Med Intensiva. 2016;40(7):395–402

medicina intensiva

www.elsevier.es/medintensiva

ORIGINAL

Mortality prediction using TRISS methodology in the Spanish ICU Trauma Registry (RETRAUCI)

M. Chico-Fernández[a], J.A. Llompart-Pou[b,*], M. Sánchez-Casado[c], F. Alberdi-Odriozola[d], F. Guerrero-López[e], M.D. Mayor-García[f], J.J. Egea-Guerrero[g], J.F. Fernández-Ortega[h], A. Bueno-González[i], J. González-Robledo[j], L. Servià-Goixart[k], J. Roldán-Ramírez[l], M.Á. Ballesteros-Sanz[m], E. Tejerina-Alvarez[n], F.I. Pino-Sánchez[e], J. Homar-Ramírez[b], in representation of the Trauma and Neurointensive Care Working Group of the SEMICYUC

[a] *Trauma and Emergencies ICU, Department of Intensive Care Medicine, Hospital Universitario 12 de Octubre, Madrid, Spain*
[b] *Department of Intensive Care Medicine, Hospital Universitari Son Espases, Palma de Mallorca, Spain*
[c] *Department of Intensive Care Medicine, Hospital Virgen de la Salud, Toledo, Spain*
[d] *Department of Intensive Care Medicine, Hospital Universitario de Donostia, San Sebastián, Spain*
[e] *Department of Intensive Care Medicine, Hospital Universitario Virgen de las Nieves, Granada, Spain*
[f] *Department of Intensive Care Medicine, Complejo Hospitalario de Torrecárdenas, Almería, Spain*
[g] *Department of Intensive Care Medicine, Hospital Universitario Virgen del Rocío, Sevilla, Spain*
[h] *Department of Intensive Care Medicine, Hospital Universitario Carlos Haya, Málaga, Spain*
[i] *Department of Intensive Care Medicine, Hospital General Universitario de Ciudad Real, Ciudad Real, Spain*
[j] *Department of Intensive Care Medicine, Complejo Asistencial Universitario de Salamanca, Salamanca, Spain*
[k] *Department of Intensive Care Medicine, Hospital Universitari Arnau de Vilanova, Lleida, Spain*
[l] *Department of Intensive Care Medicine, Complejo Hospitalario de Pamplona, Navarra, Spain*
[m] *Department of Intensive Care Medicine, Hospital Universitario Marqués de Valdecilla, Santander, Spain*
[n] *Department of Intensive Care Medicine, Hospital Universitario de Getafe, Madrid, Spain*

Received 4 September 2015 ; received in revised form 9 November 2015; accepted 20 November 2015
Available online 8 April 2016

KEYWORDS
Trauma;
Intensive Care Unit;
Trauma registry;
Mortality prediction;
TRISS

Abstract
Objectives: To validate *Trauma and Injury Severity Score (TRISS)* methodology as an auditing tool in the Spanish ICU Trauma Registry (RETRAUCI).
Design: A prospective, multicenter registry evaluation was carried out.
Setting: Thirteen Spanish Intensive Care Units (ICUs).
Patients: Individuals with traumatic disease and available data admitted to the participating ICUs.

* Corresponding author.
E-mail addresses: juanantonio.llompart@ssib.es, ja_llompart@hotmail.com (J.A. Llompart-Pou).

http://dx.doi.org/10.1016/j.medin.2015.11.003

Interventions: Predicted mortality using TRISS methodology was compared with that observed in the pilot phase of the RETRAUCI from November 2012 to January 2015. Discrimination was evaluated using receiver operating characteristic (ROC) curves and the corresponding areas under the curves (AUCs) (95% CI), with calibration using the Hosmer–Lemeshow (HL) goodness-of-fit test. A value of $p < 0.05$ was considered significant.
Main variables of interest: Predicted and observed mortality.
Results: A total of 1405 patients were analyzed. The observed mortality rate was 18% (253 patients), while the predicted mortality rate was 16.9%. The area under the ROC curve was 0.889 (95% CI: 0.867–0.911). Patients with blunt trauma ($n = 1305$) had an area under the ROC curve of 0.887 (95% CI: 0.864–0.910), and those with penetrating trauma ($n = 100$) presented an area under the curve of 0.919 (95% CI: 0.859–0.979). In the global sample, the HL test yielded a value of 25.38 ($p = 0.001$): 27.35 ($p < 0.0001$) in blunt trauma and 5.91 ($p = 0.658$) in penetrating trauma. TRISS methodology underestimated mortality in patients with low predicted mortality and overestimated mortality in patients with high predicted mortality.
Conclusions: TRISS methodology in the evaluation of severe trauma in Spanish ICUs showed good discrimination, with inadequate calibration – particularly in blunt trauma.

