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Predicting Mortality of Korean Geriatric Trauma Patients: A Comparison between Geriatric Trauma Outcome Score and Trauma and Injury Severity Score

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Purpose: The Geriatric Trauma Outcome Score (GTOS) is a new prognostic tool used to predict mortality of geriatric trauma patients. We aimed to apply this model to Korean geriatric trauma patients and compare it with the Trauma and Injury Severity Score (TRISS) method.

Materials and Methods: Patients aged ≥65 years who were admitted to a level 1 trauma center from 2014 to 2018 were included in this study. Data on age, Injury Severity Score (ISS), packed red blood cell transfusion within 24 h, TRISS, admission disposition, mortality, and discharge disposition were collected. We analyzed the validity of GTOS and TRISS by comparing the area under the survival curve. Subgroup analysis for age, admission disposition, and ISS was performed.

Results: Among 2586 participants, the median age was 75 years (interquartile range: 70–81). The median ISS was 9 (interquartile range: 4–12), with a transfusion rate (within 24 h) of 15.9% and mortality rate of 6.1%. The areas under the curve (AUCs) were 0.832 [95% confidence interval (CI), 0.817–0.846] and 0.800 (95% CI, 0.784–0.815) for GTOS and TRISS, respectively. On subgroup analysis, patients with ISS ≥9 showed a higher AUC of GTOS compared to the AUC of TRISS (p<0.05). Other subgroup analyses showed equally good power of discrimination for mortality.

Conclusion: GTOS can be used to predict mortality of severely injured Korean geriatric patients, and also be helpful in deciding whether invasive or aggressive treatments should be administered to them.

Key Words: Geriatric Trauma Outcome Score, trauma, Trauma and Injury Severity Score, prognosis score

INTRODUCTION

Although trauma has traditionally been considered more common in young and healthy populations, the number of elderly trauma patients is increasing rapidly. According to data from the National Trauma Data Bank, 39% of registered patients and 54% of deaths from trauma were of those aged above 55 years in 2014.[1] In the Republic of Korea, trauma is the fourth most common cause of death among individuals in their 60s.[2] Moreover, during prehospital and in-hospital resuscitation, a growing number of major geriatric trauma patients survive before and after arriving at hospitals. Therefore, geriatric trauma is receiving attention from both the traumatology and public health fields.

However, geriatric trauma patients have different mechanisms of injury, physiologic responses, and short-term and long-term prognoses compared to younger patients; thus, they are more often likely to die or be discharged without hope for functional recovery.[3,4] Geriatric trauma patients also have high mortality, even with fairly minor injuries or injuries that do not meet the criteria for trauma team activation,[5] and often consume tremendous resources and have prolonged intensive care unit stays only to reach delayed death or unsatisfactory statuses with

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regard to quality of life.[6]

A quantitative tool is needed to predict the prognosis of geriatric trauma patients that would aid the treatment decisions of clinicians and caregivers. Palliative care, rather than invasive treatments, might be considered for severely injured elderly who have less hope of survival. Several tools have been developed to predict the prognosis of geriatric trauma patients, including the Geriatric Trauma Outcome Score (GTOS),[7] A Severity Characterization of Trauma,[8] and Trauma-Specific Frailty Index.[9]

Trauma and Injury Severity Score (TRISS) has been the most widely used scoring system to predict survival of trauma patients for all age groups, and the Korea Trauma Data Base (KTDB) also collects TRISS of all Korean trauma patients. Nevertheless, TRISS has a limitation for geriatric patients as it includes age as a constant variable, which might be insufficient to reflect the characteristics of geriatric patients, whereas other scoring systems developed for geriatric patients, such as GTOS, have age as a variable in their equations. Additionally, TRISS requires the initial Glasgow coma scale score and vital signs, which are often missing especially for transferred patients. Among them, GTOS was developed by palliative medicine experts and first introduced in 2015, and favorable results of multicenter external validation were reported in the same year in the American Association for the Surgery of Trauma Plenary Paper.[10] The scoring system aims to help trauma surgeons make clinical decisions on the first day of injury, and it can be quickly calculated by anyone using the Injury Severity Score (ISS). Another advantage of GTOS is that it is quantitative and can be easily communicated to non-surgeons, such as palliative medicine doctors, nurses, or caregivers of geriatric patients. Since 2015, many reports have shown favorable results with GTOS as a prognostic scoring system in many countries,[10,11] and only one study has been done on Korean geriatric patients.[12] Therefore, we aimed to examine the prognostic value of GTOS by comparing it with TRISS in Korean geriatric trauma patients.

