Change in Age Distribution of the Injuries and Comparison of Different Scoring Tools in Predicting Mortality Among Geriatric Trauma Patients

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Research article

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Abstract

Purpose:

The aim of this study was to describe the age trend of trauma patients and to compare different scoring tools to predict in-hospital mortality in elderly trauma patients.

Methods:

National Trauma Database (NTDB) in the United States from 2005 to 2015 and the Trauma Register DGU® in German from 1994 to 2012 was searched to describe age change of trauma patients. Then we secondly analyzed the data published in http://datadryad.org/. According to the in-hospital survival status, patients were divided into survival group and non-survival group. Receiver Operating Characteristic Curve (ROC) analysis was used to evaluated the value of ISS (injury severity score); NISS (new injury severity score), APACHE □ (Acute Physiology and Chronic Health Evaluation □), SPAS □ (simplified acute physiology score □) and TRISS (Trauma and Injury Severity Score) in predicting in-hospital mortality among geriatric trauma patients.

Results:

The analysis of NTDB showed the percentage of geriatric trauma has increased from 0.18 to 0.30, 2005-2015. The analysis of DGU showed the mean age rose from 39.11 in 1993 to 51.10 in 2013, and the percentage of patients aged ≥60 rose from 16.5% to 37.5%. A total of 311 patients aged more than 65 years were secondly analyzed. One hundred and sixty-four (52.73%) patients died in the hospital. ISS, NISS, APACHE, and SAPS in the death group were significantly higher than those in the survival group, but TRISS in the death group was significantly lower than those in the survival group. The AUC of APACHE □ was 0.715, ISS was 0.807, NISS was 0.850, SPAS □ was 0.725, and TRISS was 0.828.

Conclusion:

The increasing number of trauma in the elderly is a challenge for current and future trauma management. Compared with APACHE and SAPS, ISS, NISS and TRISS are more suitable for predicting in-hospital mortality in elderly trauma patients.

Background

Trauma is the leading cause of death among young population aged less than 44 [1]. The improvement of care system results in decreasing of trauma associated death [2]. However, along with the aging population, we face new challenge in managing geriatric trauma patients [3]. Complicated underlying diseases, various medication use, and limited physical reserve made geriatric trauma patients more vulnerable to bad prognosis [4–6]. Studies have reported higher mortality rates in older trauma patients than in younger trauma patients [7–10]. Now more and more countries and regions gradually pay attention to the treatment of elderly trauma patients, and even some regions have established elderly trauma treatment centers [11–13]. However, the trend of age change of trauma patients and the gradual increase of the number of elderly trauma patients has not aroused global attention. Prognosis prediction of trauma patients is an important part of making diagnosis and treatment decisions [14–16]. A number of scoring tools have been used to predict mortality in trauma patients [15]. Some researchers have even proposed a prognostic scoring tool specific to older trauma patients, although its predictive accuracy does not appear to be significantly superior to traditional scoring tools [14, 16–18]. At the same time, there is a lack of research comparing traditional prognostic assessment tools in elderly patients with trauma. The aim of this study was to describe the age trend of trauma patients by analyzing the annual reports of the two trauma databases, and to compare the ability of ISS (Injury severity score), NISS (New injury severity score), APACHE Ⅱ (Acute Physiology and Chronic Health Evaluation Ⅱ), SAPS Ⅱ (Simplified acute physiology score Ⅱ) and TRISS (Trauma and Injury Severity Score) to predict in-hospital mortality in elderly trauma patients.

