Comparative Effectiveness Review
Number 182

Effective Health Care Program

Glasgow Coma Scale for Field Triage of Trauma: A Systematic Review

Executive Summary

Background

Unintentional injuries are the leading cause of death among people in the United States ages 1 to 44, and the third leading cause among people ages 45 to 64.[1] Among all age groups, motor vehicle crashes are the first or second leading cause of unintentional injury death.[2] In 2011, there were approximately 40,000,000 emergency department (ED) visits for injuries; of these approximately 2.5 million were due to trauma complications and unspecified injuries.[3] Approximately 18 percent of patients seen in the ED for an injury were transported by emergency medical services (EMS) personnel.[4] Traumatic brain injury (TBI) is an important subset of trauma. Among an estimated 1.7 million annual cases of TBI, there are 52,000 deaths and 275,000 hospitalizations.[5] TBI is a contributing factor to about one-third of injury-related deaths in the United States. From 2001 to 2010, the rate of TBI-related ED visits increased from 421 to 716 per 100,000,[6] though the rate of deaths declined from 18.5 to 17.1 per 100,000 people.

Field Triage of Patients With Trauma

Field triage by EMS is a critical aspect of trauma systems, as it helps to identify potentially seriously injured patients

Purpose of Review

To assess the predictive utility, reliability, and ease of use of the total Glasgow Coma Scale (tGCS) versus the motor component of the Glasgow Coma Scale (mGCS) for field triage of trauma, as well as comparative effects on clinical decisionmaking and clinical outcomes.

Key Messages

- The tGCS is associated with slightly greater discrimination than the mGCS or Simplified Motor Score (SMS) for in-hospital mortality, receipt of neurosurgical interventions, severe brain injury, and emergency intubation. For every 100 trauma patients, the tGCS is able to correctly discriminate 1 to 5 more patients than the mGCS or the SMS.
- Limited evidence suggests that the mGCS is easier to score correctly than the tGCS.
- The clinical significance of differences in discrimination is likely to be small and could be offset by factors such as convenience and ease of use.
- Future research is needed to understand how use of the tGCS versus the mGCS or SMS impacts clinical outcomes and risk of over- or under-triage.

Agency for Healthcare Research and Quality
Effective Health Care Program

and inform transport decisions.[7-9] Appropriate decisions regarding transport are crucial because management of severely injured patients in a Level I or a Level II trauma center has been shown to be associated with improved clinical outcomes.[9] On the other hand, unnecessarily triaging patients to high-level trauma care who do not require it may represent an inefficient use of staff and resources.[10]

EMS personnel must rapidly triage individuals who have undergone trauma in challenging environments. Therefore, EMS personnel must have assessment tools that are easy to use, reliable, and accurate. A key component of field triage for patients with suspected serious injury is level of consciousness assessment.[4] The Glasgow Coma Scale (GCS)[11,12] is an instrument widely used for assessment of consciousness at the site of injury, in EDs, and in hospitals, and to monitor progress or deterioration during treatment.[13] The GCS consists of three items (components): eye (scored 1 to 4), verbal (scored 1 to 5), and motor (scored 1 to 6). Scores on each of these components are added to obtain the total Glasgow Coma Scale (tGCS) score, ranging from 3 to 15. Lower scores on the tGCS indicate lower levels of consciousness, generally correlating with more severe injury associated with poorer prognosis and requiring more intensive care. For patients with TBI, scores of 3 to 8 are generally considered to denote severe head injury, 9 to 12 moderate, and 13 to 15 mild.[14] The 2011 field triage guidelines from the Centers for Disease Control and Prevention (CDC) National Expert Panel recommend transporting patients with tGCS scores of 13 or less to facilities providing the highest level of trauma care.[4]

In some circumstances (e.g., trauma victims who are intoxicated, intubated, or whose other injuries influence response) it may not be possible to accurately assess the verbal and eye components of the GCS. In these cases, assessments may be primarily based on the motor component of the Glasgow Coma Scale (mGCS) alone.[11,15-17] The mGCS has been proposed for assessment of trauma patients even when the tGCS can be obtained, since only one item is assessed, potentially increasing ease of use in the field.18 mGCS scores of 5 or less are considered an indication of patients with severe injury.[18,19] The Simplified Motor Score (SMS) has been proposed as a streamlined alternative to the mGCS, which is assessed on a three-point scale (scored 0 to 2, with a score of 0 corresponding to 1 to 4 on the mGCS, 1 corresponding to 5 on the mGCS, and 2 corresponding to 6 on the mGCS).[20]

Decisions regarding the use of the tGCS versus more simplified versions of the tGCS should be based on their relative performance. The ultimate goal of selecting one risk prediction instrument over another is to improve clinical outcomes (e.g., in-hospital mortality). However, information on clinical outcomes is often lacking, and decisions about use must often be based on how instruments perform on intermediate outcomes. Intermediate outcomes include measures of over- or under-triage (i.e., the degree to which patients are unnecessarily transported to a Level I or II trauma center [over-triage] or not transported to a Level I or II trauma center when needed[under-triage]) or predictive utility, as assessed using measures of discrimination (ability of an instrument to distinguish patients with the disease from those without), calibration (how well predicted risk correlates with actual risk), standard measures of diagnostic accuracy (e.g., sensitivity, specificity, and predictive values), or adjusted risk estimates (e.g., odds ratio, relative risk, hazards ratio).[21] Other factors that could inform selection of field triage risk assessment instruments include intra- and interrater reliability and ease of use (e.g., time to administer the instrument and amount of missing data).[12,22,23]