PALABRAS CLAVE
Trauma;
Unidad de Cuidados Intensivos;
Registros de trauma;
Predicción de mortalidad;
TRISS

Predicción de la mortalidad a través de la metodología TRISS en el Registro Español de Trauma en UCI (RETRAUCI)

Resumen
Objetivos: Evaluar el *Trauma and Injury Severity Score* (TRISS) como instrumento de auditoría en el Registro Español de Trauma en UCI.
Diseño: Evaluación prospectiva de un registro multicéntrico.
Ámbito: Trece UCI españolas.
Pacientes: Individuos con enfermedad traumática y datos completos ingresados en las UCI participantes.
Intervenciones: Comparamos la mortalidad predicha por el TRISS con la observada en la fase piloto del Registro Español de Trauma en UCI desde noviembre de 2012 hasta enero de 2015. La discriminación se evaluó mediante curvas *receiver operating characteristic* y el valor bajo su área (IC 95%), y la calibración, mediante el test de bondad de ajuste de Hosmer-Lemeshow. Un valor de $p < 0{,}05$ se consideró significativo.
Principales variables de interés: Mortalidad observada y predicha.
Resultados: Analizamos 1.405 pacientes. La mortalidad observada fue del 18% (253 pacientes), mientras que la predicha fue del 16,9%. El área bajo la curva *receiver operating characteristic* fue de 0,889 (IC 95% 0,867-0,911). Los pacientes con trauma cerrado (n = 1.305) presentaron un área bajo la curva *receiver operating characteristic* de 0,887 (IC 95% 0,864-0,910), y aquellos con traumatismo penetrante (n = 100), de 0,919 (IC 95% 0,859-0,979). En la muestra global, el test de Hosmer-Lemeshow mostró un valor de 25,38 (p = 0,001), siendo de 27,35 (p < 0,0001) en trauma cerrado y de 5,91 (p = 0,658) en trauma penetrante. La metodología TRISS infraestimó la mortalidad en los pacientes con mortalidad predicha baja y la sobreestimó en pacientes con mortalidad predicha elevada.
Conclusiones: La aplicación de la metodología TRISS en el trauma grave ingresado en las UCI españolas mostró buenos niveles de discriminación y una calibración inadecuada, especialmente en el traumatismo cerrado.

Introduction

Trauma registries constitute an useful tool for monitoring trauma patient care, since they accurately reflect management and care in different settings.[1,2] This allows not only improvement of individual treatment but also reorganization of the general care profile and logistics applied in the management of severe trauma patients, as well as comparisons among different registries for benchmarking purposes.[1–4]

The outcome of trauma patients is mainly determined by the initial severity of the physiological and anatomical injuries secondary to trauma itself. Severity of injury can be evaluated by severity scales obtained from the analysis of large cohorts of patients.[5] Of all the prognostic scores used in trauma patients, the *Trauma and Injury Severity Score (TRISS)* is currently the most widely used tool, and is regarded as the standard method. In this regard, TRISS methodology determines the probability of survival based on a logistic regression model that includes anatomical evaluation by means of the Injury Severity Score (ISS), physiological evaluations using the Revised Trauma Score (RTS), patient age and type of trauma (blunt or penetrating).[4] The following equation is applied:

$$\frac{1}{(1+e^{-[b_0+b_1(\mathrm{RTS})+b_2(\mathrm{ISS})+b_3(\text{age index})]})}$$

Coefficients b_0–b_3 were derived from the logistic regression analysis of the American database MTOS (*US Major Trauma Outcome Study*). This was not a population-based database, participation was voluntary, and it involved hospitals with a special interest in trauma.

