The revised Acute Physiology and Chronic Health Evaluation System (APACHE II) is more effective than the Glasgow Coma Scale for prediction of mortality in head-injured patients with systemic trauma

Sistemik travma geçirmiş kafa travmalı olguların mortalite tahmininde 'Düzeltilmiş Akut Fizyoloji ve Kronik Sağlık Değerlendirme Sistemi' (APACHE II), Glasgow Koma Skorundan daha üstündür

Ali DALGIÇ,[1] **Fikret M. ERGÜNGÖR,**[1] **Türker BECAN,**[1]
Atila ELHAN,[2] **Önder OKAY,**[1] **Bülent C. YÜKSEL**[3]

BACKGROUND

The Glasgow Coma Scale (GCS) is popular, simple, and reliable, and provides information about the level of consciousness in trauma patients. Nevertheless, the necessity of using a more complex system than GCS has been questioned recently. The revised Acute Physiology and Chronic Health Evaluation system (APACHE II) is a physiologically based system including 12 physiological variables, and it also includes GCS. In addition, it is thought to be superior to GCS due to recognition of increasing age and significant chronic health problems, which adversely affect mortality.

METHODS

This retrospective study included 266 patients (195 males, 71 females; mean age 60.5; range 14 to 87 years) with head injury associated with systemic trauma in 2003 and 2004.

RESULTS

Mortality increased in the elderly group (p<0.001). Mean survival score in APACHE II was 38.0 and death score was 68.7 (p<0.001); these values in GCS were 10.4 and 6.3, respectively (p<0.001). APACHE II at the cut-off point was better than GCS in the prediction of death and survival in patients (p<0.01). The area under the receiver operating characteristic curve for sensitivity and specificity was larger in APACHE II (0.892±0.028) than GCS (0.862±0.029).

CONCLUSION

For the assessment of mortality, the GCS score still provides simple, less-time consuming and effective information concerning head injury patients, especially in emergencies; however, for the prediction of mortality in multitrauma patients, APACHE II is superior to GCS since it includes the main physiologic parameters of patients.

Key Words: APACHE II; Glasgow Coma Scale; head injury; mortality; multitrauma.

AMAÇ

Glasgow Koma Skoru (GKS) yaygın, basit, güvenli ve travma hastalarının bilinç değerlendirilmesinde iyi bir iletişim skalasıdır. Ancak, son yıllarda GKS'den daha ayrıntılı bir sistem gerekliliği sorgulanmaktadır. Düzeltilmiş akut fizyoloji ve kronik sağlık değerlendirilmesi sistemi (APACHE II) GKS ile birlikte 12 fizyolojik parametre içeren fizyolojik temelli bir skaladır. Ayrıca mortaliteyi etkileyen kronik hastalık ve ileri yaş değişkenlerini de içermesi GKS'den daha üstün olduğunu düşündürmektedir.

GEREÇ VE YÖNTEM

Bu çalışmada, 2003 ve 2004 yıllarında kafa travması ile birlikte sistemik travma geçirmiş 266 olgu (195 erkek,71 kadın; ort. yaş 60,5; dağılım 14-87) geriye dönük olarak değerlendirildi.

BULGULAR

Mortalite ileri yaş grubunda artmıştı (p<0,001). Ortalama APACHE II skoru yaşayanlarda 38,0, ölen olgularda 68,7 (p<0,001), ortalama GKS puanı yaşayanlarda 10.4 ölen olgularda 6,3 (p<0,001) bulundu. Mortalite tahmininde APACHE II GKS'den daha belirgin sınır puanı sağladı (p<0,001). Duyarlılık ve özgünlük için yapılan ROC eğrisinde, APACHE II (0,892±0,028) eğrisi altında kalan alan GKS'den daha büyüktü (0,862±0,029).

SONUÇ

Mortalite değerlendirmesinde, özellikle acil servislerde GKS kafa travmalı olgularda yeterli öngörü sağlayan, basit ve kolay uygulanmakla birlikte sistemik travma geçirmiş olgularda APACHE II hastanın önemli fizyolojik parametrelerini de içermesi nedeniyle GKS'den üstündür.

