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ORIGINAL ARTICLE

Early identification of trauma patients in need for emergent transfusion: results of a single-center retrospective study evaluating three scoring systems

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Abstract

Background The Trauma-Induced Coagulopathy Clinical Score (TICCS) was developed to be calculable on the site of injury to discriminate between trauma patients with or without the need for damage control resuscitation and thus transfusion. This early alert could then be translated to in-hospital parameters at patient arrival. Base excess (BE) and ultrasound (FAST) are known to be predictive parameters for emergent transfusion. We emphasize that adding these two parameters to the TICCS could improve the scoring system predictability.

Methods A retrospective study was conducted in the University Hospital of Liège. TICCS was calculated for every patient. BE and FAST results were recorded and points were added to the TICCS according to the TICCS.BE definition (+ 3 points if BE < − 5 and + 3 points in case of a positive FAST). Emergent transfusion was defined as the use of at least one blood product in the resuscitation room. The capacity of the TICCS, the TICCS.BE and the Trauma-Associated Severe Hemorrhage (TASH) to predict emergent transfusion was assessed.

Results A total of 328 patients were included. Among them, 14% needed emergent transfusion. The probability for emergent transfusion grows with the TICCS and the TICCS.BE values. We did not find a significant difference between the TICCS (AUC 0.73) and the TICCS.BE (AUC 0.76). The TASH proved to be more predictive (AUC 0.89). 66.6% of the patients with a TICCS ≥ 10 and 81.5% with a TICCS.BE ≥ 14 required emergent transfusion.

Conclusion Adding BE and FAST to the original TICCS does not significantly improve the scoring system predictability. A prehospital TICCS > 10 could be used as a trigger for emergent transfusion activation. TASH could then be used at hospital arrival. Prehospital TASH calculation may be possible but should be further investigated.

Level of evidence Diagnostic test, level III.

Keywords Trauma · Prehospital care · Coagulopathy · Blood products transfusion

Background

Initiating damage control resuscitation (DCR) as early as possible after severe trauma in patients with active bleeding is pivotal for patient survival [1]. Adequate and rapid diagnosis remains, however, very challenging even for highly trained trauma surgeons [2]. Therefore, clinical judgment could be supported using objective predictive criteria such as scoring systems. Many of those have been proposed in recent years for the prediction of the need for massive transfusion (MT) [3–6], trauma-induced coagulopathy (TIC) [7] or DCR [8]. To be predictive, these scores generally include weighted and sophisticated systems, making them difficult to be used in routine practice. The large majority of them include variables such as laboratory results or medical ultrasonic or scannographic examinations, delaying their use at least a few minutes after hospital admission. Few of them are thought to be used in the prehospital setting, at the site of injury [7, 8]. The Trauma-Induced Coagulopathy Clinical Score (TICCS) was developed to be simple enough to be calculable at the site of injury by either prehospital medical

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teams or paramedics, with the objective of discriminating between trauma patients with or without the need for DCR. The three clinical components of the score were selected on the basis of practicability and known relationships with trauma severity and risk of active bleeding, namely general severity of the trauma, blood pressure, and extent of tissue injuries. The TICCS system attributes a 'score' totaling between 0 and 18 points, as described hereafter: (1) general severity of the trauma: 2 points are attributed if the patient is judged in critical condition of any kind at the end of the primary examination (airway, breathing, circulation, disability) and to be oriented to the resuscitation room (based on the general severity of the trauma: kinetics considerations, airway and breathing examinations, hemodynamic, Glasgow Coma Scale) and 0 otherwise (that is, to be oriented to a regular emergency department room); (2) Blood pressure: 5 points are attributed if the prehospital systolic blood pressure is below 90 mmHg at least once and 0 if it stays continuously above 90 mmHg; (3) extent of tissue injuries: 11 points are attributed for the extent of body injury, depending on the presence of a significant injury, as follows: 1 point for the head and neck region, 1 point for each of the four extremities, 2 points for the torso region, 2 points for the abdominal region, and 2 points for the pelvic region (Table 1).