Methods

We searched the annual reports of the National Trauma Database (NTDB) in the United States from 2005 to 2015 and the Trauma Register DGU® in German from 1994 to 2012 to describe the change in age distribution of trauma patients. Then we secondly analyzed the data published in https://datadryad.org/stash/dataset/doi:10.5061/dryad.2v6wwpzhk[19]. The authors in the original article evaluated the effects of standards of practice (SOP) on geriatric trauma patients [19]. Finally, they included 311 geriatric trauma patients and found the implementation of SOP could decrease the mortality rate of geriatric trauma patients. Categorical variables were represented as frequency (%), and continuous variables were represented as median (inter-quartile range). According to the in-hospital survival status, patients were divided into survival group and non-survival group. Difference of baseline information between two groups was evaluated using Chi-square or Fisher exact test for categorical variables, and T test or non-parameter test for continuous variables. We used Receiver Operating Characteristic Curve (ROC) to evaluated the value of TRISS, APACHE Ⅱ, SAPSⅡ, ISS, and NISS in predicting in-hospital mortality among geriatric trauma patients and corresponding area under the ROC (AUC) was calculated. All statistical process was performed using IBM SPSS 20.0 (Zhejiang University) and $P < 0.05$ was regarded as statistical significance.

Results

The analysis of NTDB showed the percentage of geriatric trauma has increased from 0.18 to 0.30, whereas the percentage of trauma patients aged less than 65 has been declining during the period 2005–2015 (Fig. 1a). The mortality rate of geriatric trauma patients was significantly higher than that of younger counterparts. And the mortality of male geriatric trauma patients was higher than that of female geriatric trauma patients (Fig. 1b). Eighty nine thousand patients with ISS (injury severity score) ≥ 9 in the DGU was analyzed (Prof. Dr. Rolf Lefering (Institut für Forschung in der Operativen Medizin; Fakultät für Gesundheit der Universität Witten/Herdecke). The mean age rose from 39.11 in 1993 to 51.10 in 2013, and the percentage of patients aged ≥ 60 rose from 16.5–37.5% (Fig. 1c, 1d). In China, major trauma accounts for more than 60 million visits annually to Chinese hospitals, and is related to 700 000 to 800 000 deaths.[20] According to the National Bureau of Statistics of the People's Republic of China, the percentage of population aged ≥ 65 increased from 0.077 to 0.101 between 2005 and 2014 Fig. 1e.

A total of 311 patients aged more than 65 years were extracted from the study by Lorenz [19], of which 59.00% were male. One hundred and sixty-four (52.73%) patients died in the hospital. Table 1 shows the detailed characteristics of included patients. There was no significantly statistical difference between the survival group and death group in trauma mechanism, base excess, body mass index, leucocytes, thrombocytes, prothrombin, systolic blood pressure, mean artery pressure, and temperature. Patients in the death group were older, had lower Glasgow coma Scale (GCS) scores, lower hemoglobin levels, higher lactate levels, shorter intensive care unit (ICU) hospital stays, and shorter overall hospital stays, compared to patients in the survival group.

Table 1
Characteristics of included patients

	Survival	Death	P value
Number of patient	147	164	
Trauma mechanism			
Blunt	144(48.30%)	154(51.70%)	0.07
Penetrating	3(23.10%)	10(76.90%)	
GCS			
3–8	47(27.30%)	125(72.7-%)	< 0.01
9–12	22(61.10%)	14(38.90%)	
13–15	78(75.70%)	25(24.30%)	
Age	74.00 (68.25 to 80.00)	78.00(72.00 to 83.00)	< 0.01
Base excess [mEq/L]	-2.80 (-5.50 to -0.80)	-3.25(-7.80 to -0.55)	0.32
Body mass index	25.95 (22.89 to 28.40)	25.90(22.04 to 29.16)	0.74
Hemoglobin [g/L]	11.80 (9.90 to 13.10)	10.60(8.10 to 12.20)	< 0.01
Lactate [mmol/L]	1.90 (1.15 to 2.80)	2.10(1.40 to 3.40)	0.03
Los of hospital [days]	16.50 (9.00 to 25.00)	1.50(1.00 to 3.00)	< 0.01
Leucocytes [10^9/L]	10.49 (7.33 to 13.96)	11.12(6.96 to 14.24)	0.86
Thrombocytes [10^9/L]	190.50(152.00 to 239.50)	174.00(132.00 to 230.00)	0.07
Prothrombin [% normal]	80.00 (59.00 to 95.00)	74.00(52.00 to 89.25)	0.08
Systolic pressure mmHg]	142.50 (115.00 to 160.000)	125.00(110.00 to 158.75)	0.09
Mean artery pressure [mmHg]	100.00 (82.00 to 112.75)	92.00(76.50 to 113.50)	0.22
Temperature	35.40(34.50 to 36.20)	35.25(34.10 to 36.00)	0.31
Los of ICU [days]	5.00 (2.00 to 12.00)	1.00(0.50 to 2.00)	< 0.01
Los of MV [days]	1.00(0.00 to 6.25)	1.00(0.25 to 2.00)	0.04
GCS, Glasgow score; Los, length of stay; ICU, Intensive care unit; MV, mechanical ventilation.			