Anahtar Sözcükler: APACHE II; Glaskow Koma Skoru; kafa travması; mortalite; multitravma.

[1]2nd Department of Neurosurgery and [3]1st General Surgery, Ankara Numune Training and Research Hospital, Ankara; [2]Department of Biostatisitcs, Ankara University, Faculty of Medicine, Ankara, Turkey.

Ankara Numune Eğitim ve Araştırma Hastanesi, [1]2. Beyin Cerrahi Kliniği, [3]1. Genel Cerrahi Kliniği, Ankara; [2]Ankara Üniversitesi Tıp Fakültesi, Biyoistatistik Anabilim Dalı, Ankara.

Correspondence *(İletişim):* Ali Dalgıç, M.D. Yeniçağ Mah., Serdar Sok., No: 77/3, Yenimahalle 06170 Ankara, Turkey.
Tel: +90 - 312 - 310 30 30 / 5271   e-mail *(e-posta):* alidalgic@yahoo.com

The Glasgow Coma Scale (GCS), introduced in 1974, has been frequently used as an important predictor of admission and outcome after head injury. [1,2] It is a popular, simple, reliable, and reproducible method of classifying and communicating information about the level of consciousness in trauma patients.[3,4] This scale, together with other neurological assessments, should be administered as soon as possible in emergency situations, and it can be repeated at intervals, especially when neurological function is fluctuating.[5]

In the last two decades, a number of recent studies have questioned the necessity of using a more complex system than GCS.[6] There seems to be a need for such evaluation scales particularly in patients with alterations in consciousness or coma.[5,7]

The revised Acute Physiology and Chronic Health Evaluation system (APACHE II) has been frequently applied in many Intensive Care Units (ICUs) throughout the world since 1985.[8,9] APACHE II is a physiologically based system including 12 physiological parameters and it also includes GCS. APACHE II has been designated as an exact predictor of outcome across a wide range of diagnostic groups, but it has yet to gain wide acceptance in neurosurgery, where instead the GCS has been the standard against which other grading systems are compared.[6] The system is thought to be superior to GCS due to its recognition of increasing age and significant underlying and/or chronic health problems, which adversely affect mortality. This study compares GCS and APACHE II scores in patients subjected to head injury associated with systemic trauma in terms of prediction of efficiency and mortality.

MATERIALS AND METHODS

Patient Selection

This retrospective study included 266 patients with head trauma associated with systemic trauma between 2003 and 2004. Patients were admitted from the emergency unit and treated at least 24 hours after their admission to our Neurosurgical Intensive Care Unit (NICU). Patients with pure head trauma were excluded from the study.

Data Collection

The data were collected and analyzed for each patient to calculate APACHE II and GCS scores at the time of admission to NICU. GCS is determined by summation of scores regarding eye opening, verbal and motor responses. The sum of GCS score ranges from 3 to 15. To minimize any bias toward a false-negative prediction of prognosis, uncertain values are raised to the best value. If the patient was intubated or unable to speak due to aphasia or deafness, clinical judgement was used to score verbal response as follows: patient generally unresponsive- 1 point; patient is responsive but ability to converse reasonably in question- 3 points; and patient appears to be oriented and able to converse- 5 points.

The method of the APACHE II scoring system was first introduced by Knaus et al.[8] in 1985. The total score in APACHE II is 71. APACHE II score consists of 12 physiological parameters (blood pressure, blood pH, GCS, etc.), the sum of which ranges from 0 to 60. The score also includes parameters of age from 0 to 6 and chronic health evaluation score from 0 to 5.

The GCS item in the APACHE II scoring system is defined as a value obtained from subtraction of a patient's GCS score from 15. The higher values in the APACHE systems represent a higher risk of death; however, the higher points in the GCS system indicate a lower risk of death.

Data Analysis

The data were collected and analyzed to calculate APACHE II and GCS scores at the time of admission to the NICU. The values were further analyzed according to age, sex, details of systemic trauma, and treatment protocol in order to test the efficiency of each scoring system in predicting mortality.

