sciendo
ORIGINAL ARTICLE
Romanian Journal of Anaesthesia and Intensive Care 2019 Vol 26 No 1, 53-58
DOI: http://dx.doi.org/10.2478/rjaic-2019-0008

The association between the APACHE-II scores and age groups for predicting mortality in an intensive care unit: a retrospective study

Ipek Saadet Edipoglu, Behiye Dogruel, Sevda Dizi, Melis Tosun, Nahit Çakar

Department of Anaesthesiology and Reanimation, Acibadem University School of Medicine, Istanbul, Turkey

Abstract

Background and Aims: In this study, we aimed to evaluate whether the age or the APACHE-II score was a better predictor of mortality in each group. The secondary objective was to investigate the factors affecting the mortality in each individual age group.

Methods: We designed this retrospective study between 2016-2017. Age groups were classified into 3 classes: Patients < 60 years were Group 1, patients between 60-70 years were Group 2, and patients > 70 years were Group 3. We recorded patients' age, ICU indication, demographic data, APACHE-II, ASA, length of hospital stays and mortality.

Results: We analysed 150 patients and reported mortality for 58 patients (38.7%). We did not detect any association between age and mortality for all groups. ASA, length of ICU stays and predicted mortality rate, were significantly higher for exitus patients ($p < 0.001$). The ROC curve for the APACHE-II score, with a cut-off point of 23, demonstrated 74.14% sensitivity, 60.87% specificity, an area under the curve (AUC) of 67.3%, with 4.5% standard deviation (SD). The ODDS ratio for APACHE-II scores was 4.459 (95% CI: 2.167-9.176). For the adjusted mortality rate, ROC analysis identified a cut-off of 60.8 with 70.69% sensitivity, 52.17% specificity, AUC of 61.2% and 4.6% SD. The ODDS ratio for the adjusted mortality rate was 2.631 (95% CI: 1.309-5.287).

Conclusion: We could not demonstrate any correlation between age and mortality. We consider APACHE-II as a valuable scoring system to predict mortality. We do not consider age as a predictor of mortality. Therefore, we do not suggest its use as a sole prognostic marker in ICU patients.

Keywords: APACHE-II, age, mortality

Received: January 21, 2019 / Accepted: March 21, 2019 **Rom J Anaesth Intensive Care 2019; 26: 53-58**

Introduction

Globally, the aging population grows especially in the developing countries [1]. Parallel to the aging population, the age and the comorbidities of the intensive care unit patients are increasing together [1]. The population of the elderly aged over 80 years of age is projected to be doubled in 2050 [2]. A recent study on the continent of Australia demonstrated that the number of patients aged 85 and over is increasing by 5.6% annually [3]. There is heterogeneity in studies evaluating whether the mortalities in intensive care unit (ICU) patients are directly associated with age [4, 5]. It is proposed that the degree of the heterogeneity in the outcomes of these studies might lie in the methodological diversities and might be due to the variations in the study populations [4].

The Acute Physiology and Chronic Health Evaluation II (APACHE-II) scoring system has been

Address for correspondence: Ipek Saadet Edipoglu, MD
Department of Anaesthesiology and Reanimation
Acibadem University School of Medicine
Halkali Merkez Mah.
Turgut Ozal Blv. No:16, 34303
Kucukcekmece/Istanbul, Turkey
E-mail: dripeks@yahoo.com

developed to predict the survival of the patients admitted to ICUs [6, 7]. The APACHE-II scoring system has been used effectively in various patient groups to monitor disease severity and prognosis [6].

Determination of the required parameters to predict the prognosis in the ICU patients is imperative. The primary objective of this study was to determine whether the age or the APACHE-II score was a better predictor of mortality in each group. The secondary objective of the study was to investigate the other factors affecting the mortality in each individual age group. And, the final objective of the study was to investigate the relation of the mortality estimation of the APACHE-II system with the real mortality rates.