The pilot phase of the Spanish Intensive Care Unit Trauma Registry (RETRAUCI) has been recently conducted in 13 Intensive Care Units (ICUs).[6] Our objective was to validate TRISS methodology almost 30 years later as an auditing tool for mortality prediction in the Spanish ICU Trauma Registry, taking into consideration the mechanisms of injury (blunt or penetrating).

Methods

The pilot phase of the RETRAUCI was conducted from 23 November 2012 to 31 January 2015. Thirteen ICUs distributed throughout Spain collected data. The RETRAUCI is endorsed by the Trauma and Neurointensive Care Working Group of the Spanish Society of Intensive Care Medicine (SEMICYUC). Ethics Committee approval for the registry was obtained. No specific interventions were required for this study.

Patients

We studied all patients admitted to the participating ICUs during the pilot phase of the RETRAUCI due to traumatic disease. In all cases, data on epidemiology, acute management, resource utilization and outcome were recorded. Patients were followed-up on until hospital discharge for outcome as a dichotomous variable (alive or dead).

The following exclusion criteria were applied:

- Missing data for calculating RTS or ISS.
- Outcome at hospital discharge not known for any reason.

Data collection

Data used for calculating RTS (respiratory rate, systolic blood pressure and Glasgow coma score) were obtained from first medical attention before initiating resuscitation and/or mechanical ventilation.

Data used for calculating the ISS were prospectively collected by the intensivist in charge of the patient after ICU admission, based on the Abbreviated Injury Scale (updated in 2008).

Statistical analysis

Quantitative data are reported as means (standard deviation) (SD) and qualitative data as absolute frequencies and percentages. Probability of survival was calculated according to TRISS methodology[5,7] and secondarily, predicted mortality was calculated as follows: (100 − predicted probability of survival). To evaluate the validity of the model, we studied discrimination and calibration in the whole sample and distributed according to blunt or penetrating mechanisms of injury. Discrimination refers to the ability to distinguish between patients who die and those that survive. Accordingly, if the model predicts a mortality rate of 20%, discrimination is perfect if the observed mortality is 20%. It can be evaluated using receiver operating characteristic (ROC) curves and the area under the curves (AUCs) (95% confidence interval, 95% CI). The greater the area, the better the discrimination. Sensitivity (S), specificity (Sp), and the positive (PPV) and negative predictive values (NPV) were recorded in each case.

Table 1 Epidemiological and clinical data of the 1405 patients included in the study.

Variable		Patients (N = 1405) Number (%)
Trauma mechanism	RTA	571 (40.7%)
	Fall	394 (28.1%)
	Aggression	105 (7.5%)
	Occupational accident	100 (7.1%)
	Self-injury	84 (6%)
	Sports-related	81 (5.8%)
	Others	69 (4.9%)
Out-of-hospital medical support		1240 (88.8%)
ISS	<15	429 (30.5%)
	15–25	600 (42.7%)
	26–50	342 (24.3%)
	>50	34 (2.4%)
Hemodynamically stable-admission		878 (66%)
ICP monitoring		233 (18.1%)
Blood transfusion 24 h		351 (25%)
Mechanical ventilation		806 (66.2%)
Mechanical ventilation (days)		6.7 (8.6)
MOF		131 (10%)
ICU stay (days)		8.1 (9.6)
Post-ICU stay (days)		14.8 (19.9)
Global mortality		253 (18%)

RTA, road traffic accident; ISS, Injury Severity Score; ICP, Intracranial pressure; MOF, Multiorgan failure; ICU, Intensive Care Unit.

The calibration of a prognostic model evaluates the concordance between the probability observed in the sample and the probability predicted by the model, describing how the prognostic scale works over wide ranges of predicted mortality. It is evaluated using the Hosmer–Lemeshow (HL) goodness-of-fit test, in patients with low (<10%), intermediate (10–50%) and high predicted mortality rates (>50%). A probability of close to 1 represents better adjustment.[8]

Statistical significance was considered for $p < 0.05$. The SPSS® version 20 statistical package (IBM Corporation 2011) was used throughout.

