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Original Article

Comparison of the prognostic effects of APACHE II score and the TRISS for geriatric trauma patients in the intensive care unit

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Abstract: Aim: To assess the prognostic effects of Acute Physiology and Chronic Health Evaluation (APACHE) II score and the Trauma-Injury Severity Score (TRISS) for Geriatric Trauma Patients in intensive care unit (ICU). Methods: A cohort of trauma patients aged ≥ 65 years, admitted to ICU of Guangzhou General Hospital of Guangzhou Command from January 2011 to December 2015, were enrolled. Demographic data, mechanism of injury, site of injury and outcome were recorded. Glasgow Coma Score (GCS), Revised Trauma Score (RTS), Injury Severity Score (ISS), and TRISS and APACHE II scores were calculated. The abilities to predict group mortality of APACHE II score and TRISS were assessed by receiver operating characteristic curve analysis (ROC), two by two decision matrices, and calibration curve analysis. Results: There were 98 patients with 66 males. Mean age, GCS, RTS, ISS and APACHE II score were 78.05 ± 8.24, 10.08 ± 4.56, 5.80 ± 2.16, 21.08 ± 15.06, and 20.18 ± 9.33, respectively. The overall mortality was 35.7%. GCS ($p < 0.001$), RTS ($p < 0.001$) and APACHE II score ($p < 0.001$) were significantly different between survivors and non-survivors. The areas under the curve for APACHE II score and TRISS were 0.898 ± 0.032 and 0.824 ± 0.043 respectively. Using two by two decision matrices with a decision criterion of 0.5, the sensitivity, specificity, and correct classification rate were 57.1%, 95.2%, and 81.6% for APACHE II score, and 68.6%, 81.0%, and 76.5% for TRISS. With a decision criterion of 0.7, the sensitivity, specificity, and correct classification rates were 28.6%, 98.4%, and 73.5% for APACHE II score, and 57.1%, 87.3%, and 76.5% for TRISS. From the calibration curves, the slopes of the regression line for APACHE II score and TRISS were 1.05 ($R^2 = 0.74$, $p = 0.001$) and 0.77 ($R^2 = 0.71$, $p = 0.002$), respectively. Conclusions: Both APACHE II score and TRISS can predict group mortality in ICU geriatric trauma patients. However, APACHE II score may be more favorable in making clinical decisions.

Keywords: Geriatric trauma, APACHE II score, TRISS, mortality

Introduction

With increasing incidence of trauma, traumatic injuries have become the fifth leading cause of death in older adults [1]. Early identification demonstrated a promising outcome for geriatric trauma patients [2-4]. Recently, the Eastern Association for the Surgery of Trauma guidelines emphasized the needs for better understanding and powerfully predicting geriatric trauma patients to promote improved outcomes [5]. In recent years, many models have been developed to accurately predict outcomes for trauma patients. Illness severity scoring such as the APACHE, Simplified Acute Physiology Score II, and Sequential Organ Failure Assessment (SOFA) and trauma scoring systems such as the Revised Trauma Scores (RTS),Triage Score (TS), Injury Severity Scores (ISS), and Trauma-Injury Severity Score (TRISS) have been becoming the important tools for predicting patient outcomes. APACHE II score and TRISS were the most widely used and accepted scoring system for trauma outcome assessment with their own strengths and weaknesses [6, 7]. However, current information about these scoring systems used in geriatric trauma patients for outcome assessment is limited. The present study was to evaluate and compare the abilities of APACHE II score and TRISS in predicting group mortality among ICU geriatric trauma patients.

Materials and methods

Study setting and data collection

After institutional approval, data were collected retrospectively from the trauma patients aged ≥ 65 years who admitted to ICU of Guangzhou General Hospital of Guangzhou Military Command for more than 24 hours from January 2011 to December 2015 were included. Exclusion criteria were burns and discharge or death within 24 hours after admission. Variables included demographic data, mechanism and site of injury, GCS, RTS, ISS, TRISS, APACHE II, and outcome. Data on admission to the emergency department were collected for calculation of RTS and ISS. TRISS was calculated using initial laboratory data from the emergency department and operative data. APACHE II score was calculated for each patient during the first 24 hours after ICU admission.

Calculation method

Four variables including mechanism of injury, age, RTS, and ISS were used to calculate the Probability of survival (Ps) of trauma patients. RTS was consisted by three physiologic variables: GCS, systolic blood pressure (SBP), and RR [6, 7].