Materials and methods

Our study was conducted retrospectively in the tertiary care ICU of our hospital. The Acýbadem University Ethical Committee approved our study. The patients, who presented to our ICU between January 2016 and January 2017, were included in the study after screening the patient files retrospectively. Age groups were classified into 3 groups. By definition, patients, who were 60 years or below were allocated to Group 1; patients who were between ages of 60 and 70 were allocated to Group 2 and patients, who were at the age of 70 or over were allocated to Group 3. Patients, who were at the age of 18 or over; patients, who were admitted to our ICU for a duration of more than 48 hours, and patients with ASA I-IV and BMI < 40 were included in the study. Patients who were younger than 18 years of age, and patients who were admitted to the ICU for the second time, and patients who stayed at the ICU for less than 48 hours were excluded. The age and sex of the patients, the underlying aetiologies in ICU admissions, comorbidities, Acute Physiology and Chronic Health Evaluation (APACHE) II scores, estimated mortality rates, adjusted mortality rates, ASA (American Society of Anesthesiologists) scores, duration of hospitalizations, duration of mechanical ventilation if needed, duration of ICU admissions, and the presence of mortalities at the hospital or at the ICU were recorded as per the records in the patient files. The adjusted mortality rate (AMR) was evaluated by dividing the number of the examined deaths by the number of the estimated deaths.

Statistical analysis

For the statistical analyses, NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) program was used. In order to evaluate the descriptive statistical methods; mean, standard deviation, median, frequency, ratios, minimums, and maximum values were used, and to evaluate the quantitative values; Student t-test and Mann Whitney U tests were used for the two-group comparisons of the data with and without normal distribution respectively. Pearson's chi-square test was used to compare the qualitative data among groups. To determine the cut-off points for the parameters, diagnostic screening tests (sensitivity, specificity, positive and negative predictive values) and ROC Curve Analysis were used. The significance was evaluated by p values smaller than < 0.05.

Results

A total of 211 patient files were examined for the study. Following the implementation of the exclusion criteria, 150 patient files, comprised of 47.3% (n = 71) female and 52.7% (n = 79) male patient files were evaluated (Table 1). The ages of the patients ranged from 19 to 95, with a mean of 64.97 ± 16.37 years. The demographic data of the patients were listed in Table 1. There were no mortalities in 61.3% (n = 92) of the cases compared to the rate of observed mortalities in 38.7% (n = 58) cases. The mean APACHE-II scores were determined to be 23.43 ± 8.29.

Table 1. General distributions of the descriptive data

Age (year)	Min-Max (Median)	19-95 (67)
	Mean ± SD	64.97 ± 16.37
	≤ 60 years	50 (33.3)
	60-70 years	37 (24.7)
	≥ 70 years	63 (42.0)
Gender; n (%)	Females	71 (47.3)
	Males	79 (52.7)
ASA scores	Mean ± SD	2.82 ± 0.83
	I	8 (5.3)
	II	42 (28.0)
	III	70 (46.7)
	IV	29 (19.3)
	V	1 (0.7)
The length of stay in the ICU (days)	Mean ± SD	12.59 ± 12.70
The length of stay in the hospital (days)	Mean ± SD	17.95 ± 15.69
APACHE-II scores	Mean ± SD	23.43 ± 8.29
The estimated mortality rate (%)	Mean ± SD	47.78 ± 23.89
The adjusted mortality rate (%)	Mean ± SD	63.45 ± 28.70
Overall mortality; n (%)	Present	58 (38.7)
	Absent	92 (61.3)

The major aetiology in ICU admissions of our patients was tumors (n = 39, 26%), followed by respiratory distress (n = 36, 24%). 22 (14.6%) patients had cerebra-vascular events (CVE) and 25 (16.6%) had cardiovascular diseases. Sepsis (n = 3, 2.0%) and trauma (n = 8, 5.3%) were the least aetiologies that our patients had.

