ORIGINAL ARTICLE

Comparison of acute physiology and chronic health evaluation II and Glasgow Coma Score in predicting the outcomes of Post Anesthesia Care Unit's patients

Mohammad Hosseini, Jamileh Ramazani[1]

Department of Nursing, North Khorasan University of Medical Sciences, Bojnourd, Iran, [1]Department of Nursing, Islamic Azad University, Bojnourd Branch, Bojnourd, Iran

Address for correspondence:
Mohammad Hosseini, Department of Nursing and Midwifery, North Khorasan University of Medical Sciences, Bojnourd, North Khorasan Province, Iran.
E-mail: hosseini182@yahoo.com

ABSTRACT

Context: Acute physiology and chronic health evaluation II (APACHE II) is one of the most general classification systems of disease severity in Intensive Care Units and Glasgow Coma Score (GCS) is one of the most specific ones. **Aims:** The aim of the current study was to assess APACHE II and GCS ability in predicting the outcomes (survivors, non-survivors) in the Post Anesthesia Care Unit's (PACU). **Settings and Design:** This was an observational and prospective study of 150 consecutive patients admitted in the PACU during 6-month period. **Materials and Methods:** Demographic information recorded on a checklist, also information about severity of disease calculated based on APACHE II scoring system in the first admission 24 h and GCS scale. **Statistical Analysis Used:** Logistic regression, Hosmer-Lemeshow test and receiver operator characteristic (ROC) curves were used in statistical analysis (95% confidence interval). **Results:** Data analysis showed a significant statistical difference between outcomes and both APACHE II and Glasgow Coma Score (GCS) ($P < 0.0001$). The ROC-curve analysis suggested that the predictive ability of GCS is slightly better than APACHE II in this study. For GCS the area under the ROC curve was 86.1% (standard error [SE]: 3.8%), and for APACHE II it was 85.7% (SE: 3.5%), also the Hosmer-Lemeshow statistic revealed better calibration for GCS ($\chi^2 = 5.177$, $P = 0.521$), than APACHE II ($\chi^2 = 10.203$, $P = 0.251$). **Conclusions:** The survivors had significantly lower APACHE II and higher GCS compared with non-survivors, also GCS showed more predictive accuracy than APACHE II in prognosticating the outcomes in PACU.

Key words: *Acute physiology and chronic health evaluation II, Glasgow Coma Score, Post Anesthesia Care Unit*

INTRODUCTION

In critically ill-patients, several scoring systems have been introduced and developed over the last three decades. The acute physiology and chronic health evaluation (APACHE) II was released in 1985.[1] It is one of the most widely used scoring systems, have been developed to prognosticate hospital mortality of Intensive Care Unit (ICU) patients.[2] The APACHE II as a general severity scoring system is beneficial in predicting outcomes such as mortality and length of stay (LOS), clinical decision making, comparison of ICU results and monitoring quality of ICU delivered care.[3] In addition, the APACHE II score has been shown to be of use for individual patients in triage.[4] The Glasgow Coma Score (GCS) was developed in 1974.[5] It is a widespread assessment tool to evaluate the level of consciousness. It is categorized as a specific scoring system. Validity and reliability of two models are obtained in several studies.[6-9] In spite of that, there are still conflicting data concerning which of the scoring systems is the best predictor tool. External validation is essential before routine application of each model to a group of patients that is different from the group originally used for model development.

Access this article online	
Quick Response Code:	Website: www.saudija.org
	DOI: 10.4103/1658-354X.152839

Prognostication is an important part of the management of any critically ill patients. There are many studies that have assessed the ability of the APACHE II and GCS to prognosticate the patient's outcomes in ICUs. Donnino *et al*.,[10] assessed the performance of APACHE II in post-cardiac arrest. In a prospective observational study, a total of 228 subjects were included in the analysis. The mean age was 70 years and 32% of the patients were female. They concluded that APACHE II score is a poor predictor of outcomes at time zero for out-of-hospital cardiac arrest, for in-hospital cardiac arrest it was a modest indicator of illness severity and predictor of mortality/neurologic morbidity. Cardoso and Chiavone,[11] analyzed the performance of APACHE II to predict the mortality rate of discharged patients from the ICU. In a prospective study using the data from 355 patients admitted to the ICU, they noted this tool was shown to be useful for stratifying the patients at greater risk of death after discharge from ICU, also they proposed the professionals, particularly nurses to pay attention to use this system in managing human and technological resources for this group of patients. Cudworth *et al*.,[12] in a 7-year retrospective study that was undertaken of all traumatic inferior vena cava (IVC) injuries presenting to a tertiary care trauma center, noted that GCS is a significant predictor of mortality in patients with traumatic IVC lesions. In another study Chou *et al*.,[9] conducted a retrospective analysis of patients with tuberculosis meningitis (TBM) from March 1996 to February 2006; they concluded GCS is an effective predictor of the discharge outcomes of adult patients with TBM.

