Comparison of Glasgow Coma Scale and GCS-Age Prognosis Score in Older Adult Patients

Yaşlı Hastalarda Glasgow Koma Skalası ve GCS-Yaş Prognoz Skorunun Karşılaştırılması

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ABSTRACT

Background: Recent data have shown that the proportion of older adult patients admitted to intensive care units is increased and the severity of illness is an independent risk factor associated with mortality. The aim of the current study was to compare the prognostic value of the Glasgow Coma Scale (GCS) and GCS-Age Prognosis (GAP) scores in older adult patients (aged ≥65 years) admitted to Medical Intensive Care Unit (MICU).

Methods: This was a prospective study of 168 consecutive older adult patients admitted to medical ICU during a 14-month period. For each patient, the GCS and GAP score in the first 24hours of admission and demographic characteristics were calculated and recorded. For statistical analysis, the logistic regression, Receiver operator characteristic (ROC) curve, and Hosmer-Lemeshow test were used (95% confidence interval).

Results: Survivors had a significantly higher GCS and GAP scores in the first 24h of MICU admission compared with nonsurvivors (p<0.001, p<0.001, respectively). The discrimination power of both models was good ((area under curve [AUC]:83.8% (standard error [SE]:3%), AUC: 85.4% (SE: 2.9%), respectively). Based on the Hosmer-Lemeshow goodness of fit test, just GCS had an acceptable calibration (x2=13.18, p=0.068).

Conclusions: For older adult patients admitted to the MICU, GCS and GAP scores reliably predict outcomes. Based on AUCs the discrimination power of models was good, but the calibration was acceptable just for GCS, thus the GCS is the better predictive model than GAP and useful in determining the prognosis of older adult patients in MICU.

Keywords: GCS, GAP, older adult, MICU

SUMMARY STATEMENT

What does this research add to existing knowledge in geriatric medicine?

- Both GCS and GAP scores showed a good predictive ability for older adult patients' mortality in the medical ICU.
- Older age was associated with a high risk of older adult mortality in the medical ICU.
- Contrary to the opinion of some researchers that GCS cannot appropriately reflect the severity of illness in older adult, we found that GCS has a good discrimination and calibration power to predict mortality-related outcomes in these group of patients.

What are the implications of this new knowledge for nursing care with the older adult?

- In clinical practice, using a valid and reliable predictive model for mortality prediction is necessary for the ICUs.
- The clinical nurses can use both of the GCS and GAP scores for predicting the mortality of older adult patients in the medical ICUs.

How could the findings be used to influence policy or practice or research or education?

- The better predictive performance of GCS makes it an advisable predictive model for older adult patients who are admitting in medical ICUs.
- The results of our study could inform health policymakers to make an evidence-based decision regarding the mortality prediction of critically ill patients, particularly the older adult.

Introduction

The validated predictive tools can help to select accurately the patients who will benefit from Intensive Care Unit (ICU) hospitalization, also they are valuable in predicting the outcome, evaluation of new therapies, monitoring of resource utilization and qualitative evaluation of ICUs (1). Since 1974, the Glasgow Coma Scale (GCS) has developed as a practical method for bedside clinical assessment of level of consciousness. During this time (over 40 years) this specific scoring system has been scrutinized, challenged, evaluated, and recalibrated in a plethora of literature (2). Although it has become the gold standard of describing the level of consciousness. Decreasing GCS score (ranging from 3-15) is associated with a worsening level of consciousness and poor prognosis (3, 4). The GCS-Age Prognosis (GAP) score is defined as age/GCS (5). In some studies, it is illustrated that older adult patients had higher mortality and comorbidity rates compared to the nonelderly and general population (6, 7). It is thought that age is strongly associated with intensive care outcomes. Some emergency care providers and researchers have expressed concerns about the accuracy and validity of the GCS (8). Also, it is suggested that the presenting GCS in older adult patients may not be able to identify the severity of the illness with the precision it determines in younger patients (9, 10). There are conflicting data, represent that the age itself is not the sole determinant for admission to the ICU and advice that other factors should be considered (11). In another study, age was an important factor affecting the relationship between anatomic traumatic brain injury (TBI) severity and the GCS score (12).

External validation is an extremely important step before application of the predictive model in the group of patients who are different from that population for which the model was originally developed and introduced (13). Kasprowicz et al. (14) investigated whether replacement of GCS with the Full Outline of UnResponsiveness (FOUR) score is beneficial in predictive models for patients after TBI. In a prospective study, a total of 162 TBI patients were enrolled. Mortality in ICU and unfavorable outcomes at three months post-injury were the primary outcomes. Comparison of the discriminant power of the models was done by determining the areas under the Receiver operator characteristic (ROC) curves (AUCs). Based on findings, FOUR scores, GCS, and age equally well predicted unfavorable outcome at three months post-injury.