When the association between the age and mortality was assessed, no statistical significances were determined in neither the intergroup nor intragroup comparisons ($p > 0.05$). The presence of mortalities varied according to the length of the ICU admissions, demonstrating a statistical significance ($p = 0.009$; $p < 0.01$). A statistically significant difference was observed between the APACHE-II scores and the presence of mortality ($p = 0.001$; $p < 0.01$). The duration of the ICU admissions and the APACHE-II scores of the deceased patients were demonstrated to be significantly higher than those of the patients who survived. The APACHE-II scores ($p = 0.001$), the estimated mortality rates ($p = 0.001$), and the adjusted mortality rates ($p = 0.021$) demonstrated statistically significant differences ($p < 0.05$) according to the presence of mortality; and the APACHE-II scores, the estimated mortality rates, and the adjusted mortality rates were found to be high in the deceased cases (Table 2).

Upon this significance, the cut-off points were calculated for the APACHE-II scores, the estimated mortality rates, and the adjusted mortality rates. In calculating the cut-off points by mortality, ROC analysis and diagnostic screening tests were made use of.

The cut-off point for the APACHE-II scores by mortality was determined to be 23 and over. The APACHE-II score with a cut-off point of 23 demonstrated a sensitivity rate of 74.14%, a specificity rate of 60.87%, a positive predictive value of 54.43, and a negative predictive value of 78.87. The area under the curve (AUC) and the standard deviation (SD) values were 67.3% and 4.5% respectively in the resulting ROC curve.

The cut-off point for the adjusted mortality rate by mortality was determined to be 60.8 years and above. The cut-off point of 60.8 for the adjusted mortality rate resulted in 70.69% rate of sensitivity, 52.17% rate of specificity, a positive predictive value of 48.24, and a negative predictive value of 73.85. The AUC was calculated as 61.2% and the SD was calculated as 4.6% in the resulting ROC curve (Figure 1).

The mortality and the APACHE-II scores were found to be statistically significant by a cut-off value of 23 ($p = 0.001$, $p < 0.01$). The risk of mortality in the cases with an APACHE-II score of 23 and over was demonstrated to increase by 4,459 folds. The ODDS ratio for APACHE-II scores was 4.459 (95% CI: 2.167-9.176). A statistically significant relationship (p

Table 2. Overall mortality assessments according to the descriptive features

		Overall mortality (+) (n = 58)	Overall mortality (-) (n = 92)	p
Age (year)	Min-Max (Median)	21-88 (65)	19-95 (68)	[a] 0.987
	Mean ± SD	65.00 ± 14.24	64.96 ± 17.66	
Age (years); n (%) among groups	≤ 60 years	18 (31.0)	32 (34.8)	[b] 0.577
	60-70 years	17 (29.3)	20 (21.7)	
	≥ 70 years	23 (39.7)	40 (43.5)	
Age (years); n (%) within-groups	≤ 60 years	18 (31.0)	32 (34.8)	[b] 0.635
	60-70 years	17 (29.3)	20 (21.7)	[b] 0.295
	≥ 70 years	23 (39.7)	40 (43.5)	[b] 0.644
Gender; n (%)	Females	23 (32.4)	48 (67.6)	[b] 0.135
	Males	35 (44.3)	44 (55.7)	
ASA scores	Min-Max (Median)	1-5 (3)	1-4 (3)	[c] 0.001 **
	Mean ± SD	3.10 ± 0.76	2.64 ± 0.82	
	I	1 (12.5)	7 (87.5)	
	II	10 (23.8)	32 (76.2)	
	III	30 (42.9)	40 (57.1)	
	IV	16 (55.2)	13 (44.8)	
	V	1 (100)	0 (0)	
The length of stay in the ICU (days)	Min-Max (Median)	2-90 (12.5)	2-50 (7)	[c] 0.009**
	Mean ± SD	15.50 ± 15.87	10.76 ± 9.88	
The length of stay in the hospital (days)	Min-Max (Median)	2-90 (14)	3-75 (12.5)	[c] 0.407
	Mean ± SD	19.34 ± 17.80	17.08 ± 14.24	
APACHE-II score	Min-Max (Median)	5-43 (26.5)	6-48 (21)	[a] 0.001 **
	Mean ± SD	26.50 ± 7.97	21.50 ± 7.93	
The estimated mortality rate (%)	Min-Max (Median)	5.8-94.1 (56.9)	6.7-97 (38.9)	[c] 0.001 **
	Mean ± SD	56.73 ± 22.70	42.14 ± 22.99	
The adjusted mortality rate (%)	Min-Max (Median)	11.6-100 (77.35)	6.7-100 (58.65)	[c] 0.021 *
	Mean ± SD	71.07 ± 24.56	58.65 ± 30.17	