We compared the differences in ISS, NISS, TRISS, APACHE Ⅱ, and SAPS Ⅱ between the survival and the death groups. ISS, NISS, APACHE, and SAPS in the death group were significantly higher than those in the survival group, but TRISS in the death group was significantly lower than those in the survival group. It is important to note that TRISS calculates the survival probability (Table 2 **and** Fig. 2). AUC was calculated to assess the ability of different scoring instruments to predict in-hospital mortality. Table 3 **and** Fig. 3 shows the AUC of APACHE Ⅱ was 0.715, ISS was 0.807, NISS was 0.850, SPAS Ⅱ was 0.725, and TRISS was 0.828. Table 4 compares the AUCs with different scores. Compared with APACHE Ⅱ and SAPS Ⅱ, the ISS, NISS, and TRISS scores appear to be better predictors of in-hospital mortality in older trauma patients. The AUC of the NISS score was the largest.

Table 2
Comparison of different scoring tools between two groups

	Survival	**Death**	**P value**
SPAS Ⅱ	34.00 (27.00 to 55.00)	55.00(34.75 to 61.00)	< 0.01
APACHE Ⅱ	15.00 (10.00 to 22.00)	23.00(19.00 to 29.00)	< 0.01
ISS	24.00 (14.50 to 29.00)	34.00(25.00 to 75.00)	< 0.01
NISS	27.00 (22.00 to 38.00)	50.00(34.00 to 75.00)	< 0.01
TRISS	0.96(0.78 to 0.99)	0.51(0.11 to 0.82)	< 0.01

SPAS Ⅱ, simplified acute physiology score Ⅱ; APACHE Ⅱ, Acute Physiology and Chronic Health Evaluation Ⅱ; ISS, injury severity score; NISS, new injury severity score; TRISS, Trauma and Injury Severity Score.

Table 3
Diagnostic value of different scoring tool in predicting in-hospital mortality

	AUC	**95% CI of AUC**
APACHE Ⅱ	0.715	0.644 to 0.778
ISS	0.807	0.743 to 0.861
NISS	0.850	0.790 to 0.898
SPAS Ⅱ	0.725	0.655 to 0.788
TRISS	0.828	0.766 to 0.880

SPAS Ⅱ, simplified acute physiology score Ⅱ; APACHE Ⅱ, Acute Physiology and Chronic Health Evaluation Ⅱ; ISS, injury severity score; NISS, new injury severity score; TRISS, Trauma and Injury Severity Score; AUC, area under the receiver operating characteristic curve.

Table 4
The matrix of AUC comparison between different scoring tool using P value

	SPAS Ⅱ	APACHE Ⅱ	ISS	NISS	TRISS
SPAS Ⅱ		0.61	0.07	< 0.01	< 0.01
APACHE Ⅱ	0.61		0.03	< 0.01	< 0.01
ISS	0.07	0.03		0.02	0.34
NISS	< 0.01	< 0.01	0.02		0.37
TRISS	< 0.01	< 0.01	0.34	0.37	

SPAS Ⅱ, simplified acute physiology score Ⅱ; APACHE Ⅱ, Acute Physiology and Chronic Health Evaluation Ⅱ; ISS, injury severity score; NISS, new injury severity score; TRISS, Trauma and Injury Severity Score; AUC, area under the receiver operating characteristic curve.