MATERIALS AND METHODS

Study settings and measures

We used KTDB data of all trauma patients aged ≥65 years and admitted to a single level 1 trauma center located in Ajou University Hospital between January 1, 2014 and December 31, 2018. The data included age, sex, ISS, injury mechanism, packed red blood cell (PRBC) transfusion within 24 h of injury, admission disposition (direct admission or transfer from other hospitals), Revised Trauma Score (RTS), TRISS, discharge disposition, and in-hospital mortality. In-hospital mortality was defined as all-cause mortality during the entire period of admission. Exclusion criteria included unknown mechanism, burn, death on arrival, unknown discharge disposition, hopeless discharge, unknown ISS, and unknown RTS (Fig. 1). Patients discharged hopelessly were excluded from a previous study, which showed that excluding hopelessly discharged patients enhances the predictability of mortality.[11] Hopelessly discharged patients were patients for whom care was withdrawn, limitations of care were instated, or those who were discharged to hospice care.

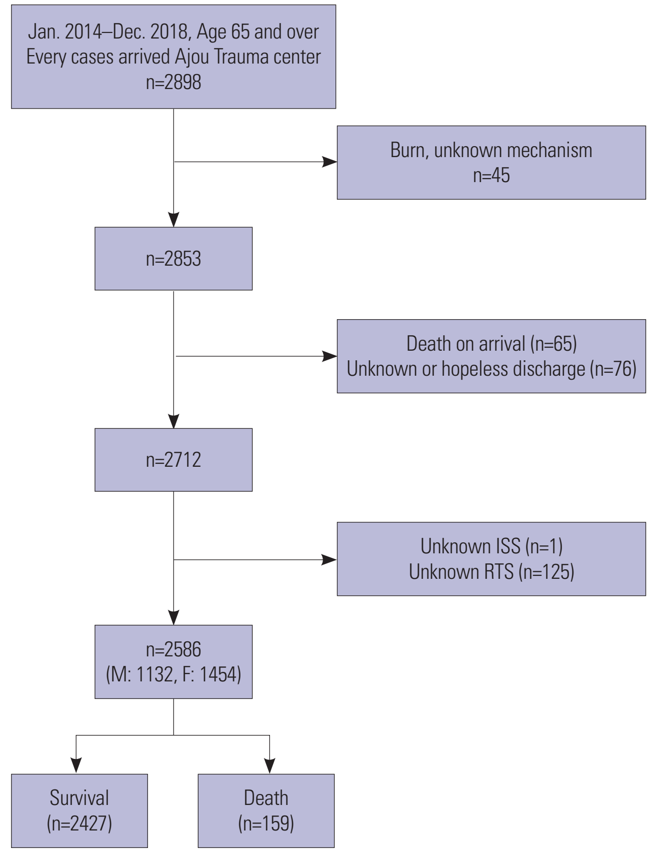

Fig. 1. Flowchart of selecting the study population. ISS, Injury Severity Score; RTS, Revised Trauma Score.

Statistical analyses

First, survival and death groups were compared using the chi-squared test. TRISS and GTOS equations were used for all included patients. The TRISS method equation is presented as follows:

$$b_{Blunt}=-0.4499+0.8085\times RTS-0.0835\times ISS-1.7430\times AgeIndex$$
$$b_{Penetrating}=-2.5355+0.9934\times RTS-0.0651\times ISS-1.1360\times AgeIndex$$

TRISS took into account the patient's age in an AgeIndex: "0" for patients aged under 55 years and "1" for patients aged 55 years and above. The GTOS equation was applied to patients as follows:

$$GTOS=age+(2.5\times ISS)+22 \text{ (if PRBC is transfused in the first 24 h after injury).}$$

We plotted the receiver operating characteristic (ROC) curves of the results and deduced the areas under the curve (AUCs), 95% confidence interval (CI), and difference between the areas. We also compared two ROC curves with the null hypothesis that GTOS is not inferior to the TRISS. Comparison of the AUCs followed the method introduced by DeLong, et al.[13] Similar processes were performed for various subgroups, which were 1) patients aged ≥70 years, 2) patients aged ≥75 years, 3) patients with ISS ≥9, 4) patients with ISS ≥15, 5) patients transferred from another hospital, and 6) patients who arrived directly from the scene. The respective ISS cutoff values for major and severe trauma were 9, which was introduced by Hannan, et al.,[14] and 15, as suggested by Copes, et al.,[15] All statistical analyses were performed using MedCalc for Windows version 12.5 (MedCalc Software, Ostend, Belgium).