[a] Student-t Test, [b] Pearson-Chi Square Test, [c] Mann Whitney U Test, * $p < 0.05$, ** $p < 0.01$

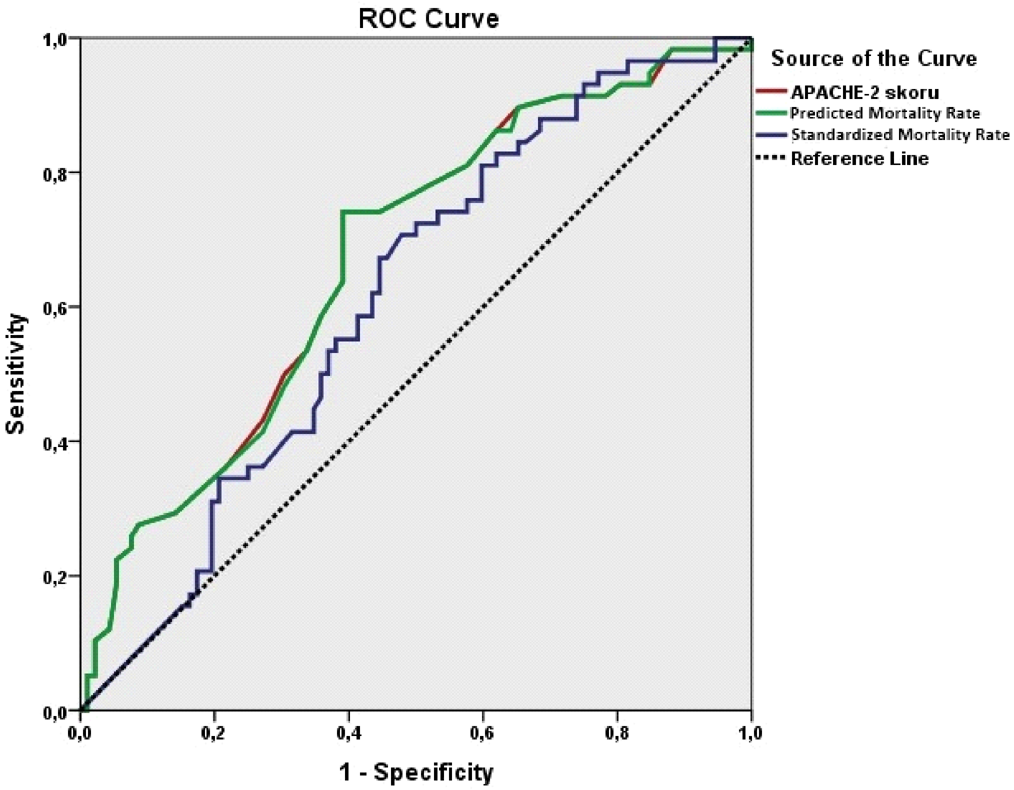

Fig. 1. The cut-off chart for the APACHE-II scores, estimated mortality rate, and adjusted mortality rate according to the presence of mortality