Discussion

With the aging of the population, the number of elderly trauma is increasing, which brings great challenges to the treatment of trauma. In this study, several databases were used to describe the age changes of trauma patients, further confirming the increasing number of elderly trauma patients. At the same time, this study compared the predictive value of different scoring tools for in-hospital mortality of elderly trauma patients. We found that the ISS, NISS, and TRISS scores were better than the SAPS Ⅱ and APACHE II scores at predicting in-hospital mortality in older trauma patients. And the NISS may be the best scoring tool.

Currently, injury is the seventh leading cause of death in the elderly (https://webappa.cdc.gov/). In addition to the United States, Germany, a number of other countries have reported an increase in the number of elderly trauma patients [21, 22]. Dealing with these patients is challenging. Firstly, several studies reported that most geriatric trauma patients were under-triaged, which may be associated with a higher risk of death [23]. Some studies have reported that adding age to triage criteria may improve outcomes in older traumatic patients [24, 25]. Moreover, Guidelines recommend lowering criteria for initiating trauma teams in older trauma patients to improve the outcome of such patients [26]. Therefore, future studies should establish a more accurate pre-hospital triage criterion for older trauma, which should include at least the following indicators: age, comorbidities, and physiological reserve, etc. Secondly, in recent years, frailty has been used more in the elderly. Frailty is defined as a syndrome of low physiologic capacity, decreased resistance to stressors, and increased vulnerability [27]. Frailty is not equal to age and more effective than age [28] In non-trauma patients, frailty has been demonstrated to be associated with poor health outcomes [29]. However, this relationship in geriatric trauma patients has not be comprehensively studied. Current tools to predict the risk of poor prognosis are inadequate, as they fail to include the effects of physiological capacity among geriatric trauma patients. It is necessary to define frailty correctly and measure frailty using an effective tool. Although general or geriatric trauma specific frailty index have been proposed, and were reported to be independently associated with poor prognosis, and could be used for risk stratification of geriatric trauma patients [30, 31]. But it is complex and time-consuming. Further studies focus on developing trauma specific frailty index and evaluating its effects on decision-making process. Finally, the complex comorbidities and medications use make the management of these patients more challenging. There is approximately 31 million people aged more than 65 use anticoagulant agent, and this number would raise to 68 million by the year 2020 in the United States [32]. Several studies have shown that pre-injury use of anti-platelet or anticoagulant agents are associated with poor outcomes [33]. Therefore, it may be necessary to identify these patients and revisal appropriately. Due to paucity of high quality studies, the standard management of these patients remain unclear [34]. In conclusion, ageing population brings great challenge to the management of trauma patients. A dedicated geriatric trauma protocol is required for quality improvement [35].