A number of factors could impact the performance of field assessment instruments. These include variability in patient populations (e.g., type of trauma, demographic characteristics, presence and severity of intoxication, and medical comorbidities), level of training and certification of administering personnel (e.g., emergency medical responder, emergency medical technician [EMT], advanced EMT, paramedic, physician, or nurse[24]), receipt of field interventions (e.g., medications, intubation), setting (e.g., country, urban vs. rural) or timing of assessment relative to injury occurrence. Evidence about field triage instruments frequently relies on extrapolation from studies conducted in EDs, as this environment is more controlled and easier to study.[25] However, the performance of the tGCS and mGCS may be different when administered soon after injury by EMS personnel in the field as opposed to later by ED personnel, after destination decisions have already been made and patients have been stabilized with initial interventions.

During the development of field triage guidelines and algorithms by the CDC National Expert Panel in 2011,[4] use of the mGCS was considered a way to potentially simplify field triage. The mGCS was not adopted, due in part to lack of evidence about the comparative accuracy and reliability of the mGCS relative to the tGCS. However, more evidence is now available on the mGCS.

Scope of Review and Key Questions

This report addresses the following Key Questions:

Key Question 1. In patients with known or suspected trauma, what is the predictive utility of the tGCS compared with the mGCS for predicting in-hospital mortality, morbidity, Injury Severity Score of 16 or greater, head Abbreviated Injury Scale (AIS) score greater than 2 (AIS-2005) or greater than 3 (AIS-1998), presence of intracranial hemorrhage, and utilization indicators of severe injury (e.g., receipt of intracranial monitoring within 48 hours of admission, receipt of a neurosurgical intervention within 12 hours of admission, or early intubation [in the field or immediately upon presentation to the ED])?

- **Key Question 1a. How does predictive utility vary according to patient age or other patient characteristics (e.g., TBI vs. unspecified or other trauma, systolic blood pressure, level of intoxication, type of trauma, intubation or receipt of medications in the field), the training and background of the person administering the instrument, and the timing/setting of assessment (i.e., in the field vs. upon presentation to the ED or urban vs. rural location)?**

Key Question 2. In patients with known or suspected trauma, what are the comparative effects of the tGCS compared with the mGCS on over- and under-triage (e.g., proportion of patients in whom initial EMS transport is to a higher or lower than appropriate level of care, or proportion transferred to a lower or higher level of care)?

- **Key Question 2a. How do effects on over- and under-triage vary according to patient age or other patient characteristics (e.g., TBI vs. unspecified or other trauma, systolic blood pressure, level of intoxication, type of trauma, intubation or receipt of medication in the field), the training and background of the person administering the instrument, and the timing/setting of assessment (i.e., in the field vs. upon presentation to the ED or urban vs. rural location)?**

Key Question 3. In patients with known or suspected trauma, what is the comparative effectiveness of the tGCS compared with the mGCS on clinical outcomes (e.g., in-hospital mortality, morbidity, quality of life)?

- **Key Question 3a. How do effects on clinical outcomes vary according to patient age or other patient characteristics (e.g., TBI vs. unspecified or other trauma, systolic blood pressure, level of intoxication, type of trauma, intubation or receipt of medication in the field), the training and background of the person administering the instrument, and the timing/setting of assessment (i.e., in the field vs. upon presentation to the ED or urban vs. rural location)?**

Key Question 4. In patients with known or suspected trauma, what is the comparative reliability (e.g., interrater and intrarater kappa) and ease of use (e.g., time to complete, amount of missing data, user reported satisfaction) of the tGCS compared with the mGCS score?

- **Key Question 4a. How do comparative reliability and ease of use vary according to patient age or other patient characteristics (e.g., TBI vs. unspecified or other trauma, systolic blood pressure, level of intoxication, type of trauma, intubation or receipt of medication in the field), the training and background of the person administering the instrument, and the timing/setting of assessment (i.e., in the field vs. upon presentation to the ED or urban vs. rural location)?**

The research questions used to guide this review were initially developed by the National Highway Traffic Safety Administration and revised with input from a Technical Expert Panel. The Key Questions focus on predictive utility, over- and under-triage, clinical outcomes of the tGCS versus the mGCS or the SMS, as well as reliability and ease of use. We included studies of children and adults with known or suspected trauma, with assessment using the tGCS, the mGCS, or the SMS. For studies evaluating measures of diagnostic accuracy (sensitivity, specificity, predictive values), we focused on studies that used standard cutoff scores (≤13 for tGCS and ≤5 for mGCS), but also included studies that used alternative cutoffs or modifications of the tGCS and mGCS. For all Key Questions, we included cohort studies and randomized trials that directly compared the tGCS with the mGCS or SMS. For Key Question 4 (reliability and ease of use), we also included cross-sectional studies and studies that assessed one of these scales, and for Key Question 1a (predictive utility) we included studies that assessed one of these scales if they addressed one of the subpopulations specified in the Key Questions not addressed well in the head-to-head studies.