Results

A total of 2242 patients formed the global cohort of the pilot phase of the RETRAUCI. Patient dropout from the sample was due to different reasons, the most important being inability to determine hospital outcome in 21.1% of the cases, due to patient transfer to the corresponding reference hospital. In most cases, transfer was done to another country, making follow-up impossible. The flowchart in Fig. 1 summarizes the final sample of 1405 patients included in the study.

The mean patient age was 46.7 (19.4) years, and 80.3% were males. The mean ISS score was 21.3 (12.1). A total of 1305 patients suffered blunt trauma (92.9%) as the main mechanism of injury, while the remaining 100 patients (7.1%) presented penetrating trauma. Table 1 shows the data referred to patient epidemiology, acute management, resource utilization and main outcome.

The observed mortality rate (including ICU and post-ICU stay) was 18% (253 patients), with a predicted mortality rate of 16.9%. In patients with blunt trauma, the observed and predicted mortality rates were 18.5% and 17.1%, respectively. In penetrating trauma, the observed and predicted mortality rates were 12% and 14.2%, respectively. Table 2 shows the distribution of patients who died in groups with low (<10%), intermediate (10–50%) and high predicted mortality (>50%).

Table 2 Distribution of patients who died in the groups with low (<10%), intermediate (10–50%) and high predicted mortality (>50%).

Predicted mortality	Patients n	Dead n (%)
0–9.99%	916	38 (4.1%)
10–50%	316	86 (27.2%)
>50%	173	129 (74.6%)
	1405	253

The global sample of 1405 patients presented an area under the ROC curve of 0.889 (95% CI: 0.867–0.911), with S = 50.9%, Sp = 96.2%, PPV = 74.6% and NPV = 89.9%. Patients with blunt trauma (Fig. 2) presented an area under the ROC curve of 0.887 (95% CI: 0.864–0.910), with S = 50.6%, Sp = 96.2%, PPV = 75.3% and NPV = 89.6%, while patients with penetrating trauma (Fig. 2) presented an area under the ROC curve of 0.919 (95% CI: 0.859–0.979), with S = 58.3%, Sp = 95.5%, PPV = 63.6% and NPV = 94.4%.

The results of the Hosmer–Lemeshow (HL) goodness-of-fit test, in both in the total cohorts of patients of patients and distributed according to the mechanism of trauma (blunt or penetrating) are shown in Table 3. The correlation between predicted and observed mortality is shown in Fig. 3.

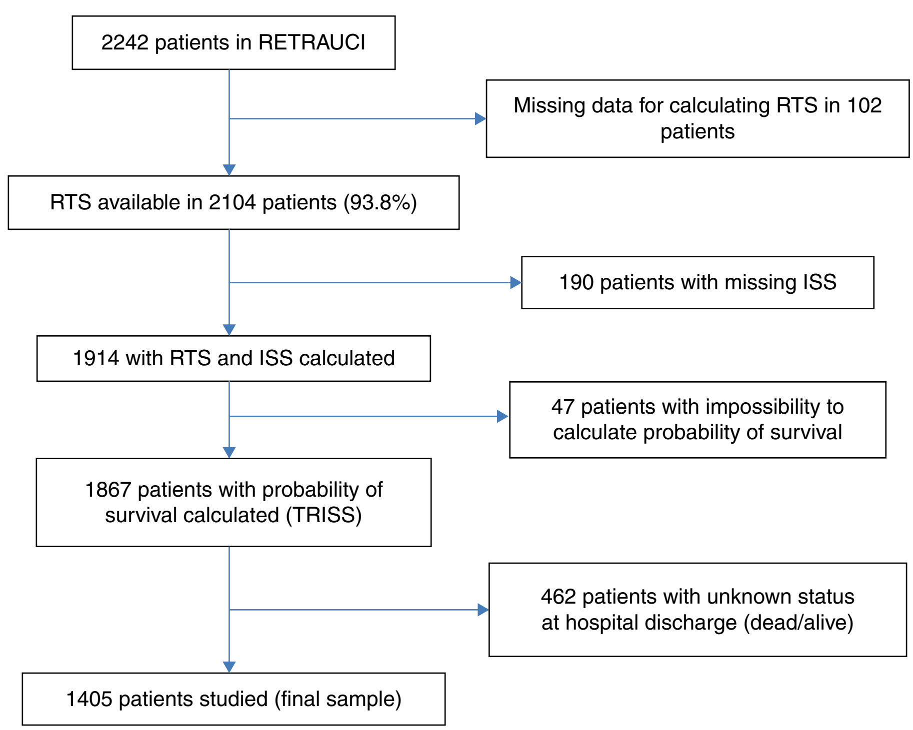

Figure 1 Flowchart of the patients in the pilot phase of RETRAUCI included in the study.

