Acute Medicine & Surgery 2017; **4**: 52–56 doi: 10.1002/ams2.228

Original Article

A survival prediction logistic regression models for blunt trauma victims in Japan

Takaaki Suzuki, Akio Kimura, Ryo Sasaki, and Tatsuki Uemura

Department of Emergency Medicine & Critical Care, Center Hospital of the National Center for Global Health and Medicine, Tokyo, Japan

Aim: This research aimed to propose a logistic regression model for Japanese blunt trauma victims.

Methods: We tested whether the logistic regression model previously created from data registered in the Japan Trauma Data Bank between 2005 and 2008 is still valid for the data from the same data bank between 2009 and 2013. Additionally, we analyzed whether the model would be highly accurate even when its coefficients were rounded off to two decimal places.

Results: The model was proved to be highly accurate (94.56%) in the recent data (2009–2013). We also showed that the model remains valid without respiratory rate data and the simplified model would maintain high accuracy.

Conclusion: We propose the equation of survival prediction of blunt trauma victims in Japan to be $Ps = 1/(1+e^{-b})$, where $b = -0.76 + 1.03 \times$ Revised Trauma Score $- 0.07 \times$ Injury Severity Score $- 0.04 \times$ age.

Key words: Japan Trauma Data Bank (JTDB), probability of survival (Ps), quality of trauma care, survival prediction, Trauma and Injury Severity Score (TRISS)

INTRODUCTION

DUE TO THE year-on-year increasing trend in the ratio of trauma deaths to the annual mortality rate worldwide, it is an urgent issue for countries worldwide to reduce the number of trauma deaths. In particular, it is highly fundamental for countries to evaluate the quality of trauma care, which calls for improvement with objective parameters and values.

If analysis of the probability of survival of trauma patients (Ps) can be analyzed using objective figures, such figures may be used to evaluate and compare the trauma care level on intrafacility and interfacility levels, contributing to the improvement of such care. Presently, the Trauma and Injury Severity Score (TRISS) proposed by Champion *et al.*[1] is widely used in Ps calculations. However, the TRISS method is based on trauma patient data in North America prior to 1990, and with the changes in the background of trauma patients and the content of trauma care, it is possible that calculating the Ps in Japan based on the TRISS method is unsuitable.

In addition, unlike patients in North America, the mortality ratio does not suddenly increase at approximately 55 years of age, which is the age classification used in the TRISS method. Moreover, due to the unavailability of respiratory rate (RR) data of patients stored at the Japan Trauma Data Bank (JTDB) in comparison to those in North America, past studies have shown that it is difficult to make a Ps calculation based on the TRISS method. Thus, the validity of the use of the TRISS method to Japanese patients requires evaluation and it is thought that careful judgment of this issue is vital.

Therefore, in 2012, the authors used the JTDB data between January 1, 2005 and December 31, 2008 (training data) (n = 15,524) and created as well as reported on a survival prediction logistic regression model for blunt trauma victims suited for Japan[2] (Table 1). However, no verification has yet been made regarding the validity of the required model using recent data. Thus, using the JTDB data between January 1, 2009 and December 31, 2013 (validation data), the validity of the model was verified.

Corresponding: *Takaaki Suzuki, MD, Department of Emergency Medicine & Critical Care, Center Hospital of the National Center for Global Health and Medicine, 1-21-1 Toyama Shinjuku-ku, Tokyo 162-8655, Japan. E-mail: takasuzuki@hosp.ncgm.go.jp.*
Received 9 Mar, 2016; accepted 6 Jun, 2016; online publication 19 Jul, 2016

Table 1. Coefficients, area under receiver–operating characteristic curves (AUROC), and accuracy of logistic regression models (2005–2008) for survival prediction in blunt trauma victims

Regression model (predictors)	Intercept	βISS	βRTS	βAGE	βcAGE	βcBP	βcGCS	βcRR	AUROC	Accuracy, %
TRISS (USA)	−0.4499	−0.0835	0.8085	×	−1.743	×	×	×	0.9625	92.74
MODEL-1 (ISS/RTS/cAGE)	−1.9502	−0.0679	1.0096	×	−1.492	×	×	×	0.9598	94.16
MODEL-2 (ISS/RTS/AGE)	−0.76266	−0.0710	1.0256	−0.0379	×	×	×	×	0.9624	94.38
MODEL-3 (ISS/AGE/cBP/cGCS/cRR)	−1.0723	−0.0711	×	−0.0383	×	0.7370	0.9318	0.4243	0.9624	94.37
MODEL-4 (ISS/AGE/cBP/cGCS)	−0.3375	−0.0707	×	−0.0369	×	0.9017	0.9814	×	0.9617	94.25

Regression models are represented by their predictor variables.
AGE, age year; β, regression coefficients; cAGE, coded value of age year; cBP, coded value of systolic blood pressure; cGCS, coded value of Glasgow Coma Scale score; cRR, coded value of respiratory rate; ISS, Injury Severity Score; RTS, Revised Trauma Score; TRISS, Trauma and Injury Severity Score.