RTS = (0.9368GCS × GCS) + (0.7326SBP × SBP) + (0.2908RR × RR)

Where 0.9368GCS, 0.7326SBP, 0.2908RR are the coefficients associated with GCS, SBP, RR.

ISS was calculated using AIS (Abbrevieted Injury Scale) which was calculated for different body regions scoring 1-6 for individual injury. The body regions included head or neck, face, chest, abdomen or pelvic contents, extremities or pelvic girdle, and external. To calculate an ISS, the highest AIS severity code in each of the three most severely injured ISS body regions was needed.

ISS = (1st AIS score)^2 + (2nd AIS score)^2 + (3rd AIS score)^2

The ISS greater than 15 was defined as major trauma. The ISS was calculated using the Abbreviated Injury Scales 2005.

$Ps = 1/(1 + e^{-b})$

Where e = 2.718 (base of natural logarithm), and b = b0 + b1 (RTS) + b2 (ISS) + b3 (Age)

The b0, b1, b2, b3 are regression coefficients derived from the MTOS in 1995 which are different for penetrating and blunt injuries.

	b0	b1	b2	b3
Blunt injuries	-1.2470	0.9544	-0.0768	-1.9052
Penetrating injuries	-0.6029	1.1430	-0.1516	-2.6676

Age = 1 if patient's age is ≥ 55 years, otherwise age = 0.

POD = Probability of Death = 1-Ps

$POD\ (APACHE\ II) = e^x/(1 + e^x)$

X = -3.517 + (APACHE II score × 0.146) + DCW + ECW, e = 2.718

DCW is diagnostic weight; ECW is emergency surgery weight.

Statistical analysis

Statistical analysis was performed by SPSS 20.0. Measurement data are presented as number of cases and percentage and enumeration data are presented as mean ± standard deviation. Age, GCS, RTS, ISS and APACHE II score were analyzed for survivors compared with non-survivors by use of the Student's t-test. Gender, Sites and Mechanism of injury were analyzed for survivors compared with non-survivors by X^2 test. Probability value of < 0.05 was accepted as significant statistically. The POD (Probability of Death) of APACHE II score and TRISS were calculated as previously described [8]. The accuracy of group outcome predicting by APACHE II score and TRISS were compared by ROC, two by two decision matrices and calibration curves.

ROCs for APACHE II score and TRISS were used to predict and observe outcomes. A plot of true positive rate against false positive rate was made and the area under the curve was derived. The area under the curve is a measure of the overall discriminatory power of the prognostic variable with a value of 0.5 equaling ran-

Table 1. Comparison of survivors and non-survivors with respect to age, sex, GCS, RTS, ISS, and APACHE II score

	Survivors (63)	Non-survivors (35)	*p* Value
Age	78.17 ± 8.86	77.83 ± 7.12	0.843
Gender			0.194
Male	40 (63.5%)	26 (74.3%)	
Female	23 (36.5)	9 (25.7)	
GCS	11.95 ± 3.58	6.71 ± 4.23	< 0.001
RTS	6.92 ± 1.06	3.76 ± 2.15	< 0.001
ISS	20.84 ± 14.6	21.51 ± 16.06	0.833
APACHE II	15.60 ± 6.38	28.43 ± 8.06	< 0.001

Table 2. Sites and Mechanism of injury

	Survivors (63)	Non-survivors (35)	Total
Sites of injury			p > 0.05
Head and Neck	11 (17.5)	8 (22.9)	19 (19.4)
Abdominal	1 (1.6)	2 (5.7)	3 (3.1)
Limbs and Pelvis	33 (52.4)	17 (48.6)	50 (51.0)
Multiple Injuries	18 (28.6)	8 (22.9)	26 (26.5)
Mechanism of injury			p > 0.05
Falls	40 (63.5)	20 (57.1)	60 (61.2)
Road traffic collisions	17 (27.0)	12 (34.3)	29 (29.6)
Fall from height	6 (9.5)	2 (5.7)	8 (8.2)
Assault	0 (0)	1 (2.9)	1 (1.0)

dom prediction, and a value of 1.0 indicating perfect discrimination. Using the nonparametric Wilcoxon method of Hanley and McNeil [6], the areas under the curves of APACHE II score and TRISS were compared.