For Key Question 1, we included measures of predictive utility for in-hospital mortality, morbidity, markers of severe injury, or utilization indicators of severe injury, as measured by diagnostic accuracy, adjusted risk estimates, measures of discrimination (e.g., the c-index), measures of calibration (e.g., the Hosmer-Lemeshow test), or risk

reclassification rates. For Key Question 2, we included studies that reported the proportion of patients who were over- or under-triaged (e.g., the proportion transferred to a higher or lower level of care); for Key Question 3, we included studies that reported clinical outcomes; and for Key Question 4, we included outcomes that assessed reliability (e.g., interrater and intrarater kappa) or ease of use (e.g., time to complete, measures of missing data, user reported satisfaction).

For all Key Questions we included prospective and retrospective studies in which the tGCS, mGCS, or SMS was administered soon after injury (conducted in the field/out-of-hospital setting by EMS personnel) or immediately upon arrival to the ED, or that were based on trauma registry data collected in the field or in the ED.

Methods

Literature Search Strategy

This review includes studies published since January 1995. This search start date was selected because of changes in trauma care over time; only five States had fully implemented trauma systems in the early 1990s.[26] In addition, the first studies to compare the predictive utility of the mGCS versus the tGCS were published in 1998 and 2003.[18,19]

The Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, CINAHL®, PsycINFO®, HaPI (Health and Psychosocial Instruments), and Ovid MEDLINE® (January1995 through June 2016) were searched for relevant studies and systematic reviews. Investigators also manually reviewed reference lists of relevant studies and searched for unpublished studies in ClinicalTrials.gov. All citations were independently reviewed by two investigators to determine eligibility for inclusion.

Risk of Bias Assessment of Individual Studies

A single investigator abstracted details about study design, patient population, comparison groups, setting, screening method, analysis, followup, and results. A second investigator reviewed data abstraction for accuracy. Two investigators independently rated the quality of studies (good, fair, poor) using prespecified criteria developed for evaluation of studies on prognosis[27] and diagnosis.[28] Investigators did not review, assess, or screen papers that they authored. Discrepancies were resolved by consensus.

Data Synthesis

We applied a "best evidence" approach in which higher quality evidence (based on study design, risk of bias, and use of head-to-head vs. indirect comparisons) is prioritized. We did not exclude studies rated high risk of bias a priori, but performed sensitivity analyses to determine how their exclusion would impact conclusions. Within each Key Question, we qualitatively synthesized overall findings and assessed how potential modifiers of effects (e.g., patient characteristics, characteristics of the people administering the instrument, threshold used for the tGCS or mGCS, timing, or setting) impacted results, as well as study design characteristics (type of study, risk of bias). We performed meta-analysis to calculate pooled differences in the area under the receiver operating characteristic curve (AUROC) using the DerSimonian-Laird random effects model with Stata/IC 13.1 (StataCorp LP, College Station, TX). We also performed analyses using the Profile Likelihood method. The AUROC value represents the probability that a patient who experiences an outcome will have a higher score on the triage scale than a person who does not experience the outcome. We defined a small difference in the AUROC a priori as a difference of less than 0.05, moderate as a difference of 0.05 to 0.10, and large as a difference of greater than 0.10. Stratified and sensitivity analyses were performed on the potential modifiers of effects.

We evaluated any differences in conclusions based on direct versus indirect comparisons, as assessments of comparative diagnostic accuracy based on direct comparisons can differ from those based on indirect comparisons, and did not combine direct and indirect evidence.

Strength of the Body of Evidence

For all comparisons and outcomes we assessed the strength of evidence using the approach described in the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*,[29] based on the overall risk of bias (graded low, moderate, or high); the consistency of results across studies (graded consistent, inconsistent, or unable to determine when only one study was available); the directness of the evidence linking the intervention and health outcomes (graded direct or indirect); the precision of the estimate of effect, based on the number and size of studies and confidence intervals (CIs) for the estimates (graded precise or imprecise); and reporting bias (suspected or undetected). Assessments of reporting bias were based on whether studies defined and reported primary outcomes and whether we identified relevant unpublished studies.

Results

Results of Literature Searches

Database searches resulted in 4,412 potentially relevant citations. After dual review of abstracts and titles, 698 articles were selected for full-text review. After dual review of full-text articles, 32 studies were included.

Key Question 1. Predictive Utility

Twenty-four studies evaluated predictive utility.[17-20,30-49] Differences between the tGCS, mGCS, and SMS in discrimination (AUROC) for in-hospital mortality, neurosurgical intervention, severe brain injury, and emergency intubation were <0.05. Results were similar in subgroups stratified by age (child vs. mixed populations of adults and children), type of trauma (TBI vs. mixed trauma), field versus ED assessment, and other subgroup and sensitivity analyses. Main findings are summarized in Table A and below.