Ethics statement

The study protocol was approved by the Ajou Institutional Review Board (no.: AJIRB-MED-MDB-19-519) and followed the latest Declaration of Helsinki (2013). Informed consent was waived.

RESULTS

Patient characteristics and demographics

A total of 2898 patients aged 65 years and above were admitted at the Ajou Trauma Center between 2014 and 2018. After excluding patients according to the exclusion criteria, 2586 patients were finally included. Table 1 shows the basic demographics and characteristics of the patients. There were 1132 male patients (44%) and 1454 female patients (56%). The median age was 76 years (70–81 years), and the blunt mechanism cases were 96.9%. Within 24 h of admission, 412 patients (15.9%) underwent PRBC transfusion. The mortality rate was 6.1% (n=159).

Primary outcome

The study population was divided into two groups: the survival group comprising 2427 individuals (93.9%) and the death group comprising 159 individuals (6.1%). Table 2 shows the comparison between the two groups. The death group comprised more male (p<0.05) and old patients (p<0.05), 3 years older than the median age. The survival group had more transferred patients (p<0.05). ISS was significantly higher in the death group (22 [9–29]) than in the survival group (9 [4–12]) (p<0.05). The transfusion rates were 53% and 14% in the death and survival groups, respectively (p<0.05). The transfusion amount among patients who received transfusions was compared between the two groups, and the mean value was 3 times higher and median value was 4 times higher in the death group than in the survival group (p<0.001). Median and quartile values of the Abbreviation Injury Scale (AIS) scores of injured sites and the proportion of each site with AIS ≥3 (which means severe injury in traumatology) were compared. Every injury site, except the face, had a higher median AIS and higher proportion of severe injury (AIS ≥3). The proportions of severe injury of the head and abdomen were especially higher than those of other organs in the death group.

To compare the predictability of mortality between the two methods, ROC curves of probability of survival were deduced from TRISS and GTOS (Fig. 2). The AUCs of GTOS and TRISS

Table 1. Basic Demographics of the Patients (n=2586)

Demographics	Value
Sex	
Male	1132 (44.0)
Female	1454 (56.0)
Age (years)	76 [70–81]
Mechanism	
Blunt	2506 (96.9)
Penetrating	80 (3.1)
PRBC transfusion within 24 h	412 (15.9)
Mortality	159 (6.1)

PRBC, packed red blood cell.
Data are presented as n (%) or median [Interquartile range].

Table 2. Survival Group vs. Death Group

Variables	Survival group (n=2427)	Death group (n=159)	p value
Sex			<0.001
Male	1035 (43)	97 (61)	
Female	1392 (57)	62 (39)	
Age (years)	75 [70–81]	78 [72–82]	0.001
Direct admission	1305 (54)	69 (43)	0.014
Transfer	1121 (46)	90 (57)	
ISS	9 [4–12]	22 [9–29]	<0.001
Transfusion (-)	2099 (86)	75 (47)	<0.001
Transfusion (+)	328 (14)	85 (53)	
Transfusion amount	4.06±4.07 2.00 [2.00–5.00]	12.47±13.97 8.00 [3.75–15.25]	<0.001
Head AIS	3.00 [3.00–4.00]	5.00 [3.00–5.00]	<0.001
AIS ≥3	443/585 (75.7)	77/83 (92.8)	<0.001
Facial AIS	2.00 [1.00–2.00]	2.00 [1.25–2.00]	0.242
AIS ≥3	3/204 (1.5)	1/20 (5.0)	0.318*
Thorax AIS	3.00 [2.00–3.00]	3.00 [2.00–3.00]	0.001
AIS ≥3	303/529 (57.3)	51/68 (74.6)	0.008
Abdomen AIS	2.00 [2.00–3.00]	3.00 [2.00–4.00]	<0.001
AIS ≥3	97/377 (25.7)	26/41 (63.4)	<0.001
Extremity AIS	3.00 [2.00–3.00]	3.00 [2.00–3.00]	<0.008
AIS ≥3	876/1518 (57.7)	56/85 (65.9)	<0.135

ISS, Injury Severity Score; AIS, Abbreviated Injury Scale; PRBC, packed red blood cell.
Data are presented as n (%) or median [Interquartile range]. All continuous variables were analyzed using the Mann-Whitney tests. Data of the AIS groups were compared using chi-squared test and Fisher test (*). The transfusion amount was compared among patients who received a PRBC transfusion.