Khan et al. (5) tried to develop a clinically applicable and simple tool for accurate prediction of the prognosis of older adult patients with TBI. During 2011, in a retrospective study, they analyzed the isolated older adult patients with TBI in the National Trauma Data Bank. They calculated the GAP score (age/GCS score) for all patients. Primary outcomes were in-hospital adverse events. To determine the discriminatory power of GAP score, Regression analysis, and AUC analysis were performed. A total of 8750 older adult patients with TBI were enrolled in the study. With the mean age of 77.8, the median GCS of 15, and the median head abbreviated injury score (AIS) of 4. The mortality rate in the hospital was 12.7%, and 34.2% of the patients finally discharged from the hospital. Higher GAP score was associated with the higher mortality rate and lower discharge rate. AUC analysis

revealed excellent discriminatory power for mortality (AUC: 0.826). At GAP score> 12, the mortality rate was over 50% and the discharge rate was 45%. They concluded a simple GAP score reliably predicts outcomes.

Except for GAP score that is newly introduced score, the GCS is still controversial whether it is the best predictive model to evaluate the level of consciousness or poor outcomes (2, 8, 9, 15, 16). Some investigators proposed that more validated simplified models should be developed, some suggested that regular re-calibration of models should be undertaken to achieve a valid predictive model of mortality (13). So far, there was no study assessing the use of the GCS and GAP scores in outcome prediction in a purely older adult population in Medical Intensive Care Unit (MICU). The aim of the current study was to compare the predictive value of the GCS and GAP score in older adult patients admitted to MICU.

Methods

The current study was a prospective observational cohort of patients from July 2016 to October 2017. Sampling was conducted at a medical ICU in a university hospital. With a predetermined effect size of 0.50, a statistical power of 0/80, and a significant alpha of 0.05, the desired sample size was calculated to be 84 (17). We increased the sample size to 168 people to reduce type II error and increase the power of the study. The inclusion criteria were age≥65 years and excluded from the study were patients with less than 24 hours ICU Length of Stay (LOS) and those with brain death at the time of admission. For each admitted older adult patients, demographic data (including age and gender) were collected and the GCS and GAP score was assessed and recorded in the first 24-hour of MICU admission.

The GCS is a reliable and objective predictive model that initially records the level of consciousness after a brain injury. It consists of eye, verbal and motor responses. Usually, brain injury is classified as Severe, GCS 3-8, Moderate, GCS 9–12, and Mild, GCS 13-15 (12). Scoring the GCS in intubated patients or patients with a tracheostomy is challenging. It is suggested to assign an Endotracheal Tube (ETT) or T to score verbal responses of this group of patients (18), given this case the maximum score for intubated patients will be 10+ ETT or 10+ T. The GCS score was calculated from the worst scores in 24 h of MICU admission and the GAP was derived from age/GCS. After registering all GCS scores in the data collection form, the calculation of the GAP score was also performed, and then the data entered the SPSS statistical software (IBM Corp., Released 2013, IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY). After calculating the GCS and GAP scores for each patient, the relationship between patients' outcomes was assessed. The primary outcomes were survivors and nonsurvivors. Patients' privacy maintained by not publishing identifying information. There was no intervention in this study.

Based on inclusion criteria, the patients who died in-hospital or classified as brain death were included in nonsurvivors and patients transferred from MICU to other wards of the hospital were included in the survivors. Encoding data, using SPSS, the characteristics of the

study population abridged by using descriptive statistics. Data were presented as means± standard deviations for continuous variables, they were all normal distributed and for categorical data, frequencies with percentages were used. Then assessing the association between GCS and GAP scores and patients' outcomes was down by logistic regression. The GCS and GAP scores were as independent continuous variables and the p-value< 0.050 was considered significant. Predictive ability of these models was assessed by measuring the discrimination and calibration power of the two models. The discrimination power of a predictive model indicates the power of distinguishing between survivors and nonsurvivors and can be assessed by calculating the area under the ROC curve. An AUC of 0.5 is equivalent to random chance (a diagonal line), AUC greater than 0.7 shows a moderate prognostic model, and AUC value greater than 0.8 reflects a good prognostic model (19). Calibration of the model is a measure of the model's ability to produce estimates of risks that are in accordance with the observed outcomes at different levels of risk; that is mean, it represents the agreement between actual outcomes and individual probabilities. Using the Hosmer–Lemeshow goodness of fit (GOF) test, the calibration was assessed. A P > 0.05 indicates the model is well-calibrated (20).