It is essential to accurately predict the prognosis of elderly patients with trauma. This is an important part of the conversation between doctors and patients their surrogate decision maker, but also an important basis for decision-making. Several scoring systems have been proposed for predicting mortality in trauma patients [15]. In 1974, the ISS was proposed, primarily based on the AIS score[36]. Later, some researchers pointed out the shortcomings of ISS and proposed NISS. Although studies suggest that NISS is better at predicting mortality in trauma patients than the ISS score, NISS is not widely used clinically [37–39]. Currently, TRISS is a classic scoring tool for predicting mortality in trauma patients[40]. The coefficients come from Major Trauma Outcome Study (MTOS) database. TRISS uses age, ISS, and RTS (physiological parameters: GCS, systolic blood pressure, and respiration rate). In 2010, the Schluter et al. updated its coefficients based on the NTDB database. But compared to the original TRISS, the updated is not widely used[41]. A Severity Characterization of Trauma (ASCOT) is another potential tool for evaluating the prognosis of trauma patients. Unlike the TRISS, the ASCOT incorporates all AIS scores for each body part[42]. Therefore, the calculation is relatively complex, and there may be great differences among different evaluators. The APACHE □ score and the SAPS □ score are routinely used to assess the severity and prognosis of patients with general critical illness, not just trauma. Although some studies have also assessed the ability of these physiologically-sensitive scoring systems to predict outcome in patients with trauma, the results suggest no significant advantage[43–52]. None of the scoring tools mentioned above are specific to older trauma patients. Both the anatomical scoring system and the physiological parameter scoring system have been reported to predict the prognosis of elderly patients with trauma[14, 53, 54]. But no studies have compared these scoring systems in older patients with trauma. This study compared the ability of ISS, NISS, TRISS, APACHE, and SAPS scores to predict in-hospital mortality in elderly trauma patients by secondary analysis. Our results suggest that the predictive power of ISS, NISS, and TRISS scores may be superior to APACHE □ and SAPS □ scores. NISS seems to be the best. These results suggest that anatomical injury is more important for the prognosis of elderly patients with trauma. We have already mentioned the specificity of the treatment of trauma in the elderly, so assessing the prognosis of elderly trauma patients may be more complex.

Geriatric Trauma Outcome Score (GTOS) was proposed specifically for predicting the prognosis of elderly trauma patients [55]. Using the variables of ISS, age, and performance of packed red blood cell (PRBC) transfusion within 24 hours of admission, GTOS was developed through a single center study and validated in a following multi-center study [56]. And in order to predict the unfavorable discharge in geriatric trauma patients, GTOS Ⅱ was developed. Compared with GTOS, GTOS Ⅱ uses the same parameters but has different coefficients [16]. Some studies have compared GTOS with TRISS, and the results suggest that GTOS does not show a significant advantage in predicting accuracy[14, 15]. Unlike TRISS, the physiological parameters obtained for the first time are required. The construction of trauma database makes it possible to obtain a large number of trauma data. On this basis, the popularization of artificial intelligence and deep learning algorithms have promoted the accurate prediction of trauma patients' clinical outcomes. It has been pointed out that the advanced deep learning algorithm can better predict the adverse outcomes of critically patients than the traditional regression algorithm [57, 58]. Therefore, in the future, we hope to optimize the trauma database and build advanced deep learning algorithm by incorporating more variables, to achieve accurate prognosis of elderly trauma patients.

Conclusion

The increasing number of trauma in the elderly is a challenge for current and future trauma management. Compared with APACHE and SAPS, ISS, NISS and TRISS are more suitable for predicting in-hospital mortality in elderly trauma patients. Considering more predictive variables and using deep learning algorithm to construct artificial intelligence real-time prediction model is the future research direction.

Abbreviations

GCS Glasgow score;

Los Length of stay;

ICU Intensive care unit;

MV Mechanical ventilation;

SPAS Ⅱ Simplified acute physiology scoreⅡ;

APACHE Ⅱ Acute Physiology and Chronic Health Evaluation Ⅱ;

ISS Injury severity score;

NISS New injury severity score;

TRISS Trauma and Injury Severity Score;

AUC Area under the receiver operating characteristic curve;

RTS Revised trauma score;

NTDB National trauma databank;

ASCOT A Severity Characterization of Trauma;

MTOS Major Trauma Outcome Study;

GTOS Geriatric Trauma Outcome Score.

Declarations

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We acknowledged Lorenz et al provide their data for this study.

Authors’ contributions

LBJ and MZ contributed to the design of the study, the acquisition of data, the analysis, and interpretation. LBJ and ZJZ conducted the statistical analysis of the data. LBJ and ZJZ drafted the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of the Second Affiliated Hospital, School of Medicine, Zhejiang University Research Ethics Committee, and the need for informed consent was waived.

