A Prehospital Glasgow Coma Scale Score ≤ 14 Accurately Predicts the Need for Full Trauma Team Activation and Patient Hospitalization after Motor Vehicle Collisions

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Background: **Trauma team activation protocols should ideally minimize the undertriage of seriously injured patients and eliminate unnecessary activations for those patients that do not require hospitalization. This study examined which physiologic parameter(s) most reliably predicted the need for hospitalization after motor vehicle collisions (MVCs).**

Methods: **A prehospital triage tool using standard physiologic parameters was developed and prospectively analyzed for reliability in predicting subsequent patient admission at a Level II trauma center after MVCs. Data were collected on 4,014 consecutive patients, 2,880 (72%) of whom had all of the physiologic parameters reported and recorded. Patients who arrived in extremis, who were dead on arrival, or who died shortly after arrival despite appropriate trauma team activation were ineligible for the study. Multivariate stepwise logistic regression analysis was used to determine which parameters were associated with hospital admission.**

Results: **The Glasgow Coma Scale (GCS) score was the only prehospital physiologic parameter providing a clinically identifiable difference between those patients admitted (13 ± 4) and those discharged to home (15 ± 0.5) (mean + SD) (relative risk for hospitalization, 2.24; 95% confidence interval, 1.86–2.70 for GCS score < 14).**

Conclusion: **The prehospital GCS score is a reliable physiologic parameter for predicting hospital admission after MVC. When obvious indicators (hypoxemia, multiple long bone fractures, focal neurologic deficits) for trauma team activation are lacking, the prehospital GCS score may be used to reduce overtriage and undertriage rates.**

Key Words: **Prehospital triage, Glasgow Coma Scale, Trauma system development, Rural trauma.**

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The assessment, resuscitation, and treatment of individuals injured in motor vehicle collisions (MVCs) requires the commitment of significant emergency department (ED) and hospital resources.[1–3] Despite guidelines and suggested triage protocols published by both the American College of Emergency Physicians[4] and the American College of Surgeons,[5] recognizing those patients who require the immediate participation of the trauma surgeon remains imprecise.[6–8] A trauma system must provide the full gamut of available resources to seriously injured patients, but frequent overtriage of patients has financial and administrative ramifications that can ultimately jeopardize trauma system viability.[2,9]

Various prehospital triage instruments have been developed by emergency medicine and trauma programs to better match individual MVC patients with the appropriate hospital resources.[2,8,10–17] Most of these triage tools were developed in large urban medical centers that use ED and surgical residents and fellows to supplement the demanding personnel requirements of most major trauma centers. Triage instruments currently rely on a variety of "trigger points" for full trauma team activation. This is partly because of the difficulty in correctly identifying a "major trauma victim" in the prehospital setting.

The ED physician, particularly in Level II and Level III trauma centers, must activate the trauma team primarily on the basis of prehospital reports and the initial impression of injury severity.[11] The number of general surgeons who are able to participate in these effort-intense activities is limited in smaller and more remote rural medical facilities. Guidelines developed by the Committee on Trauma of the American College of Surgeons appropriately require early general surgeon participation in trauma team activations at all three levels of trauma center verification. The general surgeon should be present in the ED for major resuscitations and to assist in expediting the care of seriously injured patients.[4]

Optimal trauma team activation and triage protocols should not only strive to limit the undertriage of seriously injured patients, but also should limit unnecessary trauma team activation and overtriage. This study was developed as part of a rural regional trauma system needs assessment for eastern Texas, recognizing that most of the smaller medical facilities within the evolving statewide Texas trauma system have a limited number of general surgeons to assist ED

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physicians in providing the initial care for victims of motor vehicle collisions. The goal was to reevaluate existing prehospital criteria at our trauma center to provide guidance to Level III trauma centers in the region on trauma team activation criteria.

PATIENTS AND METHODS

The study group consisted of 4,014 consecutive patients involved in MVCs who were triaged by prehospital personnel and evaluated in the ED of East Texas Medical Center (ETMC) in Tyler, Texas. Patients with no vital signs in the field, or who were pronounced dead on arrival or died within minutes after ED arrival, were excluded from the study. ETMC, a 360-bed regional referral hospital, was a state-designated and American College of Surgeons–verified Level II trauma center during the period of data acquisition. The trauma service was staffed by four board-certified general surgeons with added qualifications in surgical critical care. The hospital has subsequently been verified and designated as a Level I trauma center and serves as the lead trauma facility for a state-defined 17,000-square mile trauma region that contains 23 hospitals of various sizes and clinical resources.