- In-hospital mortality
  - For the tGCS versus the mGCS, the pooled AUROC was 0.877 (95% CI 0.847 to 0.906) versus 0.855 (95% CI 0.822 to 0.888), with a pooled mean difference of 0.015 (95% CI 0.009 to 0.022; I2=85%), based on 12 studies (strength of evidence [SOE]: Moderate).
  - For the tGCS (cutoff of ≤13) versus the mGCS (cutoff of ≤5), differences in sensitivity ranged from 0 percent to 3 percent; difference in specificity ranged from 0 percent to 5 percent in favor of the mGCS, though the CIs overlapped in most studies. (SOE: Low).
  - For the tGCS versus the SMS, the pooled AUROC was 0.884 (95% CI 0.852 to 0.916) versus 0.840 (95% CI 0.802 to 0.878), for a mean difference of 0.030 (95% CI 0.024 to 0.036, I^2=0%), based on five studies (SOE: Moderate).
  - One study found the out-of-hospital tGCS (cutoff of ≤13) associated with slightly higher sensitivity versus the SMS (cutoff of ≤1) (75%, 95% CI 73 to 76 vs. 72%, 95% CI 70 to 74) and slightly lower specificity (88%, 95% CI 87 to 88 vs. 89%, 95% CI 89 to 87) (SOE: Low).
  - For the mGCS versus the SMS, the mean difference in the pooled AUROC was 0.014 (95% CI 0.006 to 0.021, I^2=0%), based on four studies (SOE: Moderate).
- Neurosurgical intervention
  - For the tGCS versus the mGCS, the pooled AUROC was 0.786 (95% CI 0.729 to 0.842) versus 0.754 (95% CI 0.688 to 0.819), with a mean difference of 0.031 (95% CI 0.018 to 0.044; I^2=72%), based on seven studies (SOE: Moderate).
  - Two studies found inconsistent results for sensitivity (51%, 95% CI 50 to 52 vs. 46%, 95% CI 45 to 48 and 63%, 95% CI 38 to 84 vs. 68%, 95% CI 43 to 87) and no clear differences in specificity (86%, 95% CI 86 to 86 vs. 88%, 95% CI 88 to 88 and 82%, 95% CI 80 to 84 vs. 83%, 95% CI 81 to 85) between out-of-hospital tGCS (cutoff of ≤13) versus the mGCS (cutoff of ≤5) in accuracy for identifying people undergoing craniotomy (SOE: Insufficient for sensitivity, low for specificity).
  - For the tGCS versus the SMS, the pooled AUROC was 0.809 (95% CI 0.766 to 0.853) versus 0.769 (95% CI 0.711 to 0.827), with a mean difference of 0.032 (95% CI 0.025 to 0.039, I^2=0%), based on five studies (SOE: Moderate).
  - One study found the out-of-hospital tGCS (cutoff of ≤13) associated with higher sensitivity than the SMS (cutoff of ≤1) for identifying patients who underwent neurosurgical intervention (60%, 95% CI 56 to 63 vs. 53%, 95% CI 49 to 56) and slightly lower specificity (85%, 95% CI 84 to 85 vs. 86%, 95% CI 86 to 87) (SOE: Low).
  - For the mGCS versus the SMS, the mean difference in the pooled AUROC was 0.002 (95% CI -0.005 to 0.010, I^2=0%), based on four studies (SOE: Moderate).
- Severe brain injury
  - For the tGCS versus the mGCS, the pooled AUROC was 0.791 (95% CI 0.734 to 0.827) versus 0.720 (95% CI 0.666 to 0.774), with a mean difference of 0.050 (95% CI 0.034 to 0.065; I^2=57%), based on five studies (SOE: Moderate).
  - One study found no difference between out-of-hospital tGCS (cutoff of ≤13) versus the mGCS (cutoff of ≤5) in sensitivity (62%, 95% CI 55 to 68 vs. 61%, 95% CI 54 to 67) or specificity (85%, 95% CI 83 to 88 vs. 89%, 95% CI 88 to 91) for identifying people with severe head injury (defined as head Abbreviated Injury Scale score of ≥4) (SOE: Low).