Results

Overall 168 older adult patients admitted to MICU were enrolled in the study. The mean age of the cohort was 74.97±6.28 years (range 65-90 years), which 41.7% (70) were men, and 58.3% (98) were women. The overall mortality rate was 31% (52). The characteristics of the study population are shown in Table 1.

For the entire cohort of patients, GCS and GAP score in the first 24h of MICU admission were significantly different between the survivors and nonsurvivors. The survivors showed meaningfully higher GCS scores and lower GAP scores at the first 24h of admission than nonsurvivors (p<0.001, p<0.001, respectively) (Table 2).

Calculating the discrimination and calibration power of predictive tools are of known methods to evaluate the predictive performance of models. Analyzing the area under curves showed that the discrimination power of GCS and GAP scores in the first 24h of MICU admission was good (AUC= 0.838 (0.78-0.98), AUC= 0.854 (0.80-0.91), respectively). The best Youden index (sensitivity + specificity −1) was used to conclude the best cut-off score for both GCS and GAP. By cut-off score 7.5, GCS predicted MICU mortality with a sensitivity of 67%, a specificity of 90%, positive predictive value of 55.29%, negative predictive value of 93.98%, and accuracy of 74%; for GAP, a cut-off score 15.9 showed a sensitivity of 46%, a specificity of 91%, positive predictive value of 70.59%, negative predictive value of 79.10%, and an accuracy of 73%.

The Hosmer-Lemeshow Chi-Square statistic, showed that the calibration (goodness of fit test) of GCS was good ($\chi2 = 13.18$, P = 0.07), but it was poor for GAP ($\chi2 = 19.06$, P = 0.02). The ROC curve was drawn to access the predictive accuracy of two models [Figure 1]. Based on findings of this study both models had similar predictive accuracy for prognostication of older adult patients' outcomes in the MICU. In terms of gender and MICU LOS, the survivors and nonsurvivors were homogeneous. There was a significant statistical difference between survivors and nonsurvivors; the nonsurvivors were older than survivors (p<0.001) (Table1).

Using logistic regression it was determined that each point increase in the GCS score was accompanied with 39.9 % reduction in the odds of mortality rate in MICU (OR: 0.601, 95% CI, 0.504–0.717; p <0.001). Vice versa, each point increase in GAP score was accompanied with 73.1 % increase in the odds of mortality rate (Odds Ratio (OR): 0.269, 95 % CI, 0.174-0.372; p = 0.001). The relationship of both scores with mortality rate stagnant remained after adjusting for sex and age; therefore, these models were independent significant predictors for older adult patients outcomes in the MICU.

**Table 1.** The characteristics of the study samples

Characteristics	Total (n=168)	Survivors (n=116)	Nonsurvivors (n=52)	p
Age (years, mean ±SD range)	74.97±6.28	73.40±6.16	78.48±5.02	P<0.001
Sex (n, %)				
Men	70(41.7)	48(41.4)	22 (42.3)	
Women	98(58.3)	68(58.6)	30(57.7)	p=0.91
Length of MICU stay (days, mean ±SD)	19.11±11.81	18.97±12.93	19.42±8.94	p=0.79
GCS score	8.13±3.74	9.44±3.65	5.21±7.79	P<0.001
GAP score	11.69±6.18	9.36±4.70	16.90±5.93	P<0.001

SD: Standard Deviation; MICU: Medical Intensive Care Unit; GCS: Glasgow Coma Scale; GAP: GCS-Age Prognosis

Table 2. Comparison of GCS score and GAP score between survivors and nonsurvivors

Variables	Cut-off score	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)	The Area under ROC curve	95% CI	SE	Significant
GCS	7.5	67.2	90.4	55.29	93.98	74.40	0.838	0.78-0.90	0.030	0.000
GAP	15.9	46.2	91.4	70.59	79.10	73.38	0.854	0.80-0.91	0.029	0.000