A Receiver Operating Characteristic (ROC) curve depicts the relation between true positive (sensitivity or number of predicted deaths/number of deaths) and false positive (1-specificity, or number of predicted deaths/number of survivors) for each scoring system. This method compares scores without fixing arbitrary cut-off points. The area under the ROC curve is evaluated. Such an area represents the probability that a randomly chosen diseased subject is more correctly rated or ranked than a randomly chosen non-diseased subject. A value of 0.5 under the ROC curve indicates that the variable performs no better than chance, while a value of 1.0 indicates perfect discrimination. A larger area under the ROC curve represents more reliability and good discrimination of the scoring system.

The best Youden index determines the best cut-off point. The Youden index is used to compare the proportion of cases correctly classified. The higher

Table 1. History of trauma in patients admitted in emergency service

	Death	Survival
Traffic accident	38 (22.2%)	142 (78.8%)
Fall	13 (18.1%)	59 (81.9%)
Strike	1 (7.2%)	13 (92.8%)
Total	52 (19.6%)	214 (80.4%)

the Youden index, the more accurate the prediction (higher true positive and true negatives or fewer false positives and false negatives) at the cut-off point. The sensitivity, specificity and prediction of mortality for each cut-off point were calculated. SPSS for Windows 15.0 was used for data analysis. A p value less than 0.05 was considered significant.

RESULTS

The study included 266 patients (195 males, 71 females). The ages of the patients varied between 14 and 87 (mean age: 60.5 years). Patients under 16 years were not included into the study because they were admitted to the pediatric ICU. Of the 266 patients included in the study, 180 (67.7%) patients were admitted with a history of traffic accident, 72 (27.1%) with a fall and 14 (5.3%) with a strike (Table 1). The patients were analyzed according to age, sex, and details of systemic trauma (Table 2). Although there was no significant difference for sex in terms of mortality (p=0.459), mortality increased in the elderly group (p<0.001). This result supports the idea that APACHE II could be superior to GCS in terms of predicting mortality.

All of the cases were subjected to a systemic trauma including chest, abdomen, maxillofacial, or spinal trauma, and fracture of the long bones. If the trauma included more than one system, the actual region affected by the trauma was grouped accordingly. Patients with orthopedic problems formed the largest group, with 94 patients (35.3%). Other groups were categorized in a decreasing order of frequency as follows: craniofacial trauma 65 patients (24.4%), thoracic trauma 58 patients (21.8%), spinal trauma 35 patients (13.2%), and abdominal trauma 14 patients (5.3%). Fifty-two patients among the admissions died in hospital, which designates a mortality ratio of 19.5% in this study. The mortality was higher in groups with thoracic and orthopedic trauma but there was no statistical influence of associated trauma over mortality (Table 2).

Surgical treatment was performed in 94 patients (35.3%) due to head and/or systemic trauma. Mortality in patients subjected to a surgical procedure was reduced when compared to patients treated conservatively, but the difference was not found to be significant. This data was thought to be due to elimination of traumatic lesion, which supplies reconstruction of systemic balance and recovery. However, mortality was higher in the conservatively treated group due to elongation of the treatment period (Table 3).

The mean survival score using APACHE II was 38.0 and death score was 68.7 (p<0.001). These values using GCS were 10.4 and 6.3, respectively (p<0.001) (Table 4). According to the best cut-off point, sensitivity, specificity, correct prediction, Youden index and area under the ROC curve are presented in Figure 1 and Table 5. The best cut-off points for APACHE II and GCS were 0.868 and 0.914, respectively. The correct prediction outcome at the cut-

Table 2. Demographic characteristics of the patients

	Age	Sex		Trauma					Treatment	
		F	M	Orthopedic	Abdominal	Thoracic	Maxillofacial	Spinal	Conservative	Surgical
Death	51.5	16	36	20	2	20	4	6	39 (19.5%)	13 (13.8%)
Survival	34.6	55	159	74	12	38	61	29	133 (80.5%)	81 (86.2%)
p	<0.001	=0.459		=0.389					=0.061	