Two by two decision matrices were constructed to compare the accuracy of prediction of outcome, using the two systems with decision criteria of 0.5 and 0.7 as cut-offs. At a decision criterion of 0.5, patients with a calculated probability of death > 0.5 were predicted to die, while those patients with a probability of death of < 0.5 were predicted to survive. Sensitivities, specificities, percent correct classification, false positives, positive predictive values, false negatives and negative predictive values were calculated from the two by two matrices.

The observed death rates were plotted against predicted death rates stratified by 10% risk ranges in calibration curves for APACHE II score and TRISS. The observed death rates for the stratified risk groups were calculated by totaling the number of deaths divided by the number of patients in that stratified risk group. Linear regression analysis was applied and an R^2 value was obtained. The R^2 value represents the proportion of variation of the dependent variable (observed death rate) that is explained by the independent variable (predicted death rate). An R^2 of 1.0 indicates that all the plotted points lie on a straight line and that the dependent variable can be predicted from the independent variable with 100% certainty. If a predictive model fits the study data well, the observed and predicted death rates will be approximately equal across the full range of predicted risk. This fit is depicted graphically by a curve fit for the data points lying on a 45 degree line with a slope of 1. A slope of > 1 implies that the predictive model underestimated the actual death rates, while a slope of < 1 represents overestimation of actual death rates [6].

Results

Cohort characteristics

During the 5 years, 98 patients with 66 males (67.3%) and 32 females (32.7%), aged 78.05 ± 8.24 years old, met the inclusive criteria. The overall mortality was 35.7%. Mean GCS, RTS, ISS, and APACHE II score were 10.08 ± 4.56, 5.80 ± 2.16, 21.08 ± 15.06, and 20.18 ± 9.33 respectively. Age (78.17 ± 8.86 vs. 77.83 ± 7.12, p = 0.843), gender (males 67.3% vs. Females 32.7%, p = 0.194) and ISS (20.84 ± 14.6 vs. 21.51 ± 16.06, p = 0.833) were not different significantly between survivors and non-survivors. GCS (11.95 ± 3.58 vs. 6.71 ± 4.23, p < 0.001), RTS (6.92 ± 1.06 vs. 3.76 ± 2.15, P < 0.001), APACHE II score (15.60 ± 6.38 vs. 28.43 ± 8.06, P < 0.001) were different significantly between survivors and non-survivors (**Table 1**).

Major site of injuries included limb and pelvis (51.0%), multiple injuries (26.5%), head and neck (19.4%) and abdomen (3.1%). Major injury mechanisms were fall (61.2%), followed by road traffic collision (29.6%), fall from height (8.2%) and assault (1.0%) (**Table 2**).

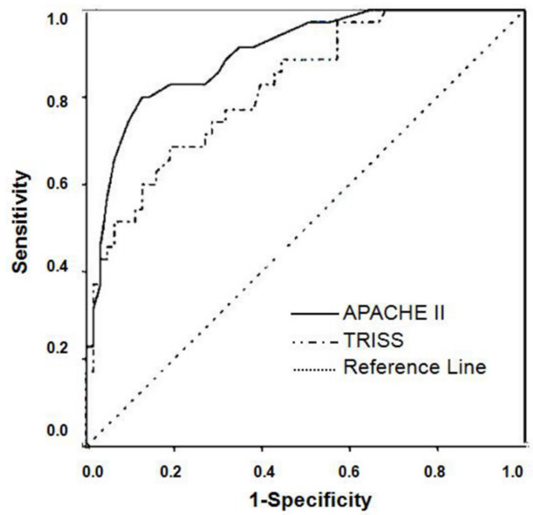

Figure 1. Receiver operating characteristic curves for APACHE II score and TRISS. Closed squares, the place at which APACHE II and TRISS points on the receiver operating characteristics curves coincide. The areas under the curve for APACHE II score and TRISS were 0.898 ± 0.032 (95% CI: 0.835-0.961, p < 0.001) and 0.824 ± 0.043 (95% CI: 0.741-0.908, P < 0.00q), respectively. The best cut-off for APACHE II score was 21, with the sensitivity of 82.9% and specificity of 81.0% and TRISS was 0.56, with the sensitivity of 68.7% and specificity of 81.0%.