A first prospective single-center validation study was conducted in 2012–2013 in the Centre Hospitalier Regional de la Citadelle, in Liège, Belgium. 82 trauma patients were included in the study and the TICCS predictability for the triple association of a demonstrated TIC, the need for emergent hemostatic procedure and the need for emergent blood products transfusion were tested [8]. The results of this prospective study suggested that the TICCS is a reliable scoring system for identifying trauma patients in need of DCR prior to hospital admission with an area under the receiver operating characteristic curve (AUC) of 0.98 (95% confidence interval CI 0.92–1.0). A TICCS cut-off value of 10 yielded the best trade-off between true positives and false positives and the corresponding sensitivity and specificity of TICCS were 100% (95% CI 53.9–100) and 95.9% (95% CI 88.2–99.2), respectively; the positive predictive value (PPV) and negative predictive value (NPV) were equal to 72.7% (95% CI 43.3–68.6) and 100% (95% CI 94.7–100), respectively. But the first validation study needed replication because of its limited population.

Table 1 Definition and scoring system of the Trauma-Induced Coagulopathy Clinical Score (TICCS)

Criteria	Number of points attributed
General severity	
Critical (to be admitted in resuscitation room)	2
Non-critical (regular ED room)	0
Blood pressure	
SBP below 90 mmHg at least once	5
SBP always above 90 mmHg	0
Extent of significant injuries	
Head and neck	1
Left upper extremity	1
Right upper extremity	1
Left lower extremity	1
Right lower extremity	1
Torso	2
Abdomen	2
Pelvis	2
Total possible score	0–18

A second validation study was thus conducted through a retrospective analysis of a large cohort of severe trauma patients, in collaboration with the TraumaRegister DGU® (TR-DGU) [9]. The aim of the study was to evaluate the population of the TR-DGU to determine whether there was a correlation between the TICCS value and the probability of emergent blood product transfusion. The TICCS was adapted to the registry structure. Blood transfusion was defined as the use of at least one unit of red blood cells (RBC) during acute hospital treatment. With an AUC of 0.700 (95% CI 0.691–0.709), the TICCS appeared to be moderately discriminant for determining the need for RBC transfusion in the trauma population of the TR-DGU. A TICCS cutoff value of ≥ 12 yielded the best trade-off between true positives and false positives. The corresponding PPV and NPV were 48.4 and 89.1%, respectively. In this second validation study, the TICCS appeared to be more effective in excluding patients without the need for transfusion, rather than reliably identifying those that did need transfusion. However, this would allow prehospital identification of trauma patients with a higher probability of requiring transfusion. We suggested that this early warning could then be translated to specific in-hospital parameters at patient arrival. The present study aims to validate this hypothesis.

The results of admission base excess (BE) and the results of the admission focused assessment with sonography for trauma (FAST) were added to the original TICCS. In the new score, named the TICCS.BE, 3 points are added if the admission BE is lower than -5 (no point is added if BE is ≥ -5) and 3 points are added in the case of a positive FAST (demonstrated blood in one or several of the quadrants).

The TICCS.BE thus ranges from 0 to 24.

We hypothesized that adding these two new parameters to the TICCS could, very quickly after the patient's arrival in the resuscitation room, improve the scoring system predictability.

Methods

A retrospective study was conducted at the University Hospital of Liège, Belgium. The study protocol was submitted to and accepted by the Ethical Committee of the University Hospital of Liège and patients' data were collected using the register of patients admitted to the emergency department (ED) from 1st January 2015 to 31st December 2016. We did not proceed to a pre-study sample size determination which should be considered in the interpretation of our results. Inclusion criteria were patients admitted in the resuscitation room with previous prehospital care and prehospital diagnosis of "trauma", "severe trauma", "road traffic accident", "fall with clinical suspicion of global and/or brain trauma", or "penetrating trauma". Children under 16 years old, pregnant women and patients who died before admission were excluded.

Based on the available data in the register, the TICCS was calculated for every patient. BE and FAST results were recorded and points were added according to the TICCS.BE definition to calculate the TICCS.BE for every patient.

The primary endpoint was to compare TICCS and TICCS.BE in the prediction of emergent blood product transfusion.

Emergent blood product transfusion was defined, in this study, as the transfusion of one or more RBC or plasma units within the first minutes after admission to the ED. This definition was preferred to the traditional definition of a massive transfusion (the transfusion of 10 or more RBC units within the first 24 h of care). In the context of predictive scores, the use of this a posteriori definition could, hence, be inappropriate as it could inadequately exclude severe patients in need for emergent surgical procedure combined with emergent blood product transfusion (with a total of RBC units below 10). As an early diagnostic tool, the TICCS (and the TICCS.BE) is meant to answer to those practical questions: is my patient bleeding and do I have to urgently transfuse him and perform hemostatic surgical procedure?