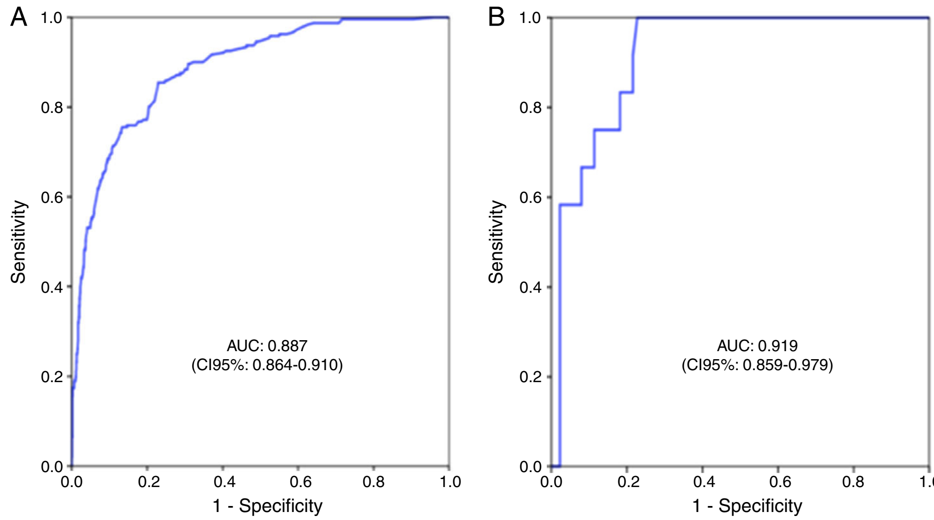

Figure 2 Discrimination based on the area under the receiver operating characteristic (ROC) curve for patients with blunt (A) and penetrating trauma (B).

Discussion

Our study shows that TRISS methodology applied in the sample of patients included in the pilot phase of the RETRAUCI presented good levels of discrimination with inadequate calibration, especially in patients with blunt trauma. Penetrating trauma showed better discrimination and good calibration. Altogether, these results suggest that newly calibrated (*b* coefficient) scales are necessary in our setting.

Our sample of patients offers an initial picture of patients with severe trauma admitted to the ICUs of our setting, taking into account the severity of injury, the care provided, length of stay and mortality. These Units represent level I and II centers. Such patients usually present high ISS values, important resource utilization, and high mortality. The TRISS methodology is based on the degree of anatomical injury (ISS), physiological response (RTS) and functional reserve (age). It was first developed in the 1980s through several logistic regression models[5,9] with different b coefficients considering blunt or penetrating injuries. Several updates have been made since then.

When applied to our patients, TRISS showed good discrimination with inadequate calibration – a fact that limits the use of this prognostic model. This observation is