After training in prehospital scoring systems (including Glasgow Coma Scale [GCS]) with prehospital personnel, a standardized trauma triage data set was collected concurrently on all patients by the emergency medical technicians (EMTs) that are responsible for receiving incoming radio calls in the ED communications center. The EMTs were trained to specifically request a standardized set of prehospital triage scores, anatomic findings, and physiologic parameters if these specific data were not given in the initial prehospital radio report. The requested data points were: prehospital GCS score; prehospital Revised Trauma Score (RTS); mechanism of injury; major long bone fractures; open fractures; systolic blood pressure, heart rate, and respiratory rate; and, a series of questions to quickly determine the patient's perceived neurologic status. The communications center EMT was also responsible for recording the notification, call-back, and ED arrival times of the trauma surgeon. In those situations where more than one value was given for a prehospital data point (such as more than one set of vital signs), the most abnormal data point was used for both triage and study purposes. Additional data were collected on those patients who were admitted to the hospital, including Injury Severity Score, outcome (lived or died), and major medical diagnoses.

The prehospital reports given to the communications center EMTs were immediately relayed to either the on-call trauma surgeon or to the ED physician in those situations where trauma team activation was not automatic. Field criteria for automatic trauma team activation were as follows: gunshot wound to the torso or neck; gunshot wound to an extremity with loss of distal pulse; identification of a femur, tibial, or spinal fracture; any long bone open fracture; prehospital identification of airway compromise or the need for intubation in the field; systolic blood pressure < 90 mm Hg; heart rate < 60 beats/min or > 130 beats/min; spontaneous respiratory rate < 10 breaths/min or > 30 breaths/min; or paralysis in one or more extremities.

Other than the gunshot wound parameters, mechanism of injury criteria were not routinely used to determine trauma team activation for victims of falls and motor vehicle crashes. Although specifically requested and recorded, prehospital GCS and RTS criteria were not used as an isolated parameter to automatically trigger trauma team activation during this study.

The questions that were asked to determine the patient's perceived neurologic status were all simple "yes/no" questions: Is the patient alert and oriented? Did the patient lose consciousness? Is the patient paralyzed in one or more extremities? Is the patient combative or intoxicated? Only a "yes" response to the paralysis question triggered automatic trauma team activation.

The current study was limited to only those patients who were involved in motor vehicle crashes. All triage protocol data sets were entered into a standardized computer file and were reviewed on a weekly basis by the director of trauma services, with particular attention to the medical decision regarding the need for full trauma team activation. Undertriage was defined as the failure to activate a full trauma team response when automatic activation criteria were met or when, in retrospect, the patient's injuries were believed to be severe enough that the presence of a surgeon could have potentially been needed to affect outcome (major splenic or liver injury, major pelvic fractures, airway issues). Overtriage was defined as the unnecessary activation of a full trauma team response when the patient's injuries were ultimately determined to be minimal. For example, a patient who triggered a trauma team activation but was discharged home from the ED would be considered an overtriaged patient.

The principal outcome evaluated in this study was the need for patient hospitalization to treat documented injuries. Multivariate stepwise logistic regression analysis was performed to determine which variables within the data set were significant predictors of admission. The dependent variable in the analysis was admission versus nonadmission. Patients with all four prehospital parameters reported and recorded (GCS scores, systolic blood pressure, heart rate, and respiratory rate) were used for the regression analysis. Raw data (i.e., the actual values for each data point) were used in the analysis with no coding of the raw data. However, to make interpretation of relative risk easier to understand, the negative of the raw prehospital GCS score was used in the regression analysis to avoid misinterpretation of the direction of effect. This is because a higher GCS score should logically predict a lower risk of hospitalization, and an increasingly abnormal (or lower) GCS score should increase the relative risk for hospitalization.

The sensitivity, specificity, positive predictive value, and negative predictive value for the prehospital GCS score was

Table 1 Prehospital Glasgow Coma Scale Score Efficacy in Predicting Admission to the Hospital

GCS Score[a]	Patient Disposition		Row Total
	Admitted	Not Admitted	
15	759	1,613	2,372
<15	434	74	508
Column total	1,193	1,687	2,880

[a] GCS sensitivity = 434/1,193 = 0.36. GCS specificity = 1,613/1,687 = 0.96. GCS positive predictive value = 434/508 = 0.854. GCS negative predictive value = 1,613/2,372 = 0.680.

derived in terms of its ability to predict the need for hospitalization. Sensitivity of the prehospital GCS score in predicting hospital admission was defined as the proportion of admitted patients who had abnormal prehospital GCS scores. Specificity was defined as the proportion of patients who were not admitted who had normal prehospital GCS scores. The positive predictive value of the prehospital GCS score for predicting hospital admission was defined as the proportion of patients with abnormal prehospital GCS scores who were admitted to the hospital, and the negative predictive value was defined as the proportion of patients with a normal prehospital GCS score who were not admitted. Table 1 illustrates these definitions and derivations. An analysis of relative probability for hospital admission was determined for all physiologic parameters, GCS score, and RTS. Continuous data were analyzed using the two-tailed Student's *t* test, and categorical variables were analyzed using the Fisher's exact test.