Secondary endpoints were to compare the two scores with the Trauma-Associated Severe Hemorrhage (TASH) score (5) for the primary endpoint (the need for emergent transfusion) and to evaluate the TICCS.BE in predicting the need for emergent surgical hemostatic procedure and the need for DCR (defined as the association of emergent transfusion and surgery).

Quantitative variables were summarized as median and interquartile range (IQR) as well as range, and frequency tables were used for categorical findings. Group comparisons were made by applying the Kruskal–Wallis test for continuous variables and the χ^2 test (or Fisher's exact test) for categorical variables. The cutoff values for TICCS, TICCS.BE and TASH were obtained by ROC curve analysis based on each endpoint (primary: emergent transfusion; secondary: emergent surgical procedure and DCR). Each score was characterized by its sensitivity, specificity, PPV and NPV and AUC with 95% confidence intervals (95% CI). The results were considered significant at the 5% critical level ($P < 0.05$). Calculations were performed with the SAS version 9.4 for Windows statistical software package (SAS Institute, Cary, NC, USA).

Results

A total of 328 patients were included in the analysis. With a median injury severity score (ISS) of 14 (7–75) and 24% of trauma patients with ISS ≥ 25, the study population reflects the actual reality of a Belgian University Hospital with moderate and major trauma patients' admission, without the existence of a regional or national trauma system and without Major Trauma Center (MTC) assignation.

Among the 328 patients, 50 (15.2%) needed emergent transfusion, 49 (14.9%) needed emergent hemostatic surgical procedure and 16 (4.9%) needed DCR.

The study population principal characteristics are displayed in Table 2.

The percentage of patients that required emergent transfusion for each TICCS and TICCS.BE value was calculated and the results are presented in Figs. 1 and 2.

The respective AUC of the three scores (TICCS, TICCS.BE and TASH) was compared, confirming that the TICCS is a moderately discriminating scoring system (AUC 0.73, 95% CI 0.64–0.82), that the TICCS.BE performs slightly, but not significantly, better (AUC 0.76, 95% CI 0.67–0.85) and that the TASH is the most discriminant scoring system (AUC 0.89, 95% CI 0.83–0.94).

Comparison of the scores did not reveal a significant difference between TICCS and TICCS.BE and confirmed the superiority of the TASH.

The cutoff values that yield the best trade-off between true positives and false positives are 6 for the TICCS, 9 for the TICCS.BE and 9 for the TASH.

These cutoffs vary from the ones previously identified for the TICCS (10 in the 2012–2013 prospective study and 12 in the 2016 retrospective study) as well as for the TASH (a TASH score of 9 only predicted a 6% probability of massive transfusion in the initial 2006 study). Those cutoff values consequently led to a poor PPV. However, considering the potential use of these scores as early prediction practical tools, PPV are of the highest interest. Of those patients with a TICCS ≥ 10, 66.6% needed transfusion. Interestingly, all patients of our cohort with a TICCS > 10

Table 2 Characteristics of the studied population

Variable	Category	*N*	*n* (%)	Median (IQR)	Range
Sex		328			
	F		80 (24.4)		
	M		248 (75.6)		
Age (year)		328		45 (28.5 to 58.5)	16 to 94
ISS		328		14 (7 to 25)	3 to 75
Mechanism		328			
	Blunt		310 (94.5)		
	Penetrating		18 (5.5)		
TICCS		328		4 (3 to 5)	2 to 13
Admission BE		328		0 (−3.6 to 0)	−25 to 2
FAST		328			
	Positive		68 (20.7)		
	Negative		260 (79.3)		
TICCS.BE		328		4 (3 to 7)	2 to 17
Hb at admission (g/L)		315		14.1 (12.6 to 15.4)	3.1 to 19.3
Emergent surgical hemostasis		328			
	Yes		49 (14.9)		
	No		279 (85.1)		
Emergent blood product transfusion		328			
	Yes		50 (15.2)		
	No		278 (84.4)		
24-h survival		328	305 (93.0%)		
30-day survival		328	287 (87.5)		

ISS Injury Severity Scale, *TICCS* Trauma-Induced Coagulopathy Clinical Score, *BE* base excess, *FAST* Focused Assessment with Sonography for Trauma, *Hb* hemoglobin