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were 0.832 (95% CI, 0.817–0.846) and 0.800 (95% CI, 0.784–0.815), respectively. The AUC of GTOS was higher than that of TRISS (p=0.02).

Subgroup analysis

Subgroup analyses were performed for different subgroups of age, ISS, and transfer (Fig. 3). For subgroup with ISS ≥9, the total number of patients was 1764. The numbers of patients in the survival group and death group were 1616 and 148, respectively, with a mortality rate of 8.39%. The AUCs of GTOS and TRISS were 0.806 (95% CI, 0.787–0.824) and 0.773 (95% CI, 0.752–0.792), respectively (p<0.05) (Fig. 3A). For subgroup with ISS ≥ 15, the total number was 562. The numbers of patients in the survival group and death group were 457 and 105, respectively, with a mortality rate of 18.68%. The AUCs of GTOS and TRISS were 0.783 (95% CI, 0.747–0.817) and 0.784 (95% CI, 0.748–0.817), respectively (p=0.99) (Fig. 3B).

The number of patients aged over 70 years was 1994; the in-hospital mortality rate was 6.77% with 135 deaths. The ROC curves showed that the AUCs of GTOS and TRISS were 0.810 (95% CI, 0.792–0.827) and 0.785 (95% CI, 0.660–0.803), respectively (p=0.13) (Fig. 3C). The same process of analysis was repeated for other subgroups. In the subgroup of patients aged ≥75 years, the total number was 1422. The numbers of patients in the survival group and death group were 1319 and 103, respectively, with a mortality rate of 7.24%. The AUCs of GTOS and TRISS were 0.794 (95% CI, 0.772–0.815) and 0.760 (95% CI, 0.737–0.7820), respectively (p=0.10) (Fig. 3D).

The fifth subgroup included patients who were transferred from other hospitals; the total number was 1374. The numbers of patients in the survival group and death group were 1305 and 69, respectively, with a mortality of 5.02%. The AUCs of GTOS and TRISS were 0.777 (95% CI, 0.754–0.798) and 0.732 (95% CI, 0.708–0.755), respectively (p=0.07) (Fig. 3E). The numbers of patients in the subgroup of directly arrived patients, survival group, and death group were 1211, 1121, and 90, respectively, with a mortality rate of 7.43%. The AUCs of GTOS and TRISS were 0.871 (95% CI, 0.851–0.890) and 0.850 (95% CI, 0.829–0.870), respectively (p=0.18) (Fig. 3F). Both GTOS and TRISS showed higher sensitivity and specificity in predictability for directly arrived patients from the scene than for transferred patients.

Each subgroup was confirmed with sensitivity and specificity on whether the AUC curves for GTOS and TRISS were statistically significant, and all AUC curves showed p<0.001. The total population and the subgroup of ISS ≥9 showed a statistically higher AUC with GTOS than with TRISS. The other subgroup analysis showed non-inferior AUCs with GTOS compared to those with TRISS. We drew additional ISS box plot with entire patients, survived patients and deceased patients to visualize distribution of ISS. Survived patients showed narrow distribution of ISS whereas death group showed much wider distribution of ISS, needless to say the former had lower value than the latter (Fig. 4).

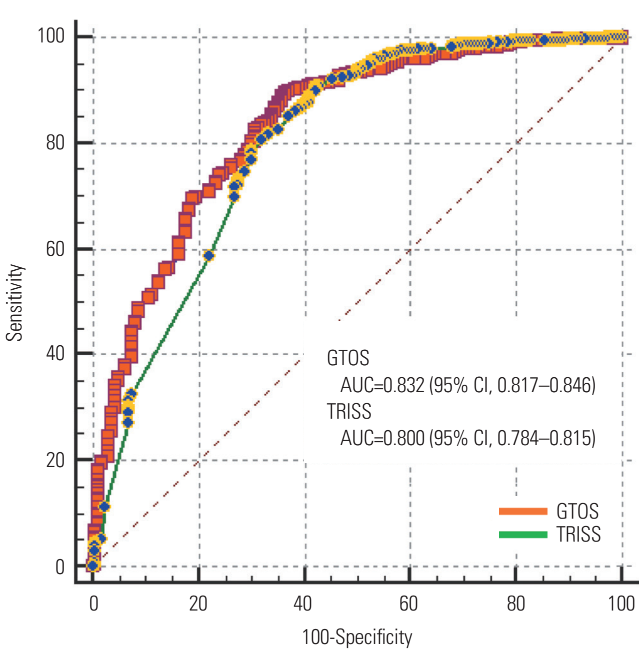

Fig. 2. ROC curves comparing GTOS and TRISS (total population). CI, confidence interval; GTOS, Geriatric Trauma Outcome Score; AUC, area under the curve; ROC, receiver operating characteristic; TRISS, Trauma and Injury Severity Score.