Most of the previous studies have shown the good discriminative power, but different calibration for APACHE II and GCS.[8,11,13-18] Differences in the performance of these two scoring systems reinforce that the external validation is essential before routine usage, due to variation in case mix, structure and organization of acute medical care and lifestyles between populations. It is recommended by the researchers that regular re-calibration should be undertaken irrespective of what scoring system is selected, in order to minimize "model fade" and provide clinicians and managers interested in benchmarking a well-validated model to predict mortality. Literature available on this subject in Iranian context is very limited. The aim of this study was to compare the prognostic accuracy of APACHE II and GCS in predicting the outcomes in Post Anesthesia Care Unit (PACU).

MATERIALS AND METHODS

Design

A prospective, observational cohort study of patients who had undergone procedures that require anesthesia, during the period from 7/2011 to 2/2012.

Population

The study population included 150 consecutive patients admitted to the PACU. Excluded from the study population were patients with ICU LOS <24 h as APACHE II cannot be calculated in these patients.

Data collection

Data collection included demographic information (including age and gender), GCS (score before sedation), pre-existing underlying disease, 12 common physiological, laboratory values necessary for computing severity of illness as assessed by APACHE II score. Patients' privacy maintained by not publishing identifying information. Based on the worst data from the first 24 h after admission to the PACU, a mark adjusting for chronic health problems and a mark for patient age APACHE II was calculated. Validity and reliability of both systems are obtained in many studies.[1,19-22] APACHE II included of 12 physiologic variables (heart rate, systolic blood pressure, temperature, oxygenation, respiratory rate, arterial pH, serum sodium, potassium and creatinine, hematocrit, white blood cell count and GCS), a chronic health evaluation and age adjustment score. Each variable is weighted from 0 to 4 score, with higher scores denoting an increasing deviation from normal. It is measured during the first 24 h of ICU admission; the maximum score is 71. Points of 25 or less denote less than 50% mortality, while points of 35 or more denote more than 80% mortality.[1] The GCS provides a score in the range 3-15; patients with scores of 3-8 are usually said to be in a coma. The total score is the sum of the scores in three categories including: Eye opening response (4 point), verbal response (5 point) and motor response (6 point).[5] Data were recorded initially on a standardized data collection form and then transferred to SPSS Statistical software version 21 (©Copyright IBM corporation and other(s) 1989-2013).

Intervention

None.

Outcome measures

The primary outcomes for this investigation were survivors and non-survivors.

Data analysis

All analyses were conducted using the SPSS Statistical software version 21 (©Copyright IBM corporation and other(s) 1989-2013). To summarize the study population, simple descriptive statistics were used. Data for continuous variable are presented as means with standard deviations. Categorical data are presented as frequencies with percentages. The association between APACHE II and GCS with outcomes was assessed by logistic regression. APACHE II and GCS were considered to be independent

continuous predictor variables. $P < 0.05$ was considered to be significant. Validation of the APACHE II and GCS were performed using standard tests to measure discrimination and calibration. Discrimination was defined as the power to distinguish between survivors and non-survivors and was assessed by calculating the area under the curve (AUC) of the receiver operator characteristic (ROC) curve. An AUC of 0.5 (a diagonal line) is equivalent to random chance, AUC >0.7 indicates a moderate prognostic model, and AUC >0.8 (a bulbous curve) indicates a good prognostic model.[23] Calibration was defined as an agreement between individual probabilities and actual outcomes, it was assessed using the Hosmer-Lemeshow Goodness-of-Fit test and $P > 0.05$ was considered as well-calibrated.