APACHE II score and TRISS for prognosis of group mortality

The areas under the curve for APACHE II score and TRISS were 0.898 ± 0.032 (95% CI: 0.835-0.961, p < 0.001) and 0.824 ± 0.043 (95% CI: 0.741-0.908, P < 0.001), respectively. There were not different significantly between the areas under the curve of APACHE II score and TRISS (p = 0.080). The best cut-off for APACHE II score was 21, with the sensitivity of 82.9% and specificity of 81.0% and TRISS was 0.56, with the sensitivity of 68.7% and specificity of 81.0% (**Figure 1**).

APACHE II score is more favorable for clinical decisions for geriatric trauma patients

The two by two decision matrices and predictive abilities for each methodology were shown in **Table 3**. At a decision criterion of 0.5, the correct classification rate and the false-positive rate for APACHE II score were > 80% and 13.0%, respectively, while for TRISS, was < 80% and > 33.3%. At a decision criterion of 0.7, the false-positive rates for APACHE II score and TRISS changed to 9.1% and 30.8% for APACHE II score and TRISS respectively. However, the sensitivity and correct classification rates were lower compared with decision criterion of 0.5 for APACHE II score. The sensitivity was lower and correct classification rate was the same compared with decision criterion of 0.5 for TRISS. This indicated that APACHE II score may be more favorable for making clinical decisions for geriatric trauma patients than TRISS.

APACHE II score fits the observed death rates more accurately than TRISS

The calibration curves for APACHE II score and TRISS are shown in **Figure 2**. Both APACHE II score and TRISS predicted death rates were significantly correlated to observed death rates (p = 0.001 and 0.002, respectively). The R^2 (0.74) from APACHE II score was higher than the R^2 (0.71) from TRISS. The regression line of APACHE II score but not TRISS was lie on the 45 degree line with the slopes of regression lines 1.05 and 0.77, respectively. The APACHE II score predicted death rates fit actual observed death rates, while TRISS predicted death rates overestimated observed death rates at low-risk ranges (< 0.17) and underestimated observed death rates at high-risk ranges (≥ 0.17).

Discussion

The American College of Surgeons (ACS) reported in Geriatric Trauma Management Guidelines that traumatic injury is increasing in prevalence with higher mortality rate in the geriatric population [9]. Currently, traumatic injuries are the fifth leading cause of death in older adults (age > 65) [1]. Due to comorbidity, polypharmacy, and the physiologic effects of aging, worse outcomes have been reported in geriatric trauma patients [10]. ACS had also reported that traumatic injuries in geriatric population were often underestimated [11]. The overall mortality rate was 8.3% in trauma patients, while rate in 18 years to 64 years old was 6.5% [12-15]. However, the overall mortality rate in trauma patients older than 65 years was 14.8% based on a meta-analysis of 65,897 patients [16], and the observed mortality rate was ranged from 5.2%-47.2% [17, 18]. The present study population consisted of 98 ICU geriatric trauma patients with 67.3% of males and 35.7% of overall mortality which constituted about 6 times increase of mortality in geriatric trauma patients [17, 18]. We found that age, gender,

Table 3. Two by two decision matrices for APACHE II score and TRISS

Actual Outcome	Predicted outcome							
	Decision Criterion of 0.5				Decision Criterion of 0.7			
	APACHE II	Dead Alive	TRISS	Dead Alive	APACHE II	Dead Alive	TRISS	Dead Alive
Dead	20	15	24	11	10	25	20	15
Alive	3	60	12	51	1	62	8	55
Predictive abilities								
Sensitivity (%)	57.1		68.6		28.6		57.1	
Specificity (%)	95.2		81.0		98.4		87.3	
Correct classification (%)	81.6		76.5		73.5		76.5	
False positive (%)	13.0		33.3		9.1		30.8	
False negative (%)	20.0		17.7		28.7		18.9	
Positive predictive (%)	87.0		66.7		90.9		71.4	
Negative predictive (%)	80.0		82.3		71.3		78.6	

and ISS were not significantly different between survivors and non-survivors which was not in accordance with the previous epidemiologic data [19-21]. This may be explained by the small sample sizes in our study. However, GCS, RTS, and APACHE II score were different significantly between survivors and non-survivors, which was consistent with previous data [19-22].