DISCUSSION

Since the first introduction of GTOS, many studies of external validation showed favorable predictability of the scoring system.[10,11] However, the comparison of GTOS with previously used survival predicting method showed incompatible results. Berea-Mendoza, et al.[16] reported a positive result in their retrospective comparison of TRISS and GTOS in patients of Spain. A recent study in Korea reported better predictability with TRISS compared to GTOS.[12] Both studies had some limitations; both were retrospective studies, though Barea-Mendoza, et al.[16] used multicenter data and Ryu, et al.[12] used single center data and relatively small number of subjects. Therefore, additional studies with larger population and different study settings might be able to offer new perspective of GTOS. The present study hypothesized that if the AUC of GTOS was not inferior to TRISS, GTOS could be useful for predicting the mortality of geriatric trauma patients, considering its simplicity to calculate. GTOS is also advantageous in that it does not need initial vital signs, which are often missing when a patient is transferred from a local hospital. We also analyzed subgroups of patients who were 1) more severely injured, 2) elderly, and 3) transferred or directly arrived to the scene.

Figs. 2 and 3 show the following results: 1) GTOS predicted in-hospital mortality in geriatric trauma patients (aged ≥65 years) not inferior to TRISS; 2) subgroup analysis showed the best predictability when the methodology was applied to patients with ISS ≥9; and 3) in the ROC curves of Figs. 2 and 3A, the left 20% of the x-axis, which corresponds to a sensitivity lower than 50%–60%, showed a larger difference between the curves of GTOS and TRISS. Although the AUCs of Fig. 3B-F showed no difference between the two methodologies, similar trends