Consent for publication

Not applicable

Competing interests

We declare no competing interests.

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Figures

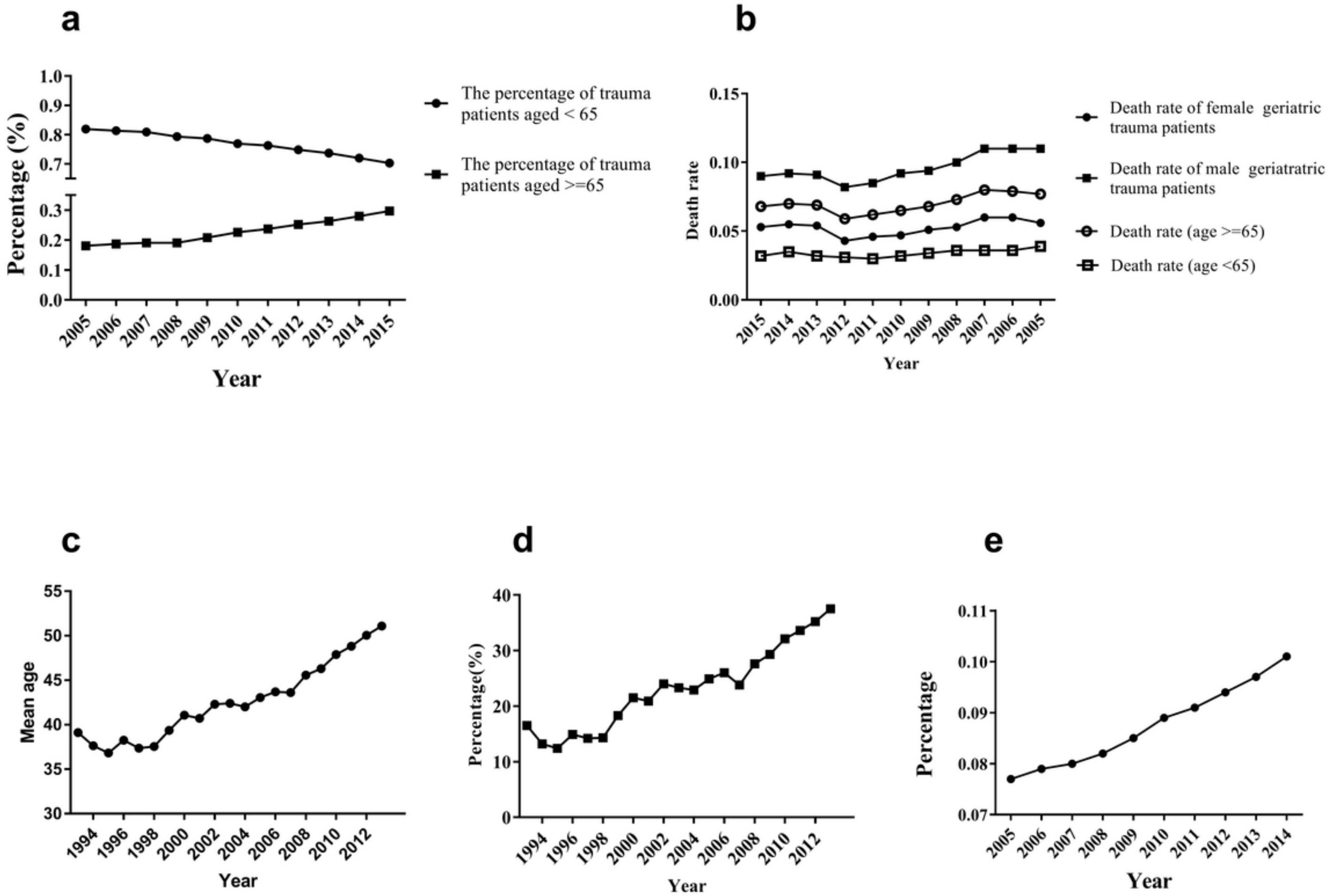

Figure 1

a)The change trend of trauma patients aged <65 vs ≥65 using the data of NTDB. b) The mortality change trend of trauma patients aged <65 vs ≥65 using the data of NTDB. c,d) The age change trend of trauma patients using data of DGU. e) The age change trend of Chinese people.