Table 3. Distribution of surgical treatment in the patients

	Surgical Treatment					
	Orthopedic	Abdominal	Thoracic	Maxillofacial	Spinal	Cranial
Death	1	–	–	–	1	11
Survival	5	11	1	2	22	40
Total	6	11	1	2	23	51

Table 4. The mean survival and death scores denote statistically significant differences between APACHE II and GCS

	APACHE II (median point)	GCS (median point)	p
Death	68.7	6.3	<0.001
Survival	38.0	10.4	

Fig. 1. The area under the ROC curve was larger in APACHE II (A) than GCS (B).

off point was higher in APACHE II (77.5%) than in GCS (75.0%). In the prediction of death, APACHE II at the cut-off point were better than GCS (p<0.01). In the prediction of survival APACHE II at the cut-off point was better than GCS (p<0.01). The sensitivity and specificity at the cut-off point was high in APACHE II. The Youden index at the above cut-off point was 0.69 in APACHE II and 0.56 in GCS (Table 5).

The area under the ROC curve was larger in APACHE II (0.892±0.028) than GCS (0.862±0.029). The area under the ROC curve had no statistical significance between APACHE II and GCS. From the ROC curve, the 'knee' of each scoring system was defined as the best cut-off point.

The sensitivity, specificity, prediction outcome, Youden index, and area of the ROC curve at the best cut-off point for hospital mortality are presented in Table 5. Because homeostasis was disrupted in the patients who suffered from multiple trauma, cut-off points for GCS and APACHE II were confirmed to be higher than with pure head injury.

DISCUSSION

The GCS is a physiological scoring system, and it remains a critical measure of neurological assessment and assessment of severity of traumatic head injury on admission. Its correlation with morbidity and mortality was approved by many authors within the last three decades. In addition, its application in other neurological diseases is accepted as true by many authors.[10,11] Because it is a widely used simple, practical and cost-effective scoring system, it is termed as a communicative language among neurosurgeons and entire medical staff.

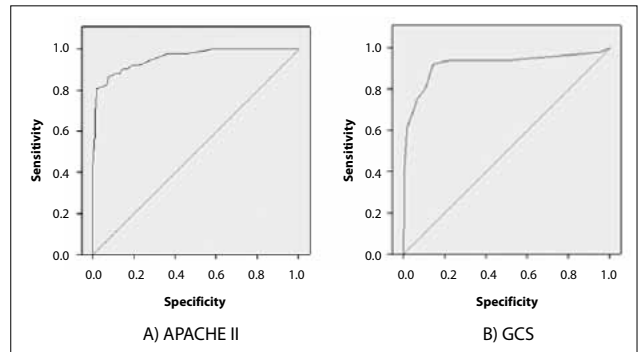It is acknowledged that a low GCS is associated with poor prognosis; however, the measurement can be complicated when it is low. This scale measurement can be difficult to assess when the patient is connected to ventilator or sedated, has suffered from maxillofacial trauma or if alcohol or related drugs were taken.[12,13] There seems to be similar problems for prediction of GCS among resuscitated patients.[14] Pharmacologic neuromuscular blockage used for intubation further complicates clinical assessment with this scale.[15] Furthermore, the age factor, which is unfavorably affected in the elder population, is underemphasized. To date, GCS is not adjusted for in the elderly population as in the pediatric population since physiological reserve decreases with aging.