= 0.001; p < 0.01) was determined between the mortality and the cut-off value of 46 of the estimated mortality rate, which meant that the cases with an estimated mortality rate of 46 and over would bear a risk of increased mortality by 4,459 folds. The ODDS ratio for the estimated mortality rate was 4.459 (95% CI: 2.167-9.176). A statistically significant relation between the mortality and the adjusted mortality rate with a value of 60.8 was found (p = 0.006; p < 0.01); meaning that the cases with adjusted mortality rates of 60.8 and over would have a risk of increased mortality by 2.631 folds. The ODDS ratio for the adjusted mortality rate was 2.631 (95% CI: 1.309-5.287) (Table 3).

Discussion

In our study on the age groups and survival, we could not determine a significant relationship between the age and mortality. In order to be able to evaluate the effect of age, we classified the patients into 3 groups to analyze. However, no significant differences were detected in the intergroup and intragroup analyses in terms of survival. A study with 572 patients to evaluate the relation between the age and mortality, by Fernandez et al, could not detect a significant relationship between the age and survival, similar to our study [8]. In another study with a similar methodology to that of our study, the patients were allocated into age groups and then the analyses were performed [5]. This study could not

Table 3. The relationship of the mortality and APACHE-II scores, the estimated mortality rate, and the adjusted mortality rate

		Mortality (-) (n = 92)	Mortality (+) (n = 58)	[b]p
		n (%)	n (%)	
APACHE-II score	< 23	56 (60.9)	15 (25.9)	0.001**
	≥ 23	36 (39.1)	43 (74.1)	
The estimated mortality rate (%)	< 46	56 (60.9)	15 (25.9)	0.001**
	≥ 46	36 (39.1)	43 (74.1)	
The adjusted mortality rate (%)	< 60.8	48 (52.2)	17 (29.3)	0.006**
	≥ 60.8	44 (47.8)	41 (70.7)	

[b] Pearson-Chi Square Test, ** p < 0.01

detect a relation of the age and mortality, neither, as reported. The authors suggested that, for survival, the levels of the APACHE-II scores and the number of organ failures was significant rather than the age [5]. A retrospective study evaluating patients at the age of 85 and over, by Chelluri et al, reported that the age was not an appropriate parameter to determine resource expenditures of ICUs [9]. In a cohort study, covering 410 patients, the elderly patients were evaluated for mortality in 3 different groups [10]. This study did not detect a relationship between the age and mortality in ICU patients. It was reported that the age was not related to the survival during the treatment period in ICU, but the APACHE-II scores were related to the ICU mortalities [10]. On the other hand, the authors stated that immobilization and age could affect survival negatively after 3 months following discharge [10]. In a prospective study, by Rockwood et al, included 1040 patients and allocated them into 2 groups as patients over 65 years of age in one group and patients below 65 in the other and similar to the findings of our study, no relationship between the age and mortality was detected during the study follow-up period of 1 year [11]. However, disease severity, respiratory failure, and length of hospitalization were detected to be related to mortality. We, too, have demonstrated the relation of the duration of stay in the ICU to the mortality by our study. Both studies reported similar results [11]. However, in the literature, there are other studies, which detected the relationship between age and mortality, and proposed that survival decreased as age increased [3, 4, 12]. Flaatten et al. investigated the factors associated with 30-day mortality for very elderly patients in a recent large sample sizes observational study. [13] They reported that scoring systems such as higher Clinical Frailty Scale and SOFA increased 30-day mortality and acute admission was their strongest impact for mortality. They stated that age has little impact on 30-day mortality. These results show similarities to our results. As a result of our evaluation, we consider that the duration of stay in ICUs, higher scores of ASA, and the APACHE-II scores affect the mortality in ICU patients rather than age.