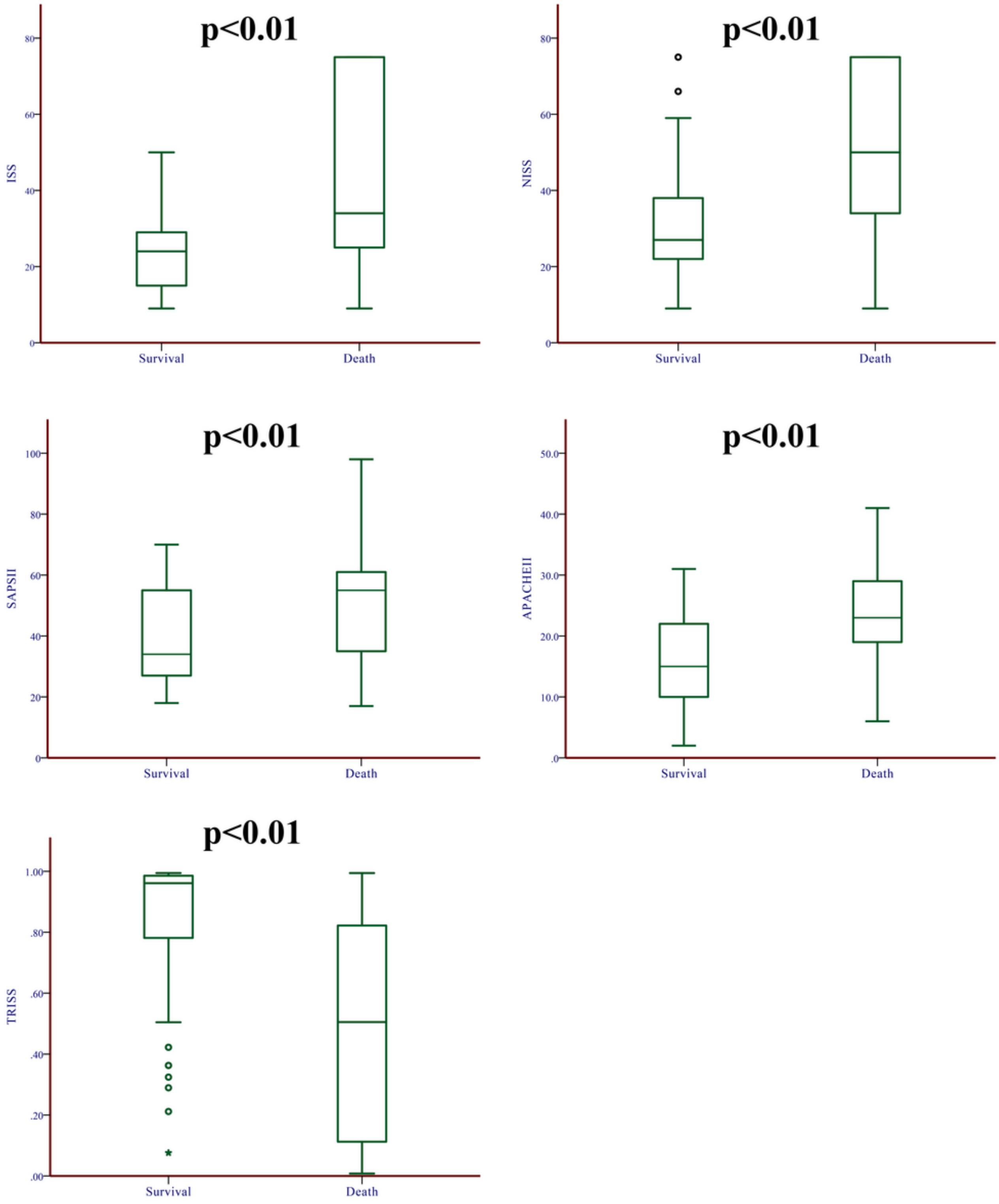

Figure 2

The comparison of ISS, NISS, APACHE Ⅱ, SPAS Ⅱ and TRISS between the survival group and death group. ISS, injury severity score; NISS, new injury severity score; SPAS Ⅱ, simplified acute physiology score Ⅱ; APACHE Ⅱ, Acute Physiology and Chronic Health Evaluation Ⅱ; TRISS, Trauma and Injury Severity Score.