  - For the tGCS versus the SMS, the pooled AUROC was 0.763 (95% CI 0.710 to 0.815) versus 0.713 (95% CI 0.654 to 0.771), respectively, with a mean difference of 0.048 (95% CI 0.038 to 0.059, I2=72%), based on five studies (SOE: Moderate).
  - One study found out-of-hospital tGCS (cutoff of ≤13) associated with slightly higher sensitivity than the SMS (cutoff of ≤1) for severe brain injury based on presence of head computed tomography (CT) imaging findings (45%, 95% CI 44 to 46 vs. 41%, 95% CI 40 to 42) and similar specificity (89%, 95% CI 89 to 90 vs. 90%, 95% CI 90 to 91) (SOE: Low).
  - For the mGCS versus the SMS, there was no difference in the AUROC (mean difference 0.000, 95% CI -0.008 to 0.007, I^2=0%), based on four studies (SOE: Moderate).
- Emergency intubation
  - For the tGCS versus the mGCS, the pooled AUROC was 0.865 (95% CI 0.830 to 0.901) versus 0.822 (95% CI 0.775 to 0.870), with a mean difference of 0.034 (95% CI 0.020 to 0.482; I^2=88%), based on six studies (SOE: Moderate).
  - One study found very small differences between out-of-hospital tGCS (cutoff of ≤13) versus the mGCS (cutoff of ≤5) in accuracy for identifying people who underwent emergency intubation (sensitivity 84%, 95% CI 83 to 84 vs. 81%, 95% CI 81 to 82; and specificity 90%, 95% CI 90 to 90 vs. 92.0%, 95% CI 92 to 92) (SOE: Low).
  - For the tGCS versus the SMS, the pooled AUROC was 0.843 (95% CI 0.823 to 0.864) versus 0.783 (95% CI 0.747 to 0.819), with a mean difference of 0.040 (95% CI 0.030 to 0.050, I^2=55%), based on five studies (SOE: Moderate).
  - One study found the out-of-hospital tGCS (cutoff of ≤13) associated with slightly higher sensitivity than the SMS (cutoff of ≤1) for identifying people who underwent emergency intubation (76%, 95% CI 74 to 77 vs. 73%, 95% CI 71 to 74) and slightly lower specificity (89%, 95% CI 89 to 89% vs. 91%, 95% CI 90 to 91) (SOE: Low).
  - For the mGCS versus the SMS, there was no difference in the AUROC (mean difference 0.000, 95% CI -0.007 to 0.007, I^2=0%), based on four studies (SOE: Moderate).
- Trauma center need
  - Two studies found small differences between the tGCS versus the mGCS in the AUROC (0.617 vs. 0.609 and 0.641 vs. 0.603), sensitivity (30% vs. 27% and 28% vs. 25%), and specificity (93% vs. 95% and 94% vs. 95%) for trauma center care need (defined as Injury Severity Score [ISS] of >15, intensive care unit [ICU] admission >24 hours, need for urgent surgery, or death in the ED) (SOE: Low).
- Severe injury
  - Two studies found the tGCS was better able to discriminate those with major injury (defined as an ISS score of >15) from those without major injury (AUROC 0.72, 95% CI 0.71 to 0.72 vs. 0.68, 95% CI 0.68 to 0.69 and 0.65, 95% CI 0.65 to 0.65 vs. 0.61, 95% CI 0.60 to 0.61) (SOE: Low).
  - One study found the out-of-hospital tGCS (cutoff of ≤13) associated with slightly higher sensitivity and slightly lower specificity than the mGCS (cutoff of ≤5) for identifying people with major injury (defined as an ISS score of >15) from those without major injury (sensitivity 31%, 95% CI 31 to 32 vs. 28%, 95% CI 28 to 28 and specificity 91%, 95% CI 91 to 91 vs. 93%, 95% CI 93 to 93) (SOE: Low).
- Age: Effects on discrimination between the tGCS versus the mGCS were similar in studies that enrolled children and those that enrolled mixed populations of adults and children (SOE: Low).
- Type of trauma: Effects on discrimination between the tGCS versus the mGCS were similar in studies that evaluated patients with TBI and those that enrolled mixed trauma patients (SOE: Low).
- Out-of-hospital versus ED assessment: One study of adults found no differences between out-of-hospital and ED GCS scores on discrimination for in-hospital mortality or neurosurgical intervention but another study of adults or children found out-of-hospital GCS scores associated with higher discrimination for in-hospital mortality than ED scores (AUROC 0.754 vs. 0.635, p-value not reported). Effects on discrimination between the tGCS and the mGCS were similar in studies that evaluated out-of-hospital GCS scores and those that used ED scores (SOE: Insufficient).
- No study evaluated how intoxication status, blood pressure, intubation status, receipt of field intubation, or level/training of field assessors impacts comparative predictive utility of the tGCS versus the mGCS or SMS.

Table A. Pooled AUROC results of head-to-head studies

Outcome and analysis	tGCS Vs. mGCS, Difference in AUROC (95% CI)	Number of Studies	I^2	tGCS Vs. SMS, Difference in AUROC (95% CI)	Number of Studies	I^2
In-hospital mortality, overall	0.015 (0.009 to 0.022)	12	85%	0.030 (0.024 to 0.036)	5	0%
Adults or mixed	0.019 (0.012 to 0.025)	10	75%	0.030 (0.024 to 0.036)	5	0%
Children	0.006 (0.002 to 0.011)	2	0%	--	--	--
Excluding NTDB studies	0.017 (0.008 to 0.025)	10	68%	0.030 (0.024 to 0.036)	5	0%
Excluding studies with potential overlap*	0.016 (0.008 to 0.024)	9	88%	0.031 (0.023 to 0.039)	3	0%
Out-of-hospital GCS	0.016 (0.007 to 0.024)	7	91%	0.031 (0.023 to 0.039)	3	0%
ED GCS	0.020 (0.006 to 0.034)	3	23%	0.030 (0.020 to 0.039)	2	0%
U.S. setting	0.015 (0.008 to 0.022)	10	87%	0.030 (0.024 to 0.036)	5	0%
TBI patients	0.009 (-0.002 to 0.020)	3	0%	--	--	--
Low risk of bias studies	0.017 (0.015 to 0.020)	5	0%	0.030 (0.022 to 0.037)	3	0%
Enrollment before 2006	0.018 (0.011 to 0.024)	10	77%	0.030 (0.024 to 0.036)	5	0%
Enrollment 2006 or later	0.006 (0.001 to 0.011)	2	0%	--	--	--
Neurosurgical intervention, overall	0.032 (0.020 to 0.043)	7	72%	0.032 (0.025 to 0.039)	5	0%
Adults or mixed	0.031 (0.018 to 0.044)	6	76%	0.032 (0.025 to 0.039)	5	0%
Children	0.034 (0.009 to 0.059)	1	--	--	--	--
Excluding studies with potential overlap*	0.032 (0.011 to 0.053)	4	79%	0.038 (0.024 to 0.052)	3	19%
Out-of-hospital GCS	0.032 (0.011 to 0.053)	4	79%	0.038 (0.024 to 0.052)	3	19%
ED GCS	0.029 (0.020 to 0.039)	2	0%	0.029 (0.020 to 0.038)	2	0%
U.S. setting	0.032 (0.020 to 0.044)	7	72%	0.032 (0.025 to 0.039)	5	0%
TBI patients	0.017 (-0.022 to 0.056)	2	66%	--	--	--
Low risk of bias studies	0.026 (0.019 to 0.034)	4	0%	0.029 (0.021 to 0.037)	3	0%
Enrollment before 2006	0.033 (0.021 to 0.045)	6	74%	0.032 (0.025 to 0.039)	5	0%
Enrollment 2006 or later	0.019 (-0.009 to 0.047)	1	--	--	--	--
Severe brain injury, overall	0.050 (0.034 to 0.065)	5	57%	0.048 (0.038 to 0.059)	5	72%
Adults or mixed	0.046 (0.038 to 0.054)	4	0%	0.048 (0.038 to 0.059)	5	72%
Children	0.121 (0.068 to 0.174)	1	--	--	--	--
Excluding NTDB studies	0.050 (0.034 to 0.065)	5	57%	0.048 (0.038 to 0.059)	5	72%
Excluding studies with potential overlap*	0.065 (0.020 to 0.111)	3	76%	0.051 (0.034 to 0.068)	3	74%
Out-of-hospital GCS	0.041 (0.028 to 0.053)	2	0%	0.051 (0.034 to 0.068)	3	74%
ED GCS	0.060 (0.028 to 0.093)	3	73%	0.044 (0.030 to 0.059)	2	51%
U.S. setting	0.050 (0.034 to 0.065)	5	57%	0.048 (0.038 to 0.059)	5	72%
TBI patients	--	--	--	--	--	--