Similar to the findings of our study, a recent study by Uzman et al. reported increased durations of stay in ICUs as the ASA scores increased [14]. ASA classification is a commonly used and recognized classification to predict mortality and morbidity for patients, who undergo surgery [14-16]. In alignment with the literature, our study has also detected increased mortality with increasing ASA scores. Similar to our findings, a study, evaluating 546 patients with acute cerebral haemorrhage, demonstrated that as APACHE-II scores increased, mortality increased, too [6]. In addition, the study reported increased mortality with an increased duration of stay in ICUs, which was a parallel finding to that of our study [6]. Another study, evaluating this subject, reported an internal APACHE-II score cut-off value of 20 [8]. Li et al. evaluated 660 patients with pneumonia, treated in an ICU [17]. They detected a significant relation of the APACHE-II scores, chronic cardiac failure, and dialysis with mortality. They reported a cut-off value of 21 for the APACHE-II scores [17]. The results of these studies resemble the APACHE-II score cut-off value of 23, found by our study. However, there are some studies proposing that APACHE-II is insufficient in terms of its efficacy [18]. Raj et al. conducted a study in traumatic brain damage, evaluating SAPS-II, APACHE-II, and Glasgow Coma Scale (GCS) scores and proposed that GCS scores were more effective in predicting long-term survival [18]. These results presented some differences compared to our study results. Similarly, another study evaluating the differences between SAPS and APACHE-II in terms of efficacy proposed that APACHE-II was inferior to predict survival compared to SAPS [19]. We consider that the discrepancies in the results of those studies are caused by the patient groups selected. A recent univariate analysis, including 1185 patients, proposed that hypoalbuminemia and APACHE-II were related to mortality [20]. Wenner et al. evaluated the reliability of APACHE-II and studied the estimated hospital mortality. They proved the reliability of APACHE-II in calculating the expected mortality rate [21]. These results were similar to the findings of our study. In this study, we detected that the estimated mortality rate and the APACHE-II scores were at the same sensitivity level in determining the rate of mortality, whereas the adjusted mortality rate was detected to be inferior compared to them.

The limitation of our study is the methodology we applied. The data, being collected by a retrospective study, and being dependent on the objectivity of the researchers are the limitations of our study. Studies with prospective designs may be more appropriate for future work.

Conclusion

In conclusion, we could not detect a significant relationship between age and mortality. We consider APACHE-II as a valuable scoring system to predict mortality. We do not consider age as a predictor of mortality. Therefore, we do not suggest that it be used as a prognostic marker alone in ICU patients.