RESULTS

A total of 150 patients admitted on PACU were evaluated. The median age of the cohort was 57.41 ± 22.80 years (range 3-97 years), which 91 (60.7%) were men, and 59 (39.3%) were women. The overall mortality for all subjects was 19.3% (21.150). The characteristics of the study samples are shown in Table 1. For the entire cohort of patients, the mean APACHE II, GCS score and length of PACU stay were significantly different between the survivors and non-survivors [Table 2]. Non-survivors showed significantly higher APACHE II scores than survivors. The mean APACHE II score for patients who died was 21.86 ± 6.91 compared with 12.19 ± 5.40 for survivors, $P < 0.0001$; Also Non-survivors had the mean GCS score 5.14 ± 1.62 compared to 7.97 ± 1.90 for survivors, $P < 0.0001$. The mean length of PACU stay (5.63 ± 9.04 days) was significantly different between survivors and non-survivors (4.80 ± 8.81; 9.11 ± 9.30 days, respectively).

Discrimination for both scoring system was good. The best Yuden index (sensitivity + specificity-1) was used to determine the best cut-off point for each scoring system. Using a cut-off score 13.5, The APACHE II score predicted hospital mortality with a sensitivity of 96.6%, a specificity of 62.8% and accuracy of 79.7%, with an area under the ROC curve of 0.857 ± 0.035 SE (95%; 0.788-0.925, $P < 0.0001$). For GCS a cut off score 8.5 showed a sensitivity of 82.8%, a specificity of 82.6% and accuracy of 82.7% [Table 3], also the area under the ROC curve was 0.861 ± 0.038 SE (95%; 0.786-0.937, $P < 0.0001$). ROC curves were drawn for the APACHE II scoring systems and GCS to assess predictive accuracy [Figure 1].

By using the Hosmer-Lemeshow Chi-square statistic, the GCS score showed better calibration ($\chi^2 = 5.177$, $P = 0.521$) than APACHE II score ($\chi^2 = 10.203$, $P = 0.251$).

DISCUSSION

Two models for predicting outcomes in the PACU have been evaluated in this study. Both mean APACHE II and GCS scores were significantly higher in non-survivors when compared to survivors ($P < 0.0001$).The predictive accuracy of mortality models is generally assessed by determining the area under the ROC curve or by calculating the Hosmer-Lemeshow Chi-square statistic. Comparing the efficacy of the predictive power for outcomes of APACHE II and GCS in patients who were admitted in PACU, we measured discrimination and calibration for both prognosticating

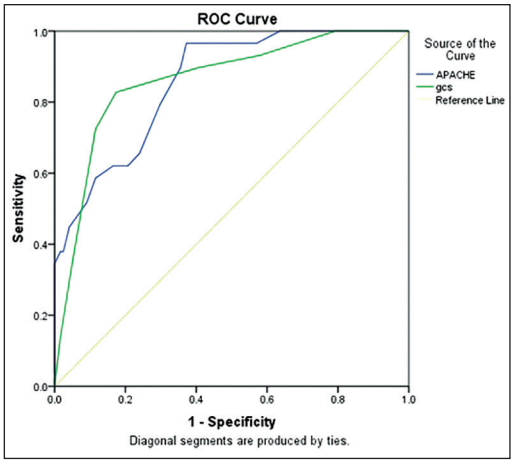

Figure 1: Receiver operator characteristic curves for acute physiology and chronic health evaluation (APACHE) II and Glasgow Coma Score (GCS) score. The area under curve is 0.857 for APACHE II and 0.861 for GCS score

Table 1: The characteristics of the study samples

Characteristics	Total (*n* = 150)	Survivors (*n* = 121)	Nonsurvivors (*n* = 29)	*P*
Age (years, median, range)	64.50 (3-97)	65 (3-97)	58 (19-90)	*P*=0.9
Sex (number, %)				
Men	91 (60.7)	73 (60.3)	48 (39.7)	*P*=0.86
Women	59 (39.3)	18 (62.1)	11 (37.9)	
Length of PACU stay (median, range, days)	2.75 (1-76.33)	2.13 (1-76.33)	6.17 (1.21-50.29)	*P*=0.02
APACHE II (median, range)	13 (2-34)	11 (2-24)	21 (10-34)	*P*<0.0001
GCS (median, range)	7.50 (3-12)	8 (3-12)	5 (6-9)	*P*<0.0001