It is well recognized that special attention should be paid on the diagnosis and treatment of geriatric trauma patients, as well as their individual needs. In order to reduce the preventable deaths, several trauma scoring systems have been developed and validated to evaluate and monitor traumatic injury outcomes, such as Trauma Score, RTS, ISS, TRISS, and A Severity Characterization of Trauma (ASCOT) [23], most of which are focused on mortality as the main outcome.

TRISS method, proposed by Champiom et al. in the 1980s, is evaluated during the acute phase of trauma resuscitation, combining RTS (a measure of the physiologic response to injury), ISS (describing the site and severity of injury), injury type (blunt or penetrating) and age. TRISS has a detailed account of the severity and location of anatomic injury, but it does not include an evaluation of chronic health status [8]. Nevertheless, it has been widely used in the assessment of trauma and in the group outcome prediction [6, 7]. APACHE II score was developed as a severity of illness scoring system for adult ICU patients in 1985, which assesses the most abnormal physiologic data in the first 24 hours of ICU care, consists of 12 physiologic variables, chronic health status and age. It is able to stratify a wide variety of patients according to prognosis because of the strong and consistent relationship between acute physiologic dysfunction and the risk of death due to acute illness [24]. However, it does not have a component for anatomical injury in trauma patients, and highly depends on the level of care given to the trauma patient during resuscitation and the timing of ICU admission. Despite this limitation, the APACHE II score has been found to compare favorably with the RTS and ISS in outcome prediction in critically injured trauma patients [7].

Using ROC, two by two decision matrices and calibration curve analysis, several studies had found that both APACHE II score and TRISS were good predictors of group mortality in ICU trauma patients [6, 7]. However, neither APACHE II score nor TRISS provided sufficient confidence for prediction of outcome of individual patients. Others had demonstrated similar findings in this subset of trauma patients [25-28]. In 1990, Rhee et al. prospectively assessed APACHE II score, Trauma Score, and ISS as the predictors of mortality in 691 helicopter transported trauma patients and showed all the three scoring systems significantly predicted mortality by simple and stepwise logistic regression [25]. In 1992, Vassar et al. reported that APACHE II score underestimated mortality while TRISS over estimated mortality in patients with high predicted risk ranges by calibration curves. Goodness-of-fit analyses showed that both APACHE II score and TRISS had poor agreement between observed and predicted outcome at various risk ranges. However, as a retrospective study, it included no area under the

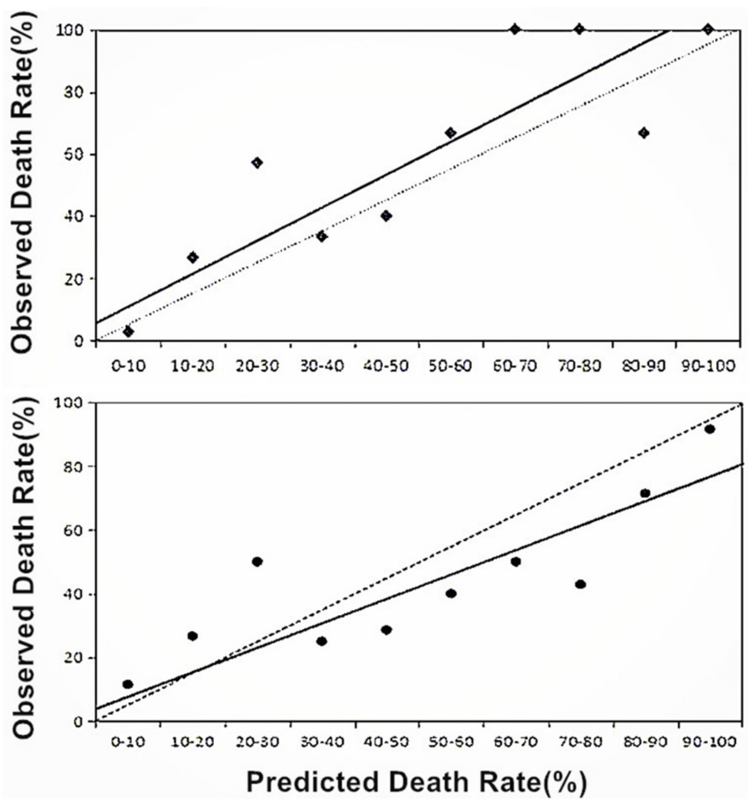

Figure 2. Top: Calibration curve for APACHE II. Bottom: Calibration curve for TRISS. The regression line of APACHE II score but not TRISS was lie on the 45 degree line with the slopes of regression lines 1.05 and 0.77, respectively. The APACHE II score predicted death rates fit actual observed death rates, while TRISS predicted death rates overestimated observed death rates at low-risk ranges (< 0.17) and underestimated observed death rates at high-risk ranges (≥ 0.17).