RESULTS

During a 27-month period, 4,014 consecutive patients involved in MVCs were triaged by prehospital personnel to ETMC. A total of 1,669 (42%) patients were admitted for further treatment, whereas 2,345 (58%) were discharged. The Injury Severity Score for admitted patients was 15.6 ± 12.7 (mean ± SD). A total of 3,109 patients met trauma team activation criteria and 1,355 (44%) were admitted. Nine hundred five patients (23%) did not meet trauma team activation criteria, but 314 (35%) patients still required hospital admission.

No significant clinical differences in systolic blood pressure, heart rate, or respiratory rate were found when patients who required hospitalization were compared with those who were discharged from the ED (Table 2). In fact, mean systolic blood pressure was higher and mean heart rate was lower in those patients who required admission. Similarly, there was no clinically significant difference between these two groups with respect to prehospital RTS.

A total of 2,880 patients (72% of the entire study group) had a prehospital GCS score available for analysis. There was a clinically significant difference in the prehospital mean GCS score when patients requiring admission (GCS score of 13 ± 4) were compared with patients not requiring admission (GCS score of 15 ± 0.5). Multivariate stepwise logistic regression analysis for systolic blood pressure, heart rate, and respiratory rate parameters that were used in the study did not identify any increased risk for hospitalization in the 2,880 patients who constituted the study group for regression analysis. An abnormal GCS score was the only parameter associated with increased relative risk for hospitalization (relative risk, 2.24; 95% confidence interval, 1.86–2.70).

When analyzing the need for hospitalization after MVCs, the GCS score defined a high-risk group (GCS score ≤ 12), an intermediate-risk group (GCS score of 13–14), and a relatively low-risk group (GCS score of 15), with hospital admission rates of 96%, 73%, and 32%, respectively (Table 3). Admission rates were identical for the GCS score of 13 and GCS score of 14 groups (73%). Sensitivity, specificity, positive predictive value, and negative predictive value for a normal versus an abnormal level of GCS score are provided in Table 1. A summary of the trauma director's assessment of undertriage and overtriage rates by GCS score is given in Table 4.

DISCUSSION

Triage parameters should ideally have high predictive validity by correlating well with the chosen outcome measure.[7] Good prehospital triage parameters should also have high "face validity" by being intuitively reasonable to field personnel.[7] The GCS was designed as a simple clinical tool for assessing the depth of impaired consciousness. Continuous reassessment using the GCS score provides a continuum from initial evaluation through therapeutic interventions to final outcome.[10,18] Although not originally designed as a prehospital evaluation tool, the GCS score has proved reliable

Table 2 Prehospital Physiologic Triage Variable Results for 4,014 Motor Vehicle Crash Patients

Variable	No. of Patients With Variable Reported		Admitted (n = 1,668) (Median)	Discharged (n = 2,346) (Median)
	No.	%		
Systolic blood pressure (mm Hg)	3,674	92	98 ± 23 (96)	93 ± 18 (90)
Heart Rate (beat/min)	3,662	91	129 ± 28 (129)	133 ± 24 (130)
Respiratory rate (breath/min)	3,172	79	21 ± 9 (20)	20 ± 4 (20)
Revised Trauma Score	2,856	71	11 ± 2 (12)	12 ± 0.3 (12)
Glasgow Coma Scale Score	2,880	72	13 ± 4 (15)	15 ± 0.5 (15)

All data reported as mean ± SD.

Table 3 Hospital Admission Rate, Injury Severity Score, and Early Mortality Rates by Glasgow Coma Scale Score[a]

GCS Score	Admitted (%)	ISS (Median)	Early Mortality Rate[b] (%)
15 (n = 2,372)	759 (32)	11.8 ± 8.6 (10)	15 (2.0)
	$p \leq 0.0001$	$p = 0.02$	$p = 0.09$
13–14 (n = 239)	175 (73)	13.6 ± 9.7 (12.5)	4 (2.3)
	$p \leq 0.0001$	$p \leq 0.0001$	$p \leq 0.0001$
≤12 (n = 269)	259 (96)	26 ± 16 (25)	71 (27)

ISS, Injury Severity Score, reported as mean ± SD.