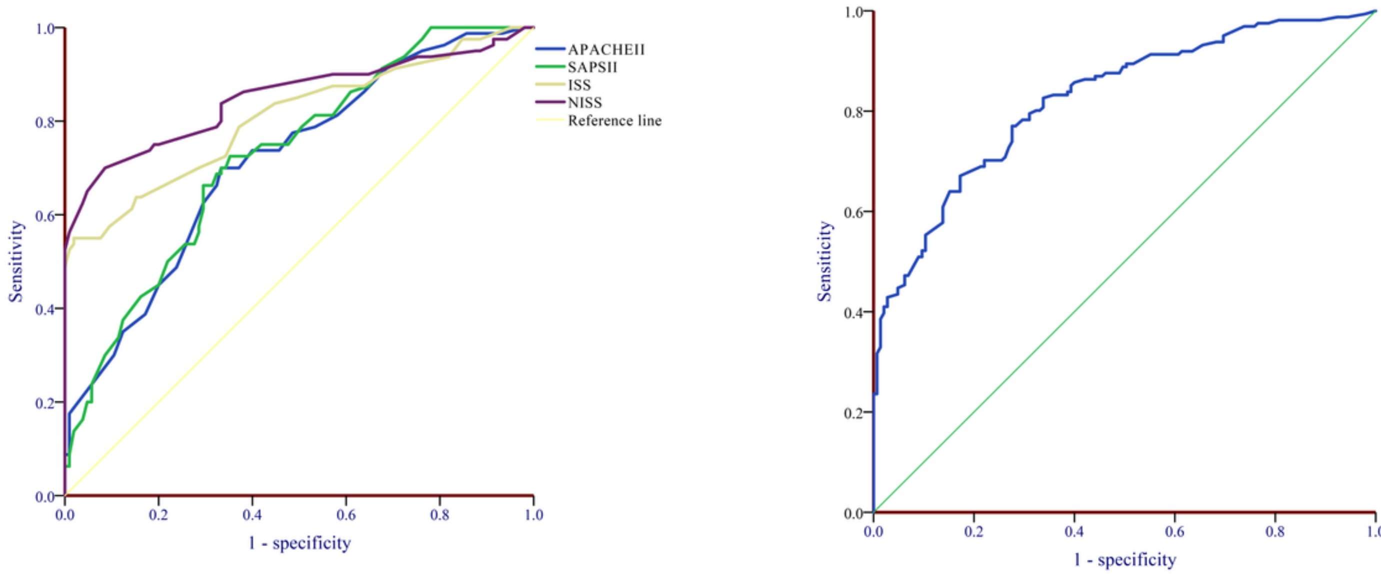

Figure 3

The AUC of ISS, NISS, APACHE Ⅱ, SPAS Ⅱ and TRISS in predicting in-hospital mortality among geriatric trauma patients. ISS, injury severity score; NISS, new injury severity score; SPAS Ⅱ, simplified acute physiology score Ⅱ; APACHE Ⅱ, Acute Physiology and Chronic Health Evaluation Ⅱ; TRISS, Trauma and Injury Severity Score.