Table A. Pooled AUROC results of head-to-head studies (continued)

Outcome and analysis	tGCS Vs. mGCS, Difference in AUROC (95% CI)	Number of Studies	I^2	tGCS Vs. SMS, Difference in AUROC (95% CI)	Number of Studies	I^2
Low risk of bias studies	0.046 (0.038 to 0.053)	3	0%	0.044 (0.035 to 0.053)	3	25%
Enrollment before 2006	0.050 (0.034 to 0.065)	5	57%	0.048 (0.038 to 0.059)	5	72%
Enrollment 2006 or later	--	--	--	--	--	--
Emergency intubation, overall	0.034 (0.020 to 0.048)	6	88%	0.040 (0.030 to 0.050)	5	55%
Adults or mixed	0.034 (0.020 to 0.048)	6	88%	0.040 (0.030 to 0.050)	5	55%
Children	--	--	--	--	--	--
Excluding studies with potential overlap*	0.026 (0.015 to 0.037)	4	68%	0.033 (0.025 to 0.040)	3	0%
Out-of-hospital GCS	0.026 (0.015 to 0.037)	4	68%	0.033 (0.025 to 0.040)	3	0%
ED GCS	0.048 (0.039 to 0.058)	2	0%	0.048 (0.039 to 0.057)	2	0%
U.S. setting	0.034 (0.020 to 0.048)	6	88%	0.040 (0.030 to 0.050)	5	55%
TBI patients	0.011 (-0.010 to 0.032)	1	--	--	--	--
Low risk of bias studies	0.037 (0.022 to 0.052)	4	79%	0.046 (0.038 to 0.054)	3	0%
Enrollment before 2006	0.038 (0.020 to 0.053)	5	91%	0.040 (0.030 to 0.050)	5	55%
Enrollment 2006 or later	0.018 (0.005 to 0.031)	1	--	--	--	--

AUROC=area under the receiver operating characteristic curve; CI=confidence interval; ED= emergency department; GCS= Glasgow Coma Scale; mGCS= motor Glasgow Coma Scale; NTDB= National Trauma Data Bank; SMS= Simplified Motor Score; TBI=traumatic brain injury; tGCS= total Glasgow Coma Scale

*When multiple studies published from the same trauma center, analysis restricted to the most recent study using out-of-hospital GCS scores (excluded Gill 2005,20 Haukoos 2007,40 Acker 201430)

Key Question 2. Over- and Under-Triage Rates

No study evaluated comparative effects of the tGCS versus the mGCS or SMS on over- or under-triage rates.

Key Question 3. Effectiveness of Clinical Outcomes

No study evaluated comparative effects of the tGCS versus the mGCS or SMS on clinical outcomes.

Key Question 4. Interrater Reliability and Ease of Use

Ten studies evaluated interrater reliability or ease of use.[41,46,50-57] Evidence on comparative interrater reliability and ease of use was very limited. There were few head-to-head studies, studies had methodological limitations, and studies on ease of use focused on scoring of written or video patient scenarios. No study assessed ease of use as measured by time to complete assessments or assessor satisfaction.