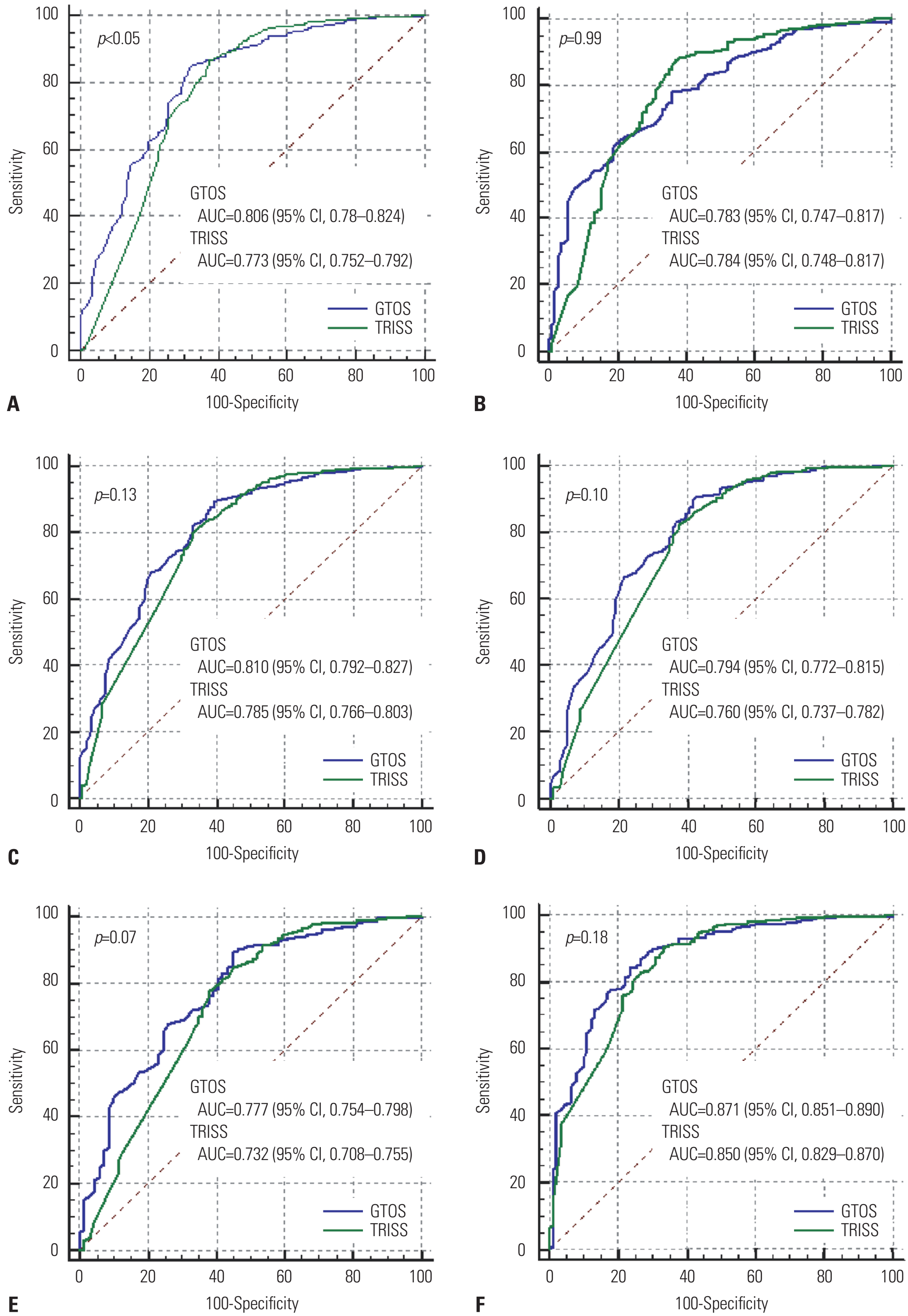

Fig. 3. ROC curves of subgroups comparing GTOS and TRISS. (A) ISS ≥9 (n=1764). (B) ISS ≥15 (n=562). (C) Age ≥70 years (n=1994). (D) Age ≥75 years (n=1422). (E) Patients who were transferred (n=1374). (F) Direct admission (n=1211). CI, confidence interval; AUC, area under the curve; GTOS, Geriatric Trauma Outcome Score; ISS, Injury Severity Score; ROC, receiver operating characteristic; TRISS, Trauma and Injury Severity Score.

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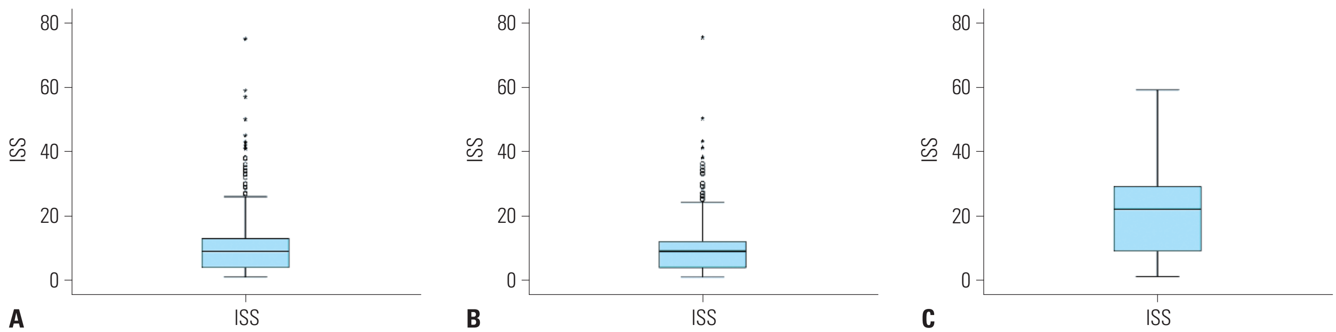

Fig. 4. Box-and-Whisker plot (box plot) of injury severity scoring systems. (A) Total study population (n=2586, ISS (median, interquartile range)=9 [4–13]). (B) Survival group (n=2427, ISS (median, interquartile range)=9 [4–12]). (C) Death group (n=159, ISS (median, interquartile range)=22 [9–29]). ISS, Injury Severity Score.

can be found in the lower halves of the graphs. Considering that the y-axis represents survival, lower than 50% on the y-axis means predicted mortality >50%. Ahl, et al.[11] and Berea-Mendoza, et al.[16] reported that both GTOS and TRISS tend to overestimate mortality when the severity of injury gets higher, which can be an important issue since the patients of interest are those who are highly suspected to die eventually.[9,16] Therefore, the last analytic result, which showed that GTOS has better predictability with higher mortality cases than TRISS, means it can provide clinicians with more reliable information for deciding between aggressive or palliative treatments. A similar trend was reported in 2018 in Spain by dividing the patients with decile predictive of mortality.[16] However, the result of the total population was different from that of the present study, and this is probably attributed to the exclusion of hopelessly discharged cases to enhance the predictability.[9]