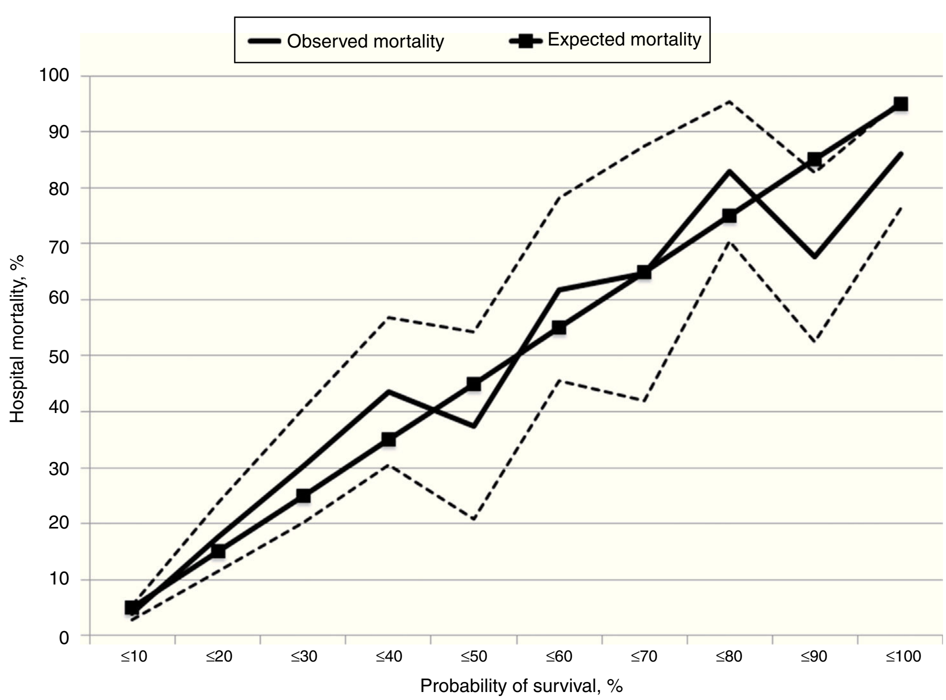

Figure 3 Calibration curve comparing predicted and observed mortality. Dashed lines indicate 95% CI.

Table 3 Hosmer–Lemeshow (HL) goodness-of-fit test.

Predicted mortality deciles (%)	*N*	Observed survivors	Predicted survivors	Observed dead	Predicted dead	H–L df *p*-value
Total sample (N = 1405)						
0–0.8	175	174	173.9	1	1.1	
0.9–1.2	157	157	155.4	0	1.6	
1.3–2.2	152	146	149.2	6	2.8	
2.3–3.5	136	128	132.1	8	3.9	
3.6–5.7	129	124	122.9	5	6.1	
5.8–9.1	134	120	124.5	14	9.5	
9.2–15	130	105	115.4	25	14.6	
15.1–31.7	140	108	109.3	32	30.7	25.38 8 0.001
31.8–63.6	123	64	66.3	59	56.7	
63.7–100	129	26	20.2	103	108.8	
Blunt trauma (N = 1305)						
0.3–0.7	123	122	122.1	1	09	
0.8–1	116	116	114.9	0	1.1	
1.1–1.7	143	141	141	2	2	
1.8–3	134	127	130.8	7	3.2	
3.1–5	132	124	126.7	8	5.3	
5.3–7.8	134	122	125.5	12	8.5	
7.9–13	132	107	118.4	25	13.6	
13.1–27.4	132	108	98.3	24	33.7	27.35 8 <0.001
27.5–63.2	134	71	76.7	63	57.3	
63.3–100	125	26	18.8	99	106.2	
Penetrating trauma (N = 100)						
0.3–0.7	10	10	9.94	0	0.06	
0.8–0.9	11	11	10.9	0	0.1	
1–1.3	10	10	9.9	0	0.1	
1.4–2.1	10	10	9.8	0	0.2	
2.2–2.6	10	10	9.7	0	0.3	
2.7–4.7	9	9	8.6	0	0.4	
4.8–7	11	9	10.3	2	0.7	
7.1–31	9	8	8.1	1	0.9	5.91 8 0.66
31.1–54.8	10	8	6.7	2	3.3	
54.9–100	10	3	1.6	7	8.4	

N = number of patients; df, degrees of freedom; H-L, Hosmer–Lemeshow goodness-of-fit test.

consistent with other studies, and in general, with other prognostic scores in the ICU setting, where the main shortcoming corresponds to inadequate calibration despite good discrimination.[10] It must be noted that in our sample of patients, those with penetrating injury showed good calibration. This fact is consistent with previous studies differentiating between blunt and penetrating trauma. In the latter type of trauma, discrimination and calibration is better, perhaps due to lesser improvement in their specific care.[11,12]

Poor calibration and discrimination does not necessarily refer to the quality of the care provided but rather to incorrect application of the model to a population with specific characteristics.[13] In addition, TRISS is considered to present lower sensitivity for blunt trauma, since it underestimates brain injury; does not consider multiple injuries in the same anatomical area; and does not consider age on an individual basis. In our sample of patients, on taking into account the different mortality groups, TRISS underestimated mortality when the predicted mortality was <60% and overestimated it when the predicted mortality was >60% (Fig. 3).