- The interrater reliability of tGCS and mGCS appears to be high, but evidence was insufficient to determine if there were differences between scales (SOE: Insufficient).
  - Evidence was insufficient to assess effects of patient or assessor characteristics on comparative interrater reliability of the tGCS versus the mGCS (SOE: Insufficient).
  - No study evaluated how comparative interrater reliability or ease of use of the tGCS versus the mGCS varies according to assessment setting (SOE: Insufficient).
- Three studies found the tGCS associated with a lower proportion of correct scores than the mGCS (differences in proportion of correct scores ranged from 6% to 27%), though the difference was statistically significant in only one study (SOE: Low).

  - The proportion of correct GCS scores was generally lowest for assessment of patient scenarios with moderate injury severity in three studies, including one study that evaluated the tGCS and the mGCS (SOE: Low).
  - Three studies found that training or use of a scoring aid increased the proportion of correct scores on both the tGCS and mGCS (increase in proportion of correct scores ranged from 32% to 70%) (SOE: Low).
  - Evidence was insufficient to determine effects of level of training or professional background on the proportion of correct scores on the tGCS versus the mGCS (SOE: Insufficient).
- One study found agreement between out-of-hospital and ED scores was similar for the tGCS and the mGCS (SOE: Low).

Discussion

Key Findings and Strength of Evidence

Based on head-to-head studies, we found that the tGCS is associated with slightly better predictive utility than the mGCS, based on the AUROC, a measure of discrimination. The tGCS is better able than the mGCS to discriminate people with trauma who undergo neurosurgical intervention, have severe TBI, or undergo emergency intubation from people who do not experience these outcomes. However, the difference in the AUROC on each of these outcomes was small (<0.05). The tGCS was also better than the mGCS at discriminating trauma patients who died during hospitalization from those who survived hospitalization, but the difference in the AUROC was even smaller (0.01) than for nonmortality outcomes. Findings for the tGCS versus the SMS were similar to findings for the tGCS versus the mGCS for nonmortality outcomes, but the SMS performed slightly worse than the mGCS for in-hospital mortality (difference in AUROC 0.03). This means that for every 100 trauma patients, the tGCS is able to correctly discriminate 1 to 3 more cases of in-hospital mortality from cases without in-hospital mortality than the mGCS or the SMS. Although studies varied in how they defined neurosurgical interventions, severe brain injury, and emergency intubation, findings were generally similar across definitions for these outcomes. Findings for discrimination were robust in sensitivity and subgroup analyses based on the age group analyzed (children vs. adults or mixed), study year (before 2006 or 2006 or later), or risk of bias ratings. However, sensitivity and subgroup analyses were limited by small numbers of studies, particularly for nonmortality outcomes.

Evidence on how age, type of trauma, intubation status, intoxication status, receipt of field interventions, timing of GCS assessment, or level of training of people administering the GCS impacted predictive utility was limited. Few studies specifically evaluated children or patients with TBI, though those available reported findings similar to studies that evaluated adults, mixed populations of adults and children, or mixed trauma patients.

Evidence on interrater reliability and ease of use was limited. For assessment of patients with trauma, only one study, with methodological limitations and imprecise estimates, was included that compared interrater reliability of the tGCS, mGCS, and SMS. Studies that addressed ease of use were limited to those that evaluated whether the measures were scored correctly compared with a reference standard (usually expert assessment). Three studies found that the percentage of correct scores was higher for the mGCS than the tGCS, though in only one study was the difference statistically significant. Limited evidence suggests that errors are more frequent when assessing patient scenarios, indicating moderate injury severity (tGCS scores of 9-13).[51,53,56] For both scales, use of a scoring aid or training appears to improve the proportion of correct scores. No study evaluated other measures of ease of use, such as time to complete the assessment or assessor satisfaction.

One study found that agreement between field and ED scores was similar for the tGCS and mGCS.[55] Although differences between field and ED scores were noted for both scales, the study also found that blood pressure readings changed. Therefore, some differences between field and ED scores may accurately reflect changing status of the patient due to receipt of out-of-hospital interventions and evolving clinical status, rather than true lack of agreement.

Applicability

Our findings on predictive utility of different GCS scales appear to have broad applicability to field triage in the United States, as they are based on large studies conducted in U.S. trauma settings in mixed populations of adults and children with various types of trauma. We also restricted study inclusion to studies published in 1995 or later, with most studies conducted in the last 5 to 10 years, suggesting a high level of applicability to use in the context of current trauma systems.

Nonetheless, we identified a number of factors that can impact applicability. Despite the broad applicability of the evidence, its applicability to specific patient populations (e.g., specific type of trauma, age, presence and severity

of intoxication, presence of medical comorbidities, and presence of other injuries) is less certain. Limited evidence suggests similar results in children versus mixed populations of adults plus children and in patients with TBI versus mixed trauma populations. No study evaluated how predictive utility varied according to the level or training of field training personnel. In fact, no study that used out-of-hospital scores reported information on the training of the people administering the GCS. Another factor that could impact applicability is that the performance of the tGCS and mGCS may be different when administered soon after injury (in the field) as opposed to later (after field stabilization and destination decisions have been made or after patients have arrived in the ED). A number of studies on predictive utility were conducted in ED settings, which is more controlled and easier to study than field settings. Evidence on the predictive utility from studies conducted in the ED may be of limited applicability to field settings. However, we found that predictive utility was similar in studies that utilized out-of-hospital versus ED GCS scores. We also found no clear differences in estimates of predictive utility when we restricted analyses to studies conducted in U.S. settings or to more recent (2006 or later) studies, which may be more applicable to current U.S. practice.