We considered several reasons for the difference in results between our study and Ryu, et al.[12] First of all, the difference of the study population might have affected the results. While Ryu, et al.[12] studied geriatric trauma patients who visited a single emergency department with ISS≥16, we included all geriatric trauma patients who visited a single level 1 trauma center. Also, since the subgroup analysis with ISS≥15 in our study showed non-inferiority, the difference of ISS cannot explain the difference. However, there were other differences between the two studies related to the quality of the analyzed data. Both studies had limited data of transferred patients due to the following reasons: 1) selection bias that only survived patients could reach the final hospital and 2) no initial vital signs and transfusion information were available at the first hospitals. Subgroup analysis of the directly arrived patients showed better predictability compared to transferred patients, which also supported this point (Fig. 3E and F). The study by Ryu, et al.[12] included 59% of transferred patients, which was higher compared to our study (46%). There were also similar and different points in AIS distribution between the two studies. Our study population consisted of the largest proportion of traumatic brain injury, similar to Ryu, et al.[12]; however, our study had higher proportion of patients with thorax and abdomen AIS ≥3. Since other previous studies with large study population did not include analysis of AIS distributions, we cannot say which study more accurately reflects the reality of severely injured geriatric trauma patients. Moreover, there are trained trauma coordinators who are hired to assess AIS and ISS scores and other required KTDB data in our trauma center, which might result in more accurate data than emergency department data. Lastly, we excluded hopelessly discharged patients according to the study by Ahl, et al.,[11] which might have led to the improved predictability of GTOS in our study.

We hypothesized that as the patients get older, the predictability of GTOS will get stronger than TRISS as it includes age as a variable in the equation; however, our results showed no statistically significant difference between the two methods in the elderly subgroups (Fig. 3C and D). Nevertheless, the tendency of higher sensitivity in patients with expected mortality >50% was constantly observed. The results for transferred and directly admitted subgroups were similar.

This study had several limitations. One of the statistical limitations was that we only assessed predictability with AUC of ROC curves and did not fully perform external validation using specific tools for assessing probability, such as the misclassification (error) rate, Tjur R^2, and Brier score.[17-19] Another limitation was that although we found the predictability of GTOS to be greater for patients with higher expected mortality, no further statistical assessment was performed to prove this trend. Furthermore, this was a single-center study; therefore, it may not represent the entire population of Korean geriatric trauma patients. To overcome these limitations, further studies are required.

Moreover, the GTOS scoring system itself has some limitations; i.e., it does not include comorbidity or frailty of geriatric patients, unlike other novel scoring systems. This can be a limitation of the predictive tool,[20] as it only predicts survival and does not provide information on disability or mobility. In a previous study, when GTOS was applied for 1-year mortality, the sensitivity and specificity worsened;[9] therefore, GTOS is not suitable for predicting long-term mortality.

In conclusion, our study showed that GTOS can be useful for predicting mortality of Korean geriatric trauma patients, and this scoring system might be more reliable for those who are highly expected to have grave prognosis. GTOS can be used for patients who do not have initial vital sign or mental status information, and it can be calculated within 24 h to provide information to help clinicians and caregivers make decisions for patients who are expected to have fatal results. Physicians can focus on relieving pain and improving the remaining quality of lives of caregivers and patients when geriatric trauma patients are expected to have a hopeless result. On the contrary, emergency physicians or trauma surgeons can persuade caregivers to treat patients aggressively when a geriatric patient is expected to have a fairly good result if actively treated.

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AUTHOR CONTRIBUTIONS

Conceptualization: Jiye Park and Yunhwan Lee. Data curation: Jiye Park. Methodology: Yunhwan Lee. Supervision: Yunhwan Lee. Validation: Jiye Park. Visualization: Jiye Park. Writing—original draft: Jiye Park. Writing—review & editing: Jiye Park and Yunhwan Lee. Approval of final manuscript: all authors.