PACU: Post Anesthesia Care Unit; APACHE II: Acute physiology and chronic health evaluation II; GCS: Glasgow Coma Score

models. Good capability of discriminating survivors from non-survivors obtained by GCS, with the area under ROC of 0.861, it was slightly better, but very close to 0.857, the value obtained from APACHE II. The cut-off score for GCS and APACHE II in our study were 6.5 and 13.5, retrospectively, and both models showed good overall accuracy. A simple prognostic model, GCS, showed better discriminating power based on AUCs. This difference may arise from case-mix and need for short-term or long-term care. Calibration as assessed by the Hosmer-Lemeshow Chi-square statistic was better for the GCS than APACHE II too (χ^2 = 5.177, P = 0.521; χ^2 = 10.203, P = 0.251, retrospectively). The GCS is an important component of APACHE II; one can argue that this difference might be explained by suitability of APACHE II in long-term ICU care.

Our results are in agreement with several studies have been cited that higher APACHE II or lower GCS scores were significantly associated with higher mortality or poor prognosis.[8,9,14,24-28] One study mentioned APACHE II may not replace the role of GCS in prognosticating the early functional outcomes in ICU, But for prediction of the late mortality, the APACHE II has better accuracy than GCS.[14] Another study cited APACHE II should not replace GCS in assessment of illness severity or prediction of mortality in non-traumatic situation.[8] Zali *et al.*,[27] pointed to the superiority of APACHE II to GCS in the prediction of mortality in patients with multiple trauma. Because there is a great variation in clinical and other patient characteristics among ICUs, it is doubtful that one scoring system can be validated in all types of populations among different ICUs. Inconsistent with our results, discriminating power of APACHE II and GCS in different studies was from good to excellent (AUC range: 0.76-0.922),[10,11,13-16] for instance: Ho *et al.*,[18] conducted a retrospective cohort study of 11,107 non-cardiac surgery ICU admissions during 11 years from 1 January 1993 to 31 December 2003, the mean 24-h APACHE II score was 15.4 and the actual hospital mortality was 16.3%; They noted the overall discrimination ability by AUC of 24-h APACHE II was 83.8% (95% confidence interval [CI]: 82.9-84.7). However, in Patel and Grant's study,[29] AUC for the APCHE II (0.672 ± 0.030) was lower than previous studies; they noted this discrepancy could be due to erratic quality of care or differences between the study population and the population in the original studies, also their study had exclusion criteria that surgical and coronary care admissions were excluded.

The results of this study are consistent with the findings of Tsai *et al.*,[7] study, the best cut-off scores were selected 8 for GCS and 13 for APACHE II compared to 8.5 for GCS and 13.5 for APACHE II in our study; They noted there may be a tendency indicating the superiority of GCS over APACHE model (AUC: GCS 92.2%, 95% CI: 83.4-100.0, P = 0.003; APACHE II 88.4%, 95% CI: 67.2-100.0, P = 0.006) that is similar to our findings too (AUC: GCS 86.1%; APACHE II 85.7%). In two other studies,[8,14] the cut off score for GCS was 5 (AUC: 88% and 86%) and for APACHE II was 19 and 17, retrospectively (both AUC: 84%). Chou *et al.*,[9] noted good sensitivity and specificity for both models, like our findings. Similar to our results, in Kim and Kim study,[30] there was a statistically significant difference between GCS and length of ICU stay in two groups of patients. The results of study conducted by Khwannimit and Geater,[16] were unlike ours, their study implemented in Thailand and APACHE II had excellent discrimination (AUC: 0.91, P < 0.001), but poor calibration (Hosmer-Lemeshow statistic was 66.59, P < 0.001), moreover, completing the study, Cerro *et al.*,[17] cited that APACHE II had no consistent performance for calibration and discrimination so concluded its application in emergency and in-hospital patients is limited. Perhaps these discrepancies can be explained by the fact that a scoring system based on a testing and validation set from one population when transferred to another population without modification will often lose predictive accuracy. Therefore, even if initially the model discriminates well, it is possible that following an improvement or deterioration in quality of care the performance of the model would change and would result in reducing applicability of the

Table 2: Comparison of APACHE II, GCS score and length of PACU stay for survivors and nonsurvivors

Variables	Outcome	Mean	SD	SEM	*P*
APACHE II	Survivors	12.19	5.404	0.491	*P*<0.0001
	Nonsurvivors	21.86	6.911	1.283	
GCS	Survivors	7.97	1.906	0.173	*P*<0.0001
	Nonsurvivors	5.14	1.620	0.301	
Length of PACU stay	Survivors	4.80	8.81	0/80	*P*=0.02
	Nonsurvivors	9.11	9.30	1.73	