Conflict of interest

Nothing to declare

References

1. de Rooij SE, Abu-Hanna A, Levi M, de Jonge E. Factors that predict outcome of intensive care treatment in very elderly patients: a review. Crit Care 2005; 9: 307-314. doi: 10.1186/cc3536
2. Nguyen YL, Angus DC, Boumendil A, Guidet B. The challenge of admitting the very elderly to intensive care. Ann Intensive Care 2011; 1: 29. doi: 10.1186/2110-5820-1-29
3. Fuchs, L., Chronaki, CE, Park, S, Novack V, Baumfeld Y, Scott D, et al. ICU admission characteristics and mortality rates among elderly and very elderly patients. Intensive Care Med 2012; 38: 1654-1661. doi: 10.1007/s00134-012-2629-6
4. Sacanella E, Pérez-Castejón JM, Nicolás JM, Masanés F, Navarro M, Castro P, et al. Functional status and quality of life 12 months after discharge from a medical ICU in healthy elderly patients: a prospective observational study. Crit Care 2011; 15: R105. doi: 10.1186/cc10121
5. Leong IY, Tai DY. Is increasing age associated with mortality in the critically ill elderly. Singapore Med J 2002; 43: 33-36
6. Huang Y, Chen J, Zhong S, Yuan J. Role of APACHE-II scoring system in the prediction of severity and outcome of acute intra-cerebral hemorrhage. Int J Neurosci 126: 1020-1024. doi: 10.3109/00207454.2015.1099099
7. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med 1985; 13: 818-829. doi: 10.1097/00003465-198603000-00013
8. Fernández Del Campo R, Lozares Sánchez A, Moreno Salcedo J, Lozano Martínez JI, Amigo Bonjoch R, Jiménez Hernández PA, et al. Age as predictive factor of mortality in an intensive and intermediate care unit. Rev Esp Geriatr Gerontol 2008; 43: 214-220
9. Chelluri L, Pinsky MR, Grenvik AN. Outcome of intensive care of the "oldest-old" critically ill patient. Crit Care Med 1992; 20: 757-761
10. Somme D, Maillet JM, Gisselbrecht M, Novara A, Ract C, Fagon JY. Critically ill old and the oldest-old patients in intensive care: short- and long-term outcomes. Intensive Care Med 2003; 29: 2137-2143. doi: 10.1007/s00134-003-1929-2
11. Rockwood K, Noseworthy TW, Gibney RT, Konopad E, Shustack A, Stollery D, et al. One-year outcome of elderly and young patients admitted to intensive care units. Crit Care Med 1993; 21: 687-691. doi: 10.1097/00003246-199305000-00011
12. Biston P, Aldecoa C, Devriendt J, Madl C, Chochrad D, Vincent JL, et al. Outcome of elderly patients with circulatory failure. Intensive Care Med 2014; 40: 50-56. doi: 10.1007/s00134-013-3121-7
13. Flaatten H, De Lange DW, Morandi A, Andersen FH, Artigas A, Bertolini G, et al. The impact of frailty on ICU and 30-day mortality and the level of care in very elderly patients (= 80 years). Intensive Care Med. 2017 Dec; 43(12): 1820-1828. doi: 10.1007/s00134-017-4940-8
14. Uzman S, Yilmaz Y, Toptas M, Akkoc I, Gul YG, Daskaya H, et al. A retrospective analysis of postoperative patients admitted to the intensive care unit. Hippokratia 2016; 20: 38-43
15. Minto G, Biccard B. Assesment of the high-risk perioperative patient. Contin Educ Anaest Crit Care Pain 2014; 14: 12-17. doi: 10.1093/bjaceaccp/mkt020
16. Sobol JB, Wunsch H. Triage of high-risk surgical patients for intensive care. Crit Care 2011; 15: 217. doi: 10.1186/cc9999
17. Li G, Cook DJ, Thabane L, Friedrich JO, Crozier TM, Muscedere J, et al. Risk factors for mortality in patients admitted to intensive care units with pneumonia. Respir Res 2016; 17: 80. doi: 10.1186/s12931-016-0397-5
18. Raj R, Skrifvars M, Bendel S, Selander T, Kivisaari R, Siironen J, et al. Predicting six-month mortality of patients with traumatic brain injury: usefulness of common intensive care severity scores. Crit Care 2014; 18: R60. doi: 10.1186/cc13814
19. Serpa Neto A, Assunção MS, Pardini A, Silva E. Feasibility of transitioning from APACHE-II to SAPS III as prognostic model in a Brazilian general intensive care unit. A retrospective study. Sao Paulo Med J 2015; 133: 199-205. doi: 10.1590/1516-3180.2013.8120014
20. Freire AX, Bridges L, Umpierrez GE, Kuhl D, Kitabchi AE. Admission hyperglycemia and other risk factors as predictors of hospital mortality in a medical ICU population. Chest 2005; 128: 3109-3116. doi: 10.1378/chest.128.5.3109
21. Wenner JB, Norena M, Khan N, Palepu A, Ayas NT, Wong H, et al. Reliability of intensive care unit admitting and comorbid diagnoses, race, elements of Acute Physiology and Chronic Health Evaluation II score, and predicted probability of mortality in an electronic intensive care unit database. J Crit Care 2009; 24: 401-407. doi: 10.1016/j.jcrc.2009.03.008