METHODS

WE UNDERTOOK A retrospective observational study to verify the validity of the Ps prediction model for blunt trauma victims in Japan. The protocol of the study was approved by the ethics committee of the National Center for Global Health and Medicine (Tokyo, Japan).

In this verification, of the trauma patient data registered with JTDB between January 1, 2009 and December 31, 2013, data of 117,907 patients were used, excluding those determined to be unsuitable by the JTDB Registry Committee, for reasons such as those clearly indicating an abnormal value in data input contents. Of the above, data of 21,161 cases (17.9%) had the RR missing. Of these, data of 12,687

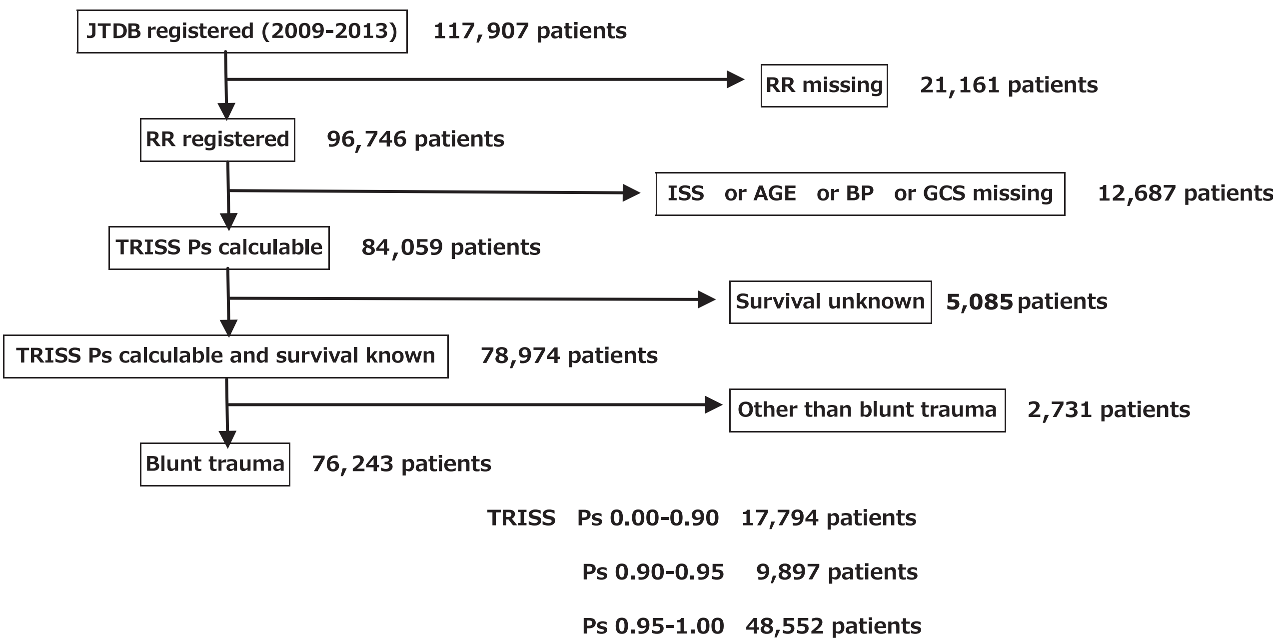

Fig. 1. Stratification and selection of patient data retrieved from the Japan Trauma Data Bank (JTDB) covering the period from 2009 to 2013. AGE, age year; BP, systolic blood pressure; GCS, Glasgow Coma Scale score; ISS, Injury Severity Score; Ps, probability of survival; RR, respiratory rate; TRISS, Trauma and Injury Severity Score.

Table 2. Demographics of each dataset and distribution of variables for survival prediction in blunt trauma victims

	Coded value	Training data (2005–2008)	Validation data (2009–2013)
Number		15,524	76,243
Gender, male, %		69.2	63.7
Age, years, mean (SD)		48.5 (23.2)	55.3 (24.4)
<55	0	55.0%	43.6%
≥55	1	45.0%	56.4%
RTS, mean (SD)		6.78 (2.13)	7.08 (1.78)
BP			
>89 mmHg	4	86.3%	89.9%
76–89 mmHg	3	3.2%	3.0%
59–75 mmHg	2	2.4%	2.1%
1–49 mmHg	1	1.3%	0.9%
No pulse	0	6.8%	4.1%
GCS score			
13–15	4	73.8%	78.8%
9–12	3	7.3%	7.1%
6–8	2	5.9%	5.0%
4–5	1	2.2%	1.6%
<4	0	10.8%	7.5%
RR			
10–29/min	4	77.9%	84.5%
>29/min	3	14.3%	10.5%
6–9/min	2	0.4%	0.3%
1–5/min	1	0.2%	0.1%
0/min	0	7.2%	4.6%
ISS mean (SD)		17.9 (13.6)	16.5 (12.5)
Survival		85.0%	89.2%