Mortality prediction according to TRISS has therefore been questioned[14,15]: its clinical application has shown opposite results,[16–18] especially when used in non-MTOS patients.[19,20] The best way to increase its predictive value is to use local correction factors to adjust for *b* coefficients.[20–22] The results of our study confirm that newly developed b coefficients are needed for trauma patients admitted to Spanish ICUs.

New scores have been developed in an attempt to improve the predictive value of TRISS. Some of them are the ASCOT (A Severity Characterization Of Trauma), which includes gender, 5 age categories and different anatomic scales; the ICISS (International Classification of Diseases Ninth revision based injury severity score); the NISS (New Injury Severity Score); the RISC (Revised Injury Severity Classification score); or the pediatric BIG score. However, although they have slightly improved the predictive ability of TRISS methodology, the latter remains the most widely used tool in clinical practice.[12,20,23–25]

Our study has a number of limitations – some attributable to the TRISS model itself, and other specific of our sample. The most relevant are (a) the limited number of patients for this kind of analysis despite the multicenter nature of the study. This corresponds to the pilot phase of the RETRAUCI. With a growing number of centers recruiting patients, we expect to solve this issue in the future; (b) up to 21% of the patients were lost for hospital outcome evaluation. This was due to the large number of patients from different countries that are admitted to our ICUs and are subsequently transferred to their reference hospitals at home, thereby making follow-up impossible.

In sum, TRISS methodology in the Spanish RETRAUCI showed good levels of discrimination, with inadequate calibration, especially in blunt trauma. Penetrating trauma showed better discrimination and good calibration. Altogether, these results suggest that newly calibrated (*b* coefficient) scales are necessary in our setting.

Collaborators

Carlos García-Fuentes, Luis Terceros-Almanza (Hospital Universitario 12 Octubre), Iker García-Sáez, Ruth Salaberria-Udabe (Hospital Universitario de Donostia), Cecilia Carbayo-Górriz (Complejo Hospitalario de Torrecárdenas), Carmen Corcobado-Márquez (Hospital General Universitario de Ciudad Real), Javier Trujillano-Cabello (Hospital Universitari Arnau de Vilanova), Eduardo Miñambres-García (Hospital Universitario Marqués de Valdecilla), Amanda Lesmes-González (Hospital Universitario de Getafe).

Funding

RETRAUCI received funding from the *Fundación Mutua Madrileña* during three years for the development of a web-based database, granted to the principal investigator (Dr. Chico-Fernández, AP117892013), on behalf of the Trauma and Neurointensive Care Working Group of the SEMICYUC.

Conflicts of interest

All authors listed in the study declare that they have no conflicts of interest.

Acknowledgements

The authors are indebted to Vicente Gómez-Tello (Hospital Moncloa, Madrid. Working Groups Coordinator, SEMICYUC), Andrés J. Chacón (Project Manager, Xferic) and Miguel Ferrero-Fernández (Department of Informatics, SEMICYUC) for their invaluable help in developing the registry and the web-based tool.