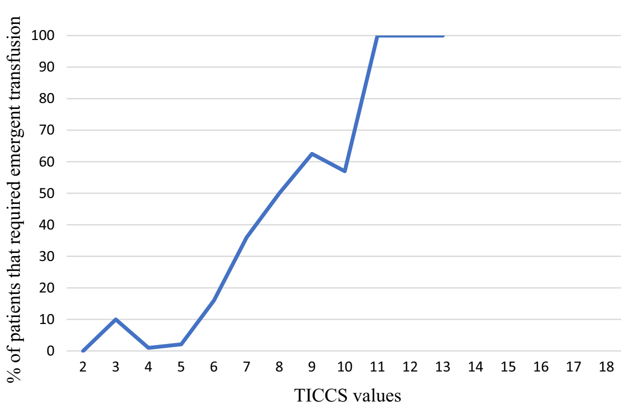

Fig. 1 Percentage of patients that required emergent transfusion for each TICCS value

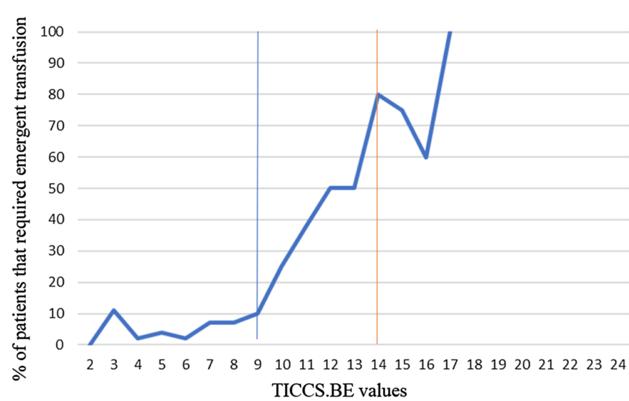

Fig. 2 Percentage of patients that required emergent transfusion for each TICCS.BE value

required emergent transfusion and the probability of emergent transfusion was very high with a TICCS.BE ≥ 14 (PPV 81.25%).

Moreover, the probability of emergent transfusion was very low for patients with a TICCS.BE < 10. Patients with TICCS.BE ranging between 10 and 14 had an intermediate probability of emergent transfusion.

Finally, 56.2% of the patients with a TICCS.BE ≥ 14 needed an emergent hemostatic surgical procedure and 50% of them needed DCR.

Discussion

Early identification of ongoing hemorrhage following severe trauma is a prerequisite for adequate management of this critical condition. Unfortunately, it remains very challenging in clinical practice, especially for blunt trauma patients. The large number of studies focusing on this aspect and the number of scoring systems developed for this purpose are, by themselves, good indicators of this difficulty [3].

Many of the existing scoring systems were developed for a same final objective: a better prediction of ongoing hemorrhage after severe trauma. They were not all designed and evaluated either with the exact same methodology or with the same context and finality. A large majority were designed to identify patients at risk for massive transfusion.

The Assessment of Blood Consumption score has been initially described in 2009 and remains until now one of the most commonly used among United States trauma centers. ABC is based on four unweighted parameters: 1—penetrating mechanism (1 point), 2—positive focused assessment sonography for trauma (1 point), 3—arrival systolic blood pressure (SBP) of 90 mmHg or less (1 point), and 4—arrival heart rate (HR) > or = 120 beats per minute bpm (1 point). The score ranges from 0 to 4 and an ABC score of 2 or greater was 75% sensitive and 86% specific for predicting massive transfusion in the initial evaluation study [4].

In 2006, clinical and laboratory variables documented in the trauma registry of the German Trauma Society (DGU) were subjected to a univariate and multivariate logistic regression analyses to predict the probability of massive transfusion and incorporated in a sophisticated scoring system named the Trauma-Associated Severe Hemorrhage (TASH) [5]. Since then, several studies confirmed the TASH ability to predict the need for massive transfusion.

Many other scoring systems have been developed and evaluated until now [3]. Their utility in clinical practice and the impact of their use both remain to be further demonstrated. However, some of them are used in the clinical setting such as ABC in most of US trauma centers, TASH in most of German trauma centers, COAST in Australia [7] or Code Red in London Helicopter Emergency Medical Service [10].