PACU: Post Anesthesia Care Unit; APACHE II: Acute physiology and chronic health evaluation II; GCS: Glasgow Coma Score; PCU: Progressive Care Unit; SD: Standard deviation; SEM: Standard error of mean

Table 3: Prediction of outcomes on the first day of PACU admission

Variables	Cut off score	Sensitivity (%)	Specificity (%)	Youden index	Overall correctness (%)
APACHE II	13.5	96.6	62.8	0.984	79.7
GCS	8.5	82.8	82.6	0.983	82.7

APACHE II: Acute physiology and chronic health evaluation II; GCS: Glasgow Coma Score; PACU: Post Anesthesia Care Unit

severity of illness scoring system to the situation. These problems may be overcome by recalibrating the model frequently to take into account changes in quality of care and improved survival.

The present study has several limitations. First, the study conducted at a single center with a limited sample size: Sample size is known to have a major influence on the measured calibration when using the Hosmer-Lemeshow goodness-of-fit test. Second, as a single-center study, there may be bias with regard to case mix, quality of ICU care and ICU policy. A multi-center study would mitigate the concerns over case mix and benefit from a larger sample size. Discrimination of the models is dependent on both the nature of the population being evaluated and the quality of care being rendered so as to improve the predictive accuracy of these models in an individual ICU such as ours, it may be necessary to customize the models, or perhaps to utilize scoring systems specific for particular disease conditions to estimate mortality.

CONCLUSION

The findings from the present study confirmed that the APACHE II and GCS with good discrimination and calibration are useful tools for the assessment of PACU outcomes. Although both models fit very well to PACU populations, the GCS had better discrimination and calibration; moreover it is simple and economical yet reliable model to predict outcomes in PACU.

