31]. In another study that has been conducted on Iranian patients, mortality rate in men have been reported to be 36% and in women was 33% [32]. However, in most studies similar to the current study, the number of males hospitalized in ICU was higher than females, and a few researches have studied the causes of mortality in males. In the study of Hashemian el al. the average age of survived patients have been higher than those patients who have died [16]. For concluding the differences between results of different studies, it can be said that part of different reports of mortality rate in studies may be due to their age factor. When patient are selected from the same age group (for example from elderly), more precise results may be obtained regarding mortality rate of patients, and this can be considered as one of the limitations of the current study.

In the current study, a direct relationship has been obtained between the increase in the mortality of patients and APACHE 4 score. The mean score of all APACHE 4 scores in our studied patients was 44.5 ± 17.7. This number in a study by Laoy was 207 ± 54 and in a study conducted in Hong Kong were 20.1. This is due to differences in health systems; also in studied patients as Terms and Conditions of patient care of different countries and the quality of patient care, and this by itself may be corroborated these difference [33].

Another result of the current study was that high APACHE scores have been correlated with levels of burn (TBSA). For example, patients survived with burns of 31-50% of trunk and deceased patients with burns of 51 to 70 per cent of the trunk and limbs had higher APACHE scores comparing to other groups. The increase of the level of burn (TBSA) is an effective and important variable in the mortality of burn patients. Increase of the percentage of burns by losing more skin cause more restorative procedures and more complications and thereby increases the mortality rate. With the increase of the level and burn percentage, healthy body parts that can be applied to the skin flap is narrowing [34,35]; however, the main disadvantage of conventional systems for determining the risk is to determine the percentage and depth of burns depends on the experience or the physician. The possibility that there might be disagreement between the two examiners in terms of percentage and depth of burn determination could have been a matter of speculation. This disadvantage can challenge the comparison of result from burn patients from different centers. The results of a study show a strong correlation between the degree of total body surface area burns and mortality rate. In this study, mortality rate of 0.25% for burns less than 10% of the total body surface, mortality rate of 5.4% for 10% of total body surface burns, mortality rate of 5.4% for 20-39% of total body surface area burns, and mortality rate of 96.6% for more than 90% of total body surface area burns have been reported [36].

Many factors affect the accuracy of predicting mortality rate. These factors include limitations of the studies as well as individual differences in ethnicity, culture, socio-economic status and most importantly restrictions of APACHE IV scoring in different studies that have been examined previously. Other factors for such difference is different criteria for hospitalization of patients in ICU of medical centers, and also the number of beds can indirectly affect the results of the study.

Based on the analysis of obtained results from this study, it can be concluded that the relationship between APACHE IV scores and mortality of hospitalized patients in ICU for burns based on the age of patients is in such a way that this system can be fairly appropriate method for predicting the mortality rate in age of 50 years and younger; however, for older age groups is not a good predictor due to various factors including cardiovascular factors, susceptibility for underlying infections, circulatory and respiratory systems capacity. Also, in age groups of above 50 years, especially above 65, patients receive higher score, and these scores do not have any significant differences for survived and deceased patients, and similar score have been obtained for these two groups; this fact it can indicate the low prediction power of APACHE IV in this age range.

On the other hand, the studies on the relationship between scores of APACHE IV with the studied variables indicate that this relationship is significant regarding the levels of burns on head and neck, trunk, extremities and perineum, and also the cumulative percentage of body surface burn, and burn depth of trunk and perineum as well as airways burns; moreover, if there is a decision to use a scoring system in burn patients, it is better to consider these factors and variables.

Based on the analysis of the data it can be concluded that scores obtained from APACHE IV in ranging score of 47.5 with a sensitivity of 84.9% and a specificity of 64.4% is a predictor of mortality while based on the other studies, the percentage of surface burn of the body (TBSA) at the cut-point of 50% from TBSA with a sensitivity of 88.7% and a specificity of 70.2% is the predictor of mortality. Therefore, the value of burned surface obtained from scores and PMR indicator from APACHE IV is higher and in cases that this system is used for evaluation of mortality of burn patients, the surface of burn must be considered as effective variable.

Therefore, it can be suggested that if it has been decided to use this scoring system in burn patients, it should be used to estimate the mortality only for young and middle aged patients, so that treatment planning and appropriate cares would be applied based on the clinical situation of patients; and in other patients, other standard clinical criteria should be used for the evaluation of patients' clinical condition.

Of course, the above results are not completely generalizable to all ICUs due to its time limitation and since it has been conducted in one center; it is recommended that more studies should be conducted with a larger sample size and in multiple treatment centers so that the comparison values would reach standard so that it can be used in as a standard system and its results could be applicable to burn patients. Using APACHE IV scoring system as a routine in ICU (due to limited number of ICU beds in the hospitals all over the country) can be useful in determining the use of ICU beds for patients who are in priority and need these cares more than others and they score higher in APACHE IV scoring system; and those patients with lower scores for APACHE IV that have also lower risks would be identified and would be placed in the second priority. Therefore, with the entrance of more critical patient and higher score, the patient would receive more treatment care, and this in turn would lower mortality (due to both correct selection of patients and providing better treatment and health services); and this would improve treatment results and lowers mortality.

At the end, based on the obtained results it can be concluded that APACHE-IV scoring system can be used as an alternative method of evaluating risks in burn patients, but for better results and extraction of clinically reliable scores, effective criteria related to burning, especially the burned surface of the body and the existence of airway burns must be calculated, and their degree of influence should be considered in the mortality of patients; ultimately, a burn modified APACHE-IV scoring system should be presented.

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