receiver operating characteristic curve (AUROC) given [26]. In 1993, Rutledge et al. used stepwise discriminate analysis to compare APACHE II score with TRISS as the predictors of outcome in 428 critically injured trauma patients and found that the APACHE II score was the better predictor of hospital and ICU mortality. Limitations of this study included its retrospective design and without actual partial R^2 values in stepwise discriminate analysis [27]. In 2009, Dossett et al. prospectively assessed APACHE II score and TRISS as predictors of mortality in 1019 critically injured adults, in which the APACHE II score was found as the best predictor of mortality (AUROC 0.77 versus AUROC 0.54 for ISS and 0.64 for TRISS) with an OR of death 1.18 (95% CI: 1.14-1.22). Limitations of this study are that patients who died or were discharged from the ICU within 48 hours were not a part of the original study cohort [28].

There have been few studies that showed that the APACHE II score and TRISS were good predictors of group mortality in ICU geriatric trauma patients. In the present study, we assessed the prognostic effects of APACHE II score and TRISS in ICU geriatric trauma patients. ROCs showed both APACHE II score and TRISS were good predictors of group mortality in ICU ger-ziatric trauma patients. The AUROC for APACHE II score and TRISS with best cut-offs 21 and 0.56 respectively, were not different significantly ($p > 0.05$), which shows they are equally accurate in this regard. In order to use predictive instruments to make patients' clinical decisions, we need to have false positives in death prediction of close to zero [6]. With decision criteria of 0.5 and 0.7, false-positive rates of APACHE II score were 13% and 9.1%, respectively, while those of TRISS were 33.3% and 30.8%, which indicated that APACHE II score may be more favorable to make clinical decisions for geriatric trauma patients. Also, the APACHE II score had a regression line lying on the 45 degree with slopes as 1.05,while TRISS regression line not (slopes 0.77). Furthermore, calibration curves showed that APACHE II score fit the observed death rates while TRISS overestimated observed death rates at low-risk ranges and underestimated observed death rates at high-risk ranges.

There are several advantages of the APACHE score over TRISS in their application to ICU geriatric trauma patients. Firstly, APACHE II score consists of 12 physiologic variables while TRISS has three only. It has been demonstrated that physiologic variables are the most powerful predictors of hospital outcome in ICU patients. Secondly, the premorbid chronic health status is included in APACHE II score but not TRISS. Taylor et al. found an association between pre-existing health status and the development of complications after injury in their analysis of 26,237 blunt geriatric trauma patients, all of which contributed to increased mortality [12]. Grossman et al. [21] and Camilloni et al. [29] concluded that the risk for death is highest in the geriatric trauma patients with more pre-existing conditions. The inclusion of chronic health status can improve the ability to predict outcome in ICU trauma patients. In 2015, Agarwal et al. retrospective assessed the ability of APACHE II score and TRISS to predict mortality of orthopaedic polytrauma patients. ROCs found that APACHE II score on admission day was relatively a better predictor than TRISS and a far better predictor than APACHE II score on admission in evaluating probability of survival of a patient [30]. Postadmission assessment seems to yield to a more accurate outcome prediction. Limitations of this study was that retrospective design, small sample sizes, case exclusions from final analyses and lack of multiple methodologies in assessing predictive ability.

The strength of this study is the use of three widely accepted statistical methodologies in assessing the predictive abilities of APACHE II score and TRISS. To our knowledge, this represents the largest analysis of the two scoring systems in geriatric trauma patients. Despite the strength, there are several important limitations. It is a retrospective design in a single-center with small sample sizes which may potentially hamper the data quality. In addition, we just assessed APACHE II score and TRISS only on admission.

In summary, both APACHE II score and TRISS could accurately predict group mortality in ICU geriatric trauma patients. Due to comorbidity, polypharmacy, and the physiologic effects of aging, APACHE II may be more helpful to make clinical decisions for geriatric trauma patients.

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Disclosure of conflict of interest

None.

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