REFERENCES

1. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: A severity of disease classification system. Crit Care Med 1985; 13:818-29.
2. Desai S, Lakhani JD. Utility of SOFA and APACHE II score in sepsis in rural set up MICU. J Assoc Physicians India 2013; 61:608-11.
3. Bouch C, Thompson J. Severity scoring systems in the critically ill. Continuing Education in Anesthesia. Crit Care Pain 2008;8:181-5.
4. Orsini J, Butala A, Ahmad N, Llosa A, Prajapati R, Fishkin E. Factors influencing triage decisions in patients referred for ICU admission. J Clin Med Res 2013;5:343-9.
5. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet 1974;2:81-4.
6. Raj R, Siironen J, Kivisaari R, Hernesniemi J, Skrifvars MB. Predicting Outcome after Traumatic Brain Injury: Development of prognostic scores based on the IMPACT and the APACHE II. J Neurotrauma 2014.
7. Tsai CL, Chu H, Peng GS, Ma HI, Cheng CA, Hueng DY. Preoperative APACHE II and GCS scores as predictors of outcomes in patients with malignant MCA infarction after decompressive hemicraniectomy. Neurol India 2012; 60:608-12.
8. Grmec S, Gasparovic V. Comparison of APACHE II, MEES and Glasgow Coma Scale in patients with nontraumatic coma for prediction of mortality. Acute physiology and chronic health evaluation. Mainz emergency evaluation system. Crit Care 2001;5:19-23.
9. Chou CH, Lin GM, Ku CH, Chang FY. Comparison of the APACHE II, GCS and MRC scores in predicting outcomes in patients with tuberculous meningitis. Int J Tuberc Lung Dis 2010;14:86-92.
10. Donnino MW, Salciccioli JD, Dejam A, Giberson T, Giberson B, Cristia C, *et al.* APACHE II scoring to predict outcome in post-cardiac arrest. Resuscitation 2013;84:651-6.
11. Cardoso LG, Chiavone PA. The APACHE II measured on patients' discharge from the Intensive Care Unit in the prediction of mortality. Rev Lat Am Enfermagem 2013; 21:811-9.
12. Cudworth M, Fulle A, Ramos JP, Arriagada I. GCS as a predictor of mortality in patients with traumatic inferior vena cava injuries: A retrospective review of 16 cases. World J Emerg Surg 2013;8:59.
13. Badreldin AM, Doerr F, Elsobky S, Brehm BR, Abul-dahab M, Lehmann T, *et al.* Mortality prediction after cardiac surgery: Blood lactate is indispensible. Thorac Cardiovasc Surg 2013; 61:708-17.
14. Cho DY, Wang YC. Comparison of the APACHE III, APACHE II and Glasgow Coma Scale in acute head injury for prediction of mortality and functional outcome. Intensive Care Med 1997;23:77-84.
15. Gilani MT, Razavi M, Azad AM. A comparison of Simplified Acute Physiology Score II, acute physiology and chronic health evaluation II and acute physiology and chronic health evaluation III scoring system in predicting mortality and length of stay at surgical Intensive Care Unit. Niger Med J 2014;55:144-7.
16. Khwannimit B, Geater A. A comparison of APACHE II and SAPS II scoring systems in predicting hospital mortality in Thai adult Intensive Care Units. J Med Assoc Thai 2007; 90:643-52.
17. Cerro L, Valencia J, Calle P, León A, Jaimes F. Validation of APACHE II and SOFA scores in 2 cohorts of patients with suspected infection and sepsis, not admitted to critical care units. Rev Esp Anestesiol Reanim 2014;61:125-32.
18. Ho KM, Dobb GJ, Knuiman M, Finn J, Lee KY, Webb SA. A comparison of admission and worst 24-hour acute physiology and chronic health evaluation II scores in predicting hospital mortality: A retrospective cohort study. Crit Care 2006;10:R4.
19. Sakr Y, Krauss C, Amaral AC, Réa-Neto A, Specht M, Reinhart K, *et al.* Comparison of the performance of SAPS II, SAPS 3, APACHE II, and their customized prognostic models in a surgical Intensive Care Unit. Br J Anaesth 2008;101:798-803.
20. Naved SA, Siddiqui S, Khan FH. APACHE-II score correlation with mortality and length of stay in an Intensive Care Unit. J Coll Physicians Surg Pak 2011;21:4-8.
21. Holdgate A, Ching N, Angonese L. Variability in agreement between physicians and nurses when measuring the Glasgow Coma Scale in the emergency department limits its clinical usefulness. Emerg Med Australas 2006;18:379-84.
22. Gill MR, Reiley DG, Green SM. Interrater reliability of Glasgow Coma Scale scores in the emergency department. Ann Emerg Med 2004;43:215-23.
23. Metz CE. Basic principles of ROC analysis. Semin Nucl Med 1978;8:283-98.
24. Marra AR, Bearman GM, Wenzel RP, Edmond MB. Comparison of severity of illness scoring systems for patients with nosocomial bloodstream infection due to Pseudomonas aeruginosa. BMC Infect Dis 2006;6:132.
25. Sam KG, Kondabolu K, Pati D, Kamath A, Pradeep Kumar G, Rao PG. Poisoning severity score, APACHE II and GCS: Effective clinical indices for estimating severity and predicting outcome of acute organophosphorus and carbamate poisoning. J Forensic Leg Med 2009;16:239-47.

26. Zhang ZY, Chen R, Zhou ZQ, Peng CH, Zhou GW. Prognostic evaluation of patients undergoing living-donor liver transplant by APACHE II and MELD scores. Exp Clin Transplant 2014.
27. Zali AR, Seddighi AS, Seddighi A, Ashrafi F. Comparison of the acute physiology and chronic health evaluation score (APACHE) II with GCS in predicting hospital mortality of neurosurgical Intensive Care Unit patients. Glob J Health Sci 2012;4:179-84.
28. Patel MJ, Khan NU, Furqan M, Awan S, Khan MS, Kashif W, *et al.* APACHE II scores as predictors of cardio pulmonary resuscitation outcome: Evidence from a tertiary care institute in a low-income country. Saudi J Anaesth 2012;6:31-5.
29. Patel PA, Grant BJ. Application of mortality prediction systems to individual Intensive Care Units. Intensive Care Med 1999;25:977-82.
30. Kim H, Kim K. Verification of validity of MPM II for neurological patients in Intensive Care Units. J Korean Acad Nurs 2011; 41:92-100.

How to cite this article: Hosseini M, Ramazani J. Comparison of acute physiology and chronic health evaluation II and Glasgow Coma Score in predicting the outcomes of Post Anesthesia Care Unit's patients. Saudi J Anaesth 2015;9:136-41.

Source of Support: Financial support by Islamic Azad University, Bojnord Branch, Bojnord, Iran, **Conflict of Interest:** None declared.