ROC: Receiver operator characteristic; CI: Confidence Interval; SD: Standard Deviation; GCS: Glasgow Coma Scale; GAP: GCS-Age Prognosis
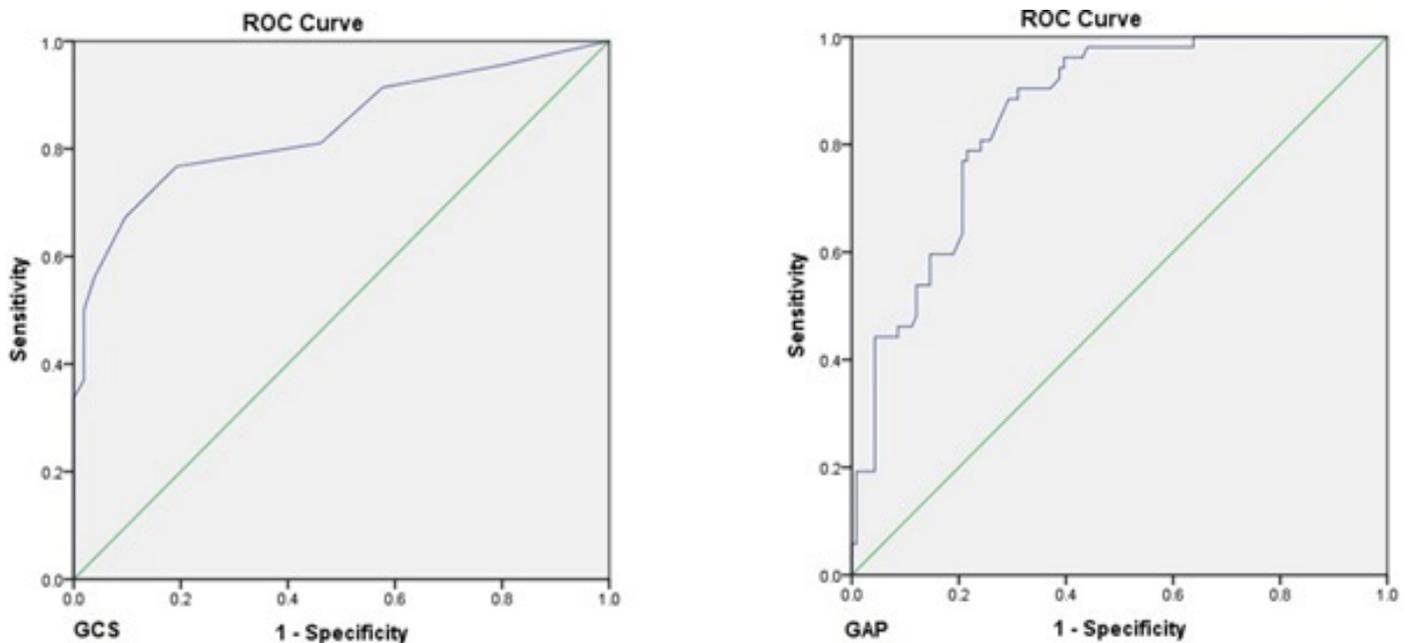
Figure 1. Receiver operator characteristic curves for the Glasgow Coma Scale and GCS-age prognosis scores of the first 24h of admission at the medical intensive care unit. The area under the curve respectively was 0.838, and 0.854.

Discussion

In this study, the performance of GCS and GAP scores have been evaluated in the medical ICU. The mean GCS score was significantly higher in survivors compared to nonsurvivors (p<0.001). In reverse, the survivors had significantly lower mean GAP scores than nonsurvivors. Analyzing the area under the ROC curve showed, both GCS and GAP score were good at discriminating survivors and nonsurvivors (p<0.001, and p<0.001, respectively). The AUC= 0.838 for GCS score and the AUC= 0.854 for GAP score pointed out that the discrimination power of models was excellent for the first 24h of admission. Compared with GAP score (poor calibration), the Hosmer-Lemeshow Chi-Square statistic test showed a good calibration for GCS score ($\chi 2$ = 13.175, P = 0.07). It indicates the applicability of GCS score is better than the GAP score in this group of patients.

The best cut off score based on the youden index was 7.5 and 15.9 for GCS and GAP, respectively. In Alsafatli et al. (21) study, the cut-off scores for the poor prognosis and death within 30 days was 10 on admission. In their study, lower GCS score on admission was associated with increased 30-day mortality and poorer short- term outcome in patients with spontaneous cerebellar hemorrhage (SCH). Also, Yousefzadeh-Chabok et al. (22) assessed the GCS ability to predict the mortality rate in children injured by trauma. The GCS ≤8 was the best cut of score with 98.4% sensitivity and 92.3% specificity, this cut of score and specificity is in line with our results.

The findings of several studies are consistent with our findings have been cited that lower GCS score was significantly accompanying with poor prognosis or higher mortality rate (4, 5, 12, 23). Okazaki et al. (3) conducted a study to identify factors affecting the neurological outcomes of older adult patients with head injury. All of the patients aged ≥65 years who were hospitalized

consecutively in Kagawa University Hospital with severe TBI were retrospectively assessed (Jan 2008- Oct 2015). Unwanted neurologic outcomes happened in 91 patients. Using multivariate analyses showed that the Charlson Comorbidity Index (OR, 1.91; 95% CI, 1.21–3.29; P = 0.011), GCS, and age were independent predictors of unwanted outcomes.