References

1. Moore L, Clark DE. The value of trauma registries. Injury. 2008;39:686–95.
2. Chico-Fernández M, García-Fuentes C, Guerrero-López F. Trauma registries: a health priority, a strategic project for the SEMICYUC. Med Intensiva. 2013;37:284–9.
3. Lefering R, Ruchholtz S. Trauma registries in Europe. Eur J Trauma Emerg Surg. 2012;38:1–2.
4. Pino Sánchez FI, Ballesteros Sanz MA, Cordero Lorenzana L, Guerrero López F, Grupo de Trabajo de Trauma y Neurointensivismo de SEMICYUC. Quality of trauma care and trauma registries. Med Intensiva. 2015;39:114–23.
5. Boyd CR, Tolson MA, Copes WS. Evaluating trauma care: the TRISS method. Trauma Score and the Injury Severity Score. J Trauma. 1987;27:370–8.
6. Chico-Fernández M, Llompart-Pou JA, Guerrero-López F, Sánchez-Casado M, García-Sáez I, Mayor-García MD, et al. Epidemiología del trauma grave en España. REgistro de TRAuma en UCI (RETRAUCI). Fase piloto. Med Intensiva. 2015, http://dx.doi.org/10.1016/j.medin.2015.07.011. pii:S0210-5691(15)00171-0.
7. http://www.trauma.org/index.php/main/article/387/ (accessed 02.08.15).
8. Lemeshow S, Hosmer DW Jr. A review of goodness of fit statistics for use in the development of logistic regression models. Am J Epidemiol. 1982;115:92–106.
9. Champion HR, Sacco WJ, Hunt TK. Trauma severity scoring to predict mortality. World J Surg. 1983;7:4–11.
10. Nassar AP Jr, Mocelin AO, Nunes AL, Giannini FP, Brauer L, Andrade FM, et al. Caution when using prognostic models: a prospective comparison of 3 recent prognostic models. J Crit Care. 2012;27:e1–7.
11. Rogers FB, Osler T, Krasne M, Rogers A, Bradburn EH, Lee JC, et al. Has TRISS become an anachronism? A comparison of mortality between the National Trauma Data Bank and Major Trauma Outcome Study databases. J Trauma Acute Care Surg. 2012;73:326–31.
12. Brockamp T, Maegele M, Gaarder C, Goslings JC, Cohen MJ, Lefering R, et al. Comparison of the predictive performance of the BIG, TRISS, and PS09 score in an adult trauma population derived from multiple international trauma registries. Crit Care. 2013;17:R134.
13. Patel PA, Grant BJ. Application of mortality prediction to individual intensive care units. Intensive Care Med. 1999;25:977–82.
14. Gabbe BJ, Cameron PA, Wolfe R. TRISS: does it get better than this? Acad Emerg Med. 2004;11:181–6.
15. Glance LG, Osler T. Beyond the major trauma outcome study: benchmarking performance using a national contemporary, population-based trauma registry. J Trauma. 2001;51:725–7.
16. 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.
17. Vassar MJ, Lewis FR, Chambers JA, Mullins RJ, O'Brien PE, Weigelt JA, et al. Prediction of outcome in intensive care unit

trauma patients: a multicenter study of Acute Physiology and Chronic Health Evaluation (APACHE), Trauma and Injury Severity Score (TRISS), and a 24-hour intensive care unit (ICU) point system. J Trauma. 1999;47:324–9.
18. Joosse P, Soedarmo S, Luitse JS, Ponsen KJ. Trauma outcome analysis of a Jakarta University Hospital using the TRISS method: validation and limitation in comparison with the major trauma outcome study. Trauma and Injury Severity Score. J Trauma. 2001;51:134–40.
19. Markle J, Cayten CG, Byrne DW, Moy F, Murphy JG. Comparison between TRISS and ASCOT methods in controling for injury severity. J Trauma. 1992;33:326–32.
20. Hannan EL, Mendeloff Szypulski L, Cayten CG, Murphy JG. Validation of TRISS and ASCOT using a non-MTOS trauma registry. J Trauma. 1995;38:83–8.
21. Schluter PJ, Nathens A, Neal ML, Goble S, Cameron CM, Davey TM, et al. Trauma and Injury Severity Score (TRISS) coefficients 2009 revision. J Trauma. 2010;68:761–70.
22. Joosse P, Goslings JC, Luitse JS, Ponsen KJ. M-study; arguments for regional trauma databases. J Trauma. 2005;58: 1272–6.
23. Lefering R. Development and validation of the Revised Injury Severity Classification score for severely injured patients. Eur J Trauma Emerg Surg. 2009;35:437–47.
24. Champion HR, Copes WS, Sacco WJ, Frey CF, Holcroft JW, Hoyt DB, et al. Improved predictions from a severity characterization of trauma (ASCOT) over Trauma and Injury Severity Score (TRISS): results of an independent evaluation. J Trauma. 1996;40:42–8.
25. Lavoie A, Moore L, LeSage N, Liberman M, Sampalis JS. The New Injury Severity Score: a more accurate predictor of in-hospital mortality than the Injury Severity Score. J Trauma. 2004;56:1312–20.