BP, systolic blood pressure; GCS, Glasgow Coma Scale score; ISS, Injury Severity Score; RR, respiratory rate; RTS, Revised Trauma Score; SD, standard deviation.

cases had the Injury Severity Score (ISS),[3] age year (AGE), systolic blood pressure (BP), Glasgow Coma Scale score (GCS) missing. Among 84,059 cases, which enabled Ps calculation by the conventional TRISS method, 78,974 cases were known their survival, and of these, 76,243 blunt trauma cases were determined as suitable for this verification. Injury Severity Score was calculated using the Abbreviated Injury Scale 90.[4]

Patients with Ps of 0.95 or higher, 0.90 or higher according to the TRISS calculation, constituted the majority of the entire trauma patient group, and it was estimated that using any of the models for this verification would result in a high Ps. In addition, each model was defined to the fourth decimal place. On the assumption that using the regression model in the actual clinical setting would result in troublesome calculation, the coefficients for each model were rounded off to the third decimal place, so that similar verification may be carried out with a user-friendly model with simplified coefficients.

The maximum likelihood estimation method was used as the estimation method for this verification.

The degree of applicability for each model was evaluated based on the area under the receiver–operating characteristic curve (AUROC) and survival prediction accuracy when survival is predicted to be Ps 0.5 or higher. Stata version 11 (StataCorp LP, College Station, TX, USA) was used for the statistical processing computer software.

RESULTS

THE GENDER, AGE, RTS, BP, RR, GCS, ISS, and survival under the validation data were compared to those of the training data (Table 2). As a result of verifying the validation data, AUROC was high even with the conventional TRISS method, but a similar high value was obtained with the model using ISS, Revised Trauma Score (RTS), and coded AGE as variables. Similarly, with the model using the continuous variable of actual age, AUROC rose to 0.9531.

Similar verifications were carried out on the patient groups with Ps of <0.95, or <0.90 calculated with the conventional TRISS method, but the results were the same as above. Even with a model calculable without RR data, which are often missing in the JTDB ($\beta_0 = -0.76$, $\beta 1 = 1.03$, $\beta = -0.07$, $\beta 3 = -0.04$), the AUROC was 0.9522, indicating that accurate results were attained for the most part. Additionally, even when the coefficients were simplified and rounded off to the third decimal place to create a user-friendly model ($\beta_0 = -0.76$, $\beta 1 = 1.03$, $\beta 2 = -0.07$, $\beta 3 = -0.04$), it was shown that the accuracy of the model was maintained (Table 3). The same held true when the RR was missing (Table 3).

DISCUSSION

AS THE TRISS method proposed by Champion *et al.*[1] was created based on data in North America prior to 1990, and due to vast differences between North America and Japan in the trauma care system including prehospital care, selection of patients registered with the trauma data bank, and exclusion criteria, it is possible that Ps calculation of trauma patients in current-day Japan using the TRISS method may be unsuitable. Furthermore, in recent years, the

Table 3. Area under the receiver–operating characteristic curve (AUROC) and accuracy of logistic regressions models (2009–2013) for survival prediction in blunt trauma patients in Japan

Regression model (predictors)	All (n = 76,243) AUROC/accuracy	Ps < 0.95 (n = 27,691) AUROC/accuracy	Ps < 0.90 (n = 17,794) AUROC/accuracy	Round off to two decimal places AUROC/accuracy
TRISS (USA)	0.9476/94.42%	0.8986/86.1%	0.8726/80.7%	0.9476/94.42%
MODEL-1 (ISS/RTS/cAGE)	0.9492/94.50%	0.9029/86.3%	0.8785/80.9%	0.9492/94.50%
MODEL-2 (ISS/RTS/AGE)	0.9531/94.56%	0.9097/86.5%	0.8852/81.2%	0.9529/94.56%
MODEL-3 (ISS/AGE/cBP/cGCS/cRR)	0.9532/94.56%	0.9098/86.5%	0.8856/81.2%	0.9530/94.56%
MODEL-4 (ISS/AGE/cBP/cGCS)	0.9522/94.50%	0.9078/86.4%	0.8822/81.0%	0.9518/94.50%

Regression models are represented by their predictor variables.
AGE, age year; cAGE, coded value of age year; cBP, coded value of systolic blood pressure; cGCS, coded value of Glasgow Coma Scale score; cRR, coded value of respiratory rate; ISS, Injury Severity Score; Ps, probability of survival; RTS, Revised Trauma Score; TRISS, Trauma and Injury Severity Score.