Systemic hypotension, intracranial hypertension, arterial hypoxia, and hypocapnia are well-known physiological factors associated with poor outcome after brain injury. These factors could also be related to head trauma; likewise, brain injury must be considered and managed as a systemic condition in which many factors termed as "extracranial" may influence outcome.[16]

Severity of coma due to head trauma could be assessed mainly by GCS; however, the prognosis could also be influenced by many factors like age, previous health state, hypoxemia, hypotension, hyponatremia, anemia, previous cardiopulmonary arrest, and coagulation disorders.[3,17-19] When a systemic trauma overlaps with cranial trauma in a patient, estimations of respiratory, urinary, hematological, hepatologic, and circulatory systems are proven to be the main

Table 5. Cut-off point, sensitivity, specificity, correct prediction outcome and the best Youden index

	Cut-off point	Sensitivity (%)	Specificity (%)	Correct prediction outcome (%)	Youden index
APACHE II	16.5	0.865	0.925	0.914	0.791
GCS	10.5	0.923	0.855	0.868	0.778

parameters that supply homeostasis. Cho and Wang [20] consider that the major improvement is based on the additional six acute physiological variables and an additional weighting assigned to the extremes of physiological measurements. These six physiological measurements are: $PaCO_2$, blood urea nitrogen, urine output, serum albumin, bilirubin, and glucose level. When exposed to systemic trauma, alteration of these parameters is inevitable.

The GCS has evolved into a rapid neurological assessment scale used in many medical diseases and correlates with mortality and functional outcomes. It has also been incorporated into various outcome prediction models including Trauma Score, the Revised Trauma Score, APACHE II, APACHE III, and the Trauma-Injury Severity Score.[5,14,21] The basis for the development of APACHE depends on the hypothesis that the severity of acute disease can be measured by quantifying the degree of abnormality from multiple physiologic variables. APACHE II contains 12 physiologic variables that are useful predictors of hospital outcome in ICU patients.[7,14] Moreover, it covers GCS, age and chronic health conditions, which are thought to reflect physiological reserve defined for regulation of homeostasis. Sacco et al.[22] reported that premorbid chronic health status is included in APACHE II, and Milzman et al.[23] concluded that pretraumatic medical status or organ dysfunction had a significantly adverse effect on survival of trauma patients. The inclusion of chronic health status can improve the prediction of outcome in ICU trauma patients.[14] Superior prognostic results were reported among cases having both occlusive cerebrovascular and coronary diseases,[24,25] and beneficial results were noted among patients having eclampsia[26] when APACHE II was performed. Pathophysiological changes predicted in an organism after systemic trauma could be demonstrated easily by the APACHE II scoring system. However, there are several limitations of the APACHE II scoring system. For example, APACHE II classifies trauma patients into two separate groups of patients as head trauma and multiple trauma, or postoperative and non-operated groups. Multiple trauma designates patients with multiple system trauma in addition to head trauma. [9,20] APACHE-predicted risk of death was found to underestimate definite risk for patients with multiple trauma.[14]

For the assessment of early mortality, GCS score still provides simple, less-time consuming and effective information concerning head injury patients,

especially in an emergency situation. Although GCS provides a quick assessment of severity of illness in head trauma in patients with multiple trauma, an accurate evaluation score could be obtained by APACHE II scoring system in a separate group of patients.

Both systems provide clear estimates about the risk of hospital death and/or mortality. Both scoring systems were found to be sensitive in predicting mortality of patients within this study. When GCS and APACHE II systems were assessed by ROC analysis, area under the curve was detected as 0.87±0.049 for GCS and 0.94±0.025 for APACHE II, respectively. It was shown that both systems have adequate value in predicting mortality, with a higher sensitivity and specificity; however, APACHE II was found to be more sensitive when compared to GCS.

Patients have a higher hospital mortality rate if they bare preinjury factors such as cardiopulmonary resuscitation before admission, increased serum creatinine concentration, hypotension, continuous intravenous drug therapy, increased prothrombin time, low hematocrit, coma or deep stupor at the time of admission, hypoxemia, intracranial mass effect, mechanical ventilation, limitations in previous health state, and older age.[3,14] APACHE II scoring system covers many of the parameters described above. Moreover, it includes the GCS system; thus, it could be expected that APACHE II is more advantageous than GCS in predicting mortality.

In conclusion, for the assessment of mortality, the GCS score still provides simple, less-time consuming and effective information concerning head injury patients, especially in emergencies; however, for the prediction of mortality, APACHE II is better than GCS as it additionally includes the main physiologic parameters of the patient.

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