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REFERENCES

1. American College of Surgeons Committee on Trauma. National trauma data bank 2014 annual report [accessed on 2015 January 1]. Available at: https://www.facs.org/-/media/files/quality-programs/trauma/ntdb/ntdb-annual-report-2014.ashx.
2. Statistics Korea. Cause of death 2019 annual report [accessed on 2020 September 20]. Available at: http://kostat.go.kr/portal/korea/kor_nw/1/6/1/index.board?bmode=read&bSeq= &aSeq=385219&pageNo=2&rowNum=10&navCount=10&currPg=&searchInfo=&sTarget=title&sTxt=
3. McGwin G Jr, MacLennan PA, Fife JB, Davis GG, Rue LW 3rd. Preexisting conditions and mortality in older trauma patients. J Trauma 2004;56:1291-6.
4. Goodmanson NW, Rosengart MR, Barnato AE, Sperry JL, Peitzman AB, Marshall GT. Defining geriatric trauma: when does age make a difference? Surgery 2012;152:668-74.
5. Demetriades D, Sava J, Alo K, Newton E, Velmahos GC, Murray JA, et al. Old age as a criterion for trauma team activation. J Trauma 2001;51:754-6.
6. Calland JF, Ingraham AM, Martin N, Marshall GT, Schulman CI, Stapleton T, et al. Evaluation and management of geriatric trauma: an Eastern Association for the Surgery of Trauma practice management guideline. J Trauma Acute Care Surg 2012;73:S345-50.
7. Zhao FZ, Wolf SE, Nakonezny PA, Minhajuddin A, Rhodes RL, Paulk ME, et al. Estimating geriatric mortality after injury using age, injury severity, and performance of a transfusion: the geriatric trauma outcome score. J Palliat Med 2015;18:677-81.
8. Champion HR, Copes WS, Sacco WJ, Lawnick MM, Bain LW, Gann DS, et al. A new characterization of injury severity. J Trauma 1990; 30:539-45.
9. Joseph B, Pandit V, Zangbar B, Kulvatunyou N, Tang A, O'Keeffe T, et al. Validating trauma-specific frailty index for geriatric trauma patients: a prospective analysis. J Am Coll Surg 2014;219:10-7.e1.
10. Cook AC, Joseph B, Inaba K, Nakonezny PA, Bruns BR, Kerby JD, et al. Multicenter external validation of the geriatric trauma outcome score: a study by the Prognostic Assessment of Life and Limitations After Trauma in the Elderly (PALLIATE) consortium. J Trauma Acute Care Surg 2016;80:204-9.
11. Ahl R, Phelan HA, Dogan S, Cao Y, Cook AC, Mohseni S. Predicting in-hospital and 1-year mortality in geriatric trauma patients using geriatric trauma outcome score. J Am Coll Surg 2016;224:264-9.
12. Ryu HW, Ahn JY, Seo KS, Park JB, Kim JK, Lee MJ, et al. Comparison of the new and conventional injury severity scoring systems for predicting mortality in severe geriatric trauma. J Korean Soc Emerg Med 2020;31:543-52.
13. DeLong ER, DeLong DM, Clarke-Pearson DL. Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. Biometrics 1988;44:837-45.
14. Hannan EL, Waller CH, Farrell LS, Rosati C. Elderly trauma inpatients in New York state: 1994-1998. J Trauma 2004;56:1297-304.
15. Copes WS, Champion HR, Sacco WJ, Lawnick MM, Keast SL, Bain LW. The injury severity score revisited. J Trauma 1988;28:69-77.
16. Barea-Mendoza JA, Chico-Fernández M, Sánchez-Casado M, Molina-Díaz I, Quintana-Díaz M, Jiménez-Moragas JM, et al. Predicting survival in geriatric trauma patients: a comparison between the TRISS methodology and the geriatric trauma outcome score. Cir Esp (Engl Ed) 2018;96:357-62.
17. Schmid CH, Griffith JL. Multivariate classification rules: calibration and discrimination. Hoboken: John Wiley & Sons, Ltd.; 2014.
18. Tjur T. Coefficients of determination in logistic regression models—A new proposal: the coefficient of discrimination. Am Stat 2009;63:366-72.
19. Brier GW. Verification of forecasts expressed in terms of probability. Mon Weather Rev 1950;78:1-3.
20. Duvall DB, Zhu X, Elliott AC, Wolf SE, Rhodes RL, Paulk ME, et al. Injury severity and comorbidities alone do not predict futility of care after geriatric trauma. J Palliat Med 2015;18:246-50.

https://doi.org/10.3349/ymj.2022.63.1.88