actual mortality rate of blunt trauma victims in Japan is on a downward trend, and since 2007, the upper limit of the 95% confidence interval of the standard mortality ratio omitting the predicted value using the TRISS method (1 − Ps) has fallen below 1. Amid such a background, the creation of a survival prediction logistic regression model was needed that is more suited to the Ps calculation of blunt trauma victims in Japan. Thus, in 2012, the authors pursued and reported on a regression model using the JTDB data between 2005 and 2009. However, due to the background of the divide between the predicted value from the TRISS method and the actual mortality rate of trauma victims in Japan becoming greater year by year, the validity thereof needs to be constantly verified with the latest data. Therefore, we carried out verification of the regression model using the JTDB data between 2009 and 2013. As a result, regarding age, in order to attain better discriminative ability, using the actual age as a continuous variable instead of a category variable could result in achieving a more conformant model. Moreover, even without RR data (which is often missing in the JTDB data in Japan) a highly conformant Ps calculation is possible.

From the results herein, it is appropriate to use the following TRISS method in Japan (JTRISS): $Ps = 1/(1 + e^{-b})$, $b = -0.76 + 1.03 \times RTS - 0.07 \times ISS - 0.04 \times AGE$. If the RR is unknown, it is recommended that a modified JTRISS be used, namely $Ps = 1/(1 + e^{-b})$ $b = -0.34 - 0.07 \times ISS - 0.04 \times AGE + 0.90 \times \text{coded BP} + 0.98 \times \text{coded GCS}$. Furthermore, in order to facilitate use in the clinical setting, it is thought that the model can be simplified by rounding the coefficient off to the third decimal place.

In recent years, based on reports discussing the possibilities that changes to various coefficients, such as use of actual age and changes to the 55-year age classification, have on the accuracy of the regression model[6] and the background of the remarkable improvement in the survival rate of patients with unstable vital signs on admission, reports have acknowledged that there is less need for RR and BP as variables, particularly at the Level 1 trauma center.[7] These results also support the verification results attained herein.

There are several limitations to this report. First, because the data registered with JTDB do not include reports on all community-based surveys, JTRISS cannot be said to encompass the entirety of trauma patients in Japan. In addition, due to the fact that this study excludes cases with missing data, there is a possibility of selection bias; with regard to missing data, no missing value processing or analyses complementing the missing values have been implemented. Furthermore, with regard to JTDB data, data missing items other than RR, such as BP and GCS, are also comparatively many compared to those of the USA. As with the modified JTRISS, consideration should be given in the future to the creation of other regression models for missing data other than RR to address the needs.

Using a survival prediction logistic regression model that is more suitable to Japan will possibly lead to a more accurate evaluation of the quality of trauma care in the future, ultimately resulting in improvement of the quality of trauma care. In countries with high-quality trauma patient care, it is possible to pursue a regression model more suitable to each country in a similar manner to this study. There is a possibility that the creation of a regression model will improve the quality of trauma care in that country, contributing to the decrease in trauma deaths.

CONCLUSION

BASED ON THIS study, it is appropriate that the JTRISS method shall be defined as $Ps = 1/(1 + e^{-b})$ $b = -0.76 + 1.03 \times RTS - 0.07 \times ISS - 0.04 \times AGE$. Furthermore, if the RR data is missing, a modified JTRISS can be used as follows: $b = -0.34 - 0.07 \times ISS - 0.04 \times AGE + 0.90 \times$ coded BP + 0.98 coded GCS.

CONFLICT OF INTEREST

NONE.

REFERENCES

1 Champion HR, Copes WS, Sacco WJ, *et al.* The major trauma outcome study: establishing national norms for trauma car. J. Trauma 1990; 30: 1356–65.
2 Kimura A, Chadbunchachai W, Nakahara S. Modification of the Trauma and Injury Severity Score (TRISS) method provides better survival prediction in Asian blunt trauma victims. World J. Surg. 2012;36:813–8.
3 Baker SP, O'Neill B, Haddon W Jr, *et al.* The injury severity score:a method for describing patients with multiple injuries and evaluating emergency care. J. Trauma 1974;14:187–96.
4 Association for the Advancement of Automotive Medicine. The Abbreviated Injury Scale. Des Plaines, IL: AAAM, 1990 Revision, updated 1998.
5 Champion HR, Sacco WJ, Copes WS, *et al.* A revision of the trauma score. J. Trauma 1989;29:623–9.
6 Chan CK, Yau KK, Cheung MT. Trauma survival prediction in Asian population: a modification of TRISS to improve accuracy. Emerg. Med. J. 2014; 31: 126–33.
7 Gunning AC, Leenen LP. Applicability of the predictors of the historical trauma score in the present Dutch trauma population: modelling the TRISS predictors. J. Trauma Acute Care Surg. 2014; 77: 614–9.