[a] *p* values for admission and mortality rates determined by Fisher's exact test; *p* value for ISS comparisons determined by two-way analysis of variance.

[b] Early mortality rate = death within first 24 h after hospital admission.

in predicting head injury severity and probability of survival. An indication of the power of the GCS as a field triage tool is the disproportionately high weighted coefficient it receives in the regression analysis formula of the three-component Revised Trauma Score.[19] It has been estimated that the value for the GCS motor component (GCSM) has a 90% predictive value for the total GCS score.[20] Hoping to further streamline and simplify the prehospital use of the GCS, recent studies have documented that the GCSM is equivalent to the RTS in predicting patient mortality,[16] and the GCSM is as accurate as the three-component GCS in predicting head injury severity.[17] Hence, in the large population of "stable" patients who are being triaged after MVC, a single-component triage tool (the GCSM) may prove to be the most simple, accurate, and easily applied means for triage and trauma team activation.

The present study was designed to evaluate traditional triage parameters for predicting hospitalization after MVC. The GCS score was the only prehospital physiologic parameter that provided a clinically relevant and measurable difference between patients who were hospitalized versus those who were discharged from the ED, excluding patients who were in extremis and died shortly after arrival. This reliability was not changed by the presence of positive prehospital anatomic criteria or prehospital airway issues. Three tiers of probability for admission were evident: a very high probability (96%) for GCS score ≤ 12, a high probability (73%) for GCS score of 13 to 14, and a relatively low probability (32%) for GCS score of 15. Neither the suspected presence or absence of drugs, alcohol, or a reported loss of consciousness compromised the accuracy of the GCS as a predictor for imminent hospitalization. This is not surprising, because disorientation, belligerence, mild confusion, or history of loss of consciousness does not significantly affect the GCS score. Retrospectively, had a GCS score of 14 been used to trigger trauma team activation, the overall undertriage rate of 19.1% would have improved to 4.4%.

Table 4 Overtriage and Undertriage Rates by Glasgow Coma Scale Score

GCS Score	Overtriage (%)	Undertriage (%)
15 (n = 2,372)	202 (8.5)	105 (4.4)
14 (n = 165)	21 (12.7)	11 (6.7)
13 (n = 74)	9 (12.1)	4 (5.4)
≤12 (n = 269)	5 (1.8)	7 (2.6)
Total	237 (35.1)	127 (19.1)

As with all triage tools and prehospital scoring systems, our proposed use of the GCS as a screening tool for the immediate ED presence of the trauma surgeon after MVC is not intended to supplant sound clinical judgment or clear indicators that a serious or life-threatening injury might be present. Rather, the GCS may prove to be a highly accurate means for triaging the limited resources present in many of our regional trauma system receiving facilities, and may ensure that needed care is provided in an expeditious manner. Similar to the intended conservation of scarce resources that prompted the tiered trauma team alert in some urban Level I trauma centers,[15] the GCS score enhances the ability of prehospital and ED personnel to more accurately determine the need for early arrival of the trauma surgeon.

For a triage tool to be useful, it must be used. Despite educating all prehospital personnel on the use of the GCS, an actual score was only reported in 72% of our patients before arrival in the ED. On the basis of the data provided by this study, our Level I facility now uses a GCS score < 14 as a definite trigger for immediate activation of the trauma surgeon. Depending on other associated prehospital criteria, a GCS score of 14 may also trigger a trauma team response. Continuous education of prehospital personnel to provide accurate GCS scores is also being provided.

There are several potential criticisms of the current study. The authors did not look specifically at different ranges for systolic blood pressure, heart rate, and respiratory

rate. It is possible that a lower trigger value for systolic blood pressure (rather than < 90 mm Hg) should be used. Likewise, heart rate and respiratory rate parameters may need to be adjusted. It is again emphasized that patients who were in extremis and died shortly after arrival were excluded, since trauma team activation was automatic in those patients. There are still obvious physiologic parameters where the need for trauma team activation is unquestionable, but the authors of the current study are not convinced that these are the traditional physiologic parameters that were used in the current study. A second criticism concerns the possibility that some patients were admitted simply for observation or as a convenience to family, patient, or trauma surgeon. This was not specifically addressed in the study, but the presence of alcohol, drugs, or a history of loss of consciousness did not change the GCS results, so this is unlikely. Finally, a GCS score was not given in 27% of the patients. It is possible that our conclusions may be different had a GCS score been provided in all 4,014 patients.

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