The TICCS was created, as opposed to the other existing scoring systems at that time, to be used by prehospital clinicians, at the site of injury, in the very first minutes after injury for the prehospital flagging of trauma patients at risk of ongoing hemorrhage and TIC and thus in need of DCR. However, the simplicity of the scoring system leads to a logical relatively poor PPV. This was confirmed in the retrospective study evaluating the TICCS in 33,385 trauma patients from the TR-DGU [9].

BE and FAST results are known to be predictive parameters for transfusion and massive transfusion and are, in consequence, frequently included in trauma scoring systems [3, 4].

The present study first confirms that those two parameters could be of interest for a better prediction of the need for emergent blood product transfusion in severe trauma patients.

Indeed, TICCS.BE seems to be a potentially interesting tool for the early identification of patients who will very likely require emergent transfusion, hemostatic surgical procedure and DCR (using the following trigger: TICCS.BE ≥ 14). It could also be used for the reliable exclusion of patients without this need (using the trigger TICCS.BE < 10). Patients with TICCS.BE between 10 and 14 remain challenging and probably need either other explorations or a replication of the TICCS.BE calculation to assess potential positive or negative evolution.

In a very practical way of thinking, clinicians facing blunt trauma patients and asking themselves whether they should initiate emergent blood product transfusion, activate the blood bank and potentially the local massive hemorrhage protocol, and whether they should activate the surgical team could use the TICCS.BE.

We built the TICCS.BE using BE and FAST not only because they are known to be useful parameters but also because both could theoretically be used in the prehospital setting. Several studies have already illustrated the potential interest of prehospital point-of-care ultrasound in trauma [11–15]. Many prehospital medical teams around the world, including ours, already routinely use prehospital ultrasound in the management of trauma patients. Point-of-care devices like the i-STAT® system (Abbott Point-of-care Inc., NJ, USA) or the epoc® blood gas analysis system (Siemens Health Care Diagnostics Inc., GmbH, Erlangen, Germany) can potentially be used in the prehospital setting [16, 17].

TICCS.BE could hence be potentially calculated in the prehospital setting, like the TICCS, and thus be of great interest for the early flagging of trauma patients in need of emergent transfusion and DCR. Many point-of-care blood sample analysis systems also include hemoglobin, allowing a potential prehospital TASH calculation (which would need to be evaluated). Further investigations should, moreover, explore if prehospital BE and hemoglobin can be used for TICCS.BE or TASH calculation as they differ from in-hospital later values.

The present study confirms that the TICCS itself, despite its simplicity and its moderate discriminating capacity (AUC 0.73 95% CI 0.64–0.82), is an interesting very early and very simple tool to predict the need for emergent transfusion. Every patient with a TICCS > 10 in the present study indeed required emergent transfusion.

In the absence of prehospital point-of-care ultrasound and BE, TICCS could still be useful.

Finally, the present study, like many previous studies, confirms that the TASH is a very high-performing scoring system.

Based on these results, we can confirm that TICCS, TICCS.BE and TASH are interesting tools to help clinicians in assessing the need for emergent blood product transfusion after trauma. The more the score increases, the more the patient is likely to be in need for transfusion.

In the studied population, TICCS.BE, however, does not significantly overcome TICCS. TASH does, with better predictive value compared to the TICCS and the TICCS.BE.

Moreover, we are also able to propose a very practical algorithm: depending on the prehospital human and technical resources, a prehospital TICCS > 10 and/or a (in- or prehospital) TASH > 16 could be used as triggers for the activation of DCR components, including blood product transfusion.

Conclusions

Early identification of trauma patients in need of DCR and thus emergent blood product transfusion remain very challenging. The TICCS was developed with the original idea of being calculable at the site of injury, by prehospital medical or paramedical teams, for an early flagging. This prehospital identification can, therefore, lead to adequate prehospital management and pre-activation of specific resources in the receiving hospital.

Because of its precocity and its simplicity, the TICCS, however, may suffer from a relatively low PPV. The TICCS.BE was developed by adding the results of the BE and the FAST to the TICCS. The present retrospective study does not demonstrate a significant difference between the TICCS and the TICCS.BE, thus confirming the potential practical interest of the two scores (which could theoretically both be used in the prehospital setting) and confirms the quality of the TASH. In clinical practice, the PPV of early predictive tools is of the highest interest. A prehospital TICCS > 10 and/or a (in- or prehospital) TASH > 16 could be used as triggers for the activation of DCR components, including blood product transfusion.

Compliance with ethical standards

Conflict of interest The authors declare that they have no relevant conflicts of interest

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