Zhang and Yang (23) investigated the effect of GCS on choosing a therapeutic strategy in acute hypertensive intracerebral hemorrhage. 186 out of 286 patients underwent an operation and the rest went through conservative treatment. The Glasgow Outcome Scale (GOS) was used to evaluate the curative effect after 3-6 months follow-up. Their findings revealed that the prognosis of patients was positively correlated to GCS score at admission time. The higher GCS score will result in a higher GOS.

Kehoe et al. (9) in a study with the aim of exploring the relationship between age and presenting GCS in patients with isolated TBI, performed a retrospective study using the Trauma Audit and Research Network database. Between 1 January 2009 and 31 May 2014 all of the patients with isolated TBI were included in their study. Abbreviated injury scale (AIS) score, demographic, mechanistic, resource use, physiological, and outcomes were recorded. Patients were categorized into patients older and younger than 65 years at admission time. Based on findings, older adult patients who had sustained isolated severe TBI presented with higher GCS scores than younger patients. They concluded and proposed that the triage tools that use the GCS should be re-calibrated for use in older adult patients with TBI. For the first time, Khan et al. (5) introduced and identified the GAP score as a reliable predictive tool in older adult patients with TBI.

Several studies pointed out that GCS needs some modification to become a reliable predictive tool in older adult patients (8-10,

12). Braine and Cook (2) announced that a strong educational strategy is needed to maximize GCS consistency in its use in practice. Based on their investigation there is a piece of evidence illustrate discrepancy and misunderstanding in using the GCS, this can potentially compromise the quality of care.

In this study, the discrimination power of GCS and GAP scores was good and based on the Hosmer-Lemeshow test, these two models had acceptable and poor calibration power, respectively. In agreement with our findings, most studies have pointed out at good or excellent discrimination power for GCS and GAP (24). In Mena et al. (25) study the discrimination of GCS was excellent. The AUC ROC curve was 0.922 (95% CI, 0.917-0.926). They compared GCS with modified GCS model and evaluated the discrimination power of two predictive models using the AUC and the calibration power using the Hosmer-Lemeshow goodness of fit test. The typical model (GCS) demonstrated better calibration than the modified model (similar to our findings).

Sepahvand et al. (26) investigated the prognostic power of FOUR score and GCS in a prospective study of 198 patients with traumatic brain injuries. 65.2% of all patients survived and 34.8% died. GCS had a sensitivity of 0.85 (higher than our findings). Similar to our results the mean GCS score for nonsurvivors and survivors were 4.59±2.36 and 10.71±2.24, respectively.

In this study, the goodness of fit test showed that the calibration power was just acceptable for GCS, and it was poor for GAP (p=0.07vs. p=0.02, respectively). There are several studies, noted that the calibration for GCS or other scoring systems is varying in different studies (24, 25). These discrepancies and different sensitivity and specificity values in some studies (9, 16, 27) can be illuminated by the fact, when predictive models are used in a population different from the population for which it was first validated, they will not have the precision (13). Recalibrating these models frequently can be helpful to overcome these problems with considering the changes in population, quality of care and critical care management.

The nonsurvivors were older than survivors, this difference was statistically significant (p<0.001). The results of Vosylious et al. (7) was in line with ours; they compared the clinical characteristics of two groups of patients (older adult patients (age≥65 years) and younger patients) admitted to the ICU. Their findings showed that older adult patients aged ≥75 years had higher hospital mortality rates than the patients aged <65 years (39% versus 19%, P <0.001).

The overall mortality rate in our study was 31%, which was 26.5% in Mokhopadhyay et al. (6) and 17% in Reyes et al. (11) study. Different inclusion criteria, the severity of illness of patients who were involved in studies and quality of care can illustrate these differences.

Developing and improving the reliable models through training, education and standardization of assessment across different settings, and consensus on the procedure to address confounders and customizing an appropriate model will maintain predictive model's role in research and clinical practice in the future (28, 29). The current study has several limitations: Firstly, the effect of sample size is known to have a substantial influence on models calibration. Secondly, different settings (case mix), quality of care, new technologies, guidelines and policies can lead to bias. In this study, ethical considerations have been considered.

Conclusion

Both GCS and GAP scores showed good discrimination power, but good calibration was seen just for GCS. The better predictive performance of GCS makes it an advisable predictive model for older adult patients who are admitting in medical ICUs.

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