Research Recommendations

Head-to-head observational or randomized studies that assess one set of patients with the tGCS and another set with the SMS or mGCS are needed to understand effects on clinical outcomes as well as risk of over- or under-triage. For over- and under-triage, studies should utilize standardized, validated measures to determine the appropriateness of transport and triage decisions. For predictive utility, prospective studies that independently assess patients using the tGCS and the mGCS or SMS would be useful for confirming the findings of the currently available retrospective studies. Studies are needed to better understand the predictive utility in important subpopulations, including children, older patients, patients with specific types of trauma, and patients who have received field interventions prior to assessment. For patients who are intoxicated or intubated, studies that measure how frequently the tGCS reverts to the mGCS due to the inability to assess the other GCS components would be helpful. Studies that evaluate how the predictive utility of the tGCS compares with the mGCS or SMS varies according to the level or type of training of assessing personnel in the field are also needed. Finally, studies that assess measures of predictive utility other than discrimination (e.g., calibration, adjusted risk estimates, diagnostic accuracy, risk reclassification) would be useful for providing more complete information regarding predictive utility.

Conclusions

The tGCS is associated with slightly greater discrimination than the mGCS or SMS for in-hospital mortality, receipt of neurosurgical interventions, severe brain injury, and emergency intubation, with differences in the AUROC ranging from 0.01 to 0.05. The clinical significance of small differences in discrimination is likely to be small, and could be offset by factors such as convenience and ease of use. Research is needed to understand how use of the tGCS versus the mGCS or SMS impacts clinical outcomes and risk of over- or under-triage.

References

1. Centers for Disease Control and Prevention. 10 Leading Causes of Death by Age Group, United States - 2014. http://www.cdc.gov/injury/images/lc-charts/leading_causes_of_death_age_group_2014_1050w760h.gif. Accessed May 5, 2016.
2. Centers for Disease Control and Prevention. 10 Leading Causes of Injury Deaths by Age Group Highlighting Unintentional Injury Deaths, United States - 2014. http://www.cdc.gov/injury/images/lc-charts/leading_causes_of_injury_deaths_unintentional_injury_2014_1040w740h.gif. Accessed May 5, 2016.
3. Centers for Disease Control and Prevention. National Hospital Ambulatory Medical Care Survey: 2011 Emergency Department Summary Tables. http://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2011_ed_web_tables.pdf. Accessed May 5, 2016.
4. Sasser SM, Hunt RC, Faul M, et al. Guidelines for field triage of injured patients: recommendations of the national expert panel on field triage, 2011. MMWR Recomm Rep. 2012 Jan 13;61(RR-1): 1-20. PMID: 22237112.
5. Faul M, Xu L, Wald MM, et al. Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations and Deaths 2002–2006. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control: 2010. http://www.cdc.gov/traumaticbraininjury/pdf/blue_book.pdf.
6. Centers for Disease Control and Prevention. Rates of TBI-related emergency department visits, hospitalizations, and deaths-United States, 2001–2010. Injury Prevention & Control: Traumatic Brain Injury. 2016.
7. Committee on Trauma, American College of Surgeons, Rotondo MF, et al., eds. Resources for Optimal Care of the Injured Patient. 6th ed. Chicago: American College of Surgeons; 2014.
8. Baxt WG, Moody P. The impact of advanced prehospital emergency care on the mortality of severely brain-injured patients. J Trauma. 1987 Apr;27(4):365-9. PMID: 3573084.

9. MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of trauma-center care on mortality. N Engl J Med. 2006 Jan 26;354(4):366-78. doi: 10.1056/NEJMsa052049. PMID: 16436768.

10. Cook CH, Muscarella P, Praba AC, et al. Reducing overtriage without compromising outcomes in trauma patients. Arch Surg. 2001 Jul;136(7):752-6. PMID: 11448384.

11. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet. 1974 Jul 13;2(7872):81-4. PMID: 4136544.

12. Teasdale G, Maas A, Lecky F, et al. The Glasgow Coma Scale at 40 years: standing the test of time. Lancet Neurol. 2014 Aug;13(8):844-54. doi: 10.1016/S1474-4422(14)70120-6. PMID: 25030516.

13. Marshall LF. Evoked potentials: a decade later. Crit Care Med. 1991 Nov;19(11):1337. PMID: 1935149.

14. Bradshaw D. Report to the Surgeon General: Traumatic Brain Injury Task Force. May 15, 2007. 2008. https://www.hsdl.org/?view&did=482727. Accessed December 22, 2015.

15. Singh B, Murad MH, Prokop LJ, et al. Meta-analysis of Glasgow Coma Scale and Simplified Motor Score in predicting traumatic brain injury outcomes. Brain Inj. 2013;27(3):293-300. doi: 10.3109/02699052.2012.743182. PMID: 23252405.

16. Brown KM, Hirshon JM, Alcorta R, et al. The implementation and evaluation of an evidence-based statewide prehospital pain management protocol developed using the national prehospital evidence-based guideline model process for emergency medical services. Prehosp Emerg Care. 2014;18 Suppl 1:45-51. doi: 10.3109/10903127.2013.831510. PMID: 24134543.

17. Beskind DL, Stolz U, Gross A, et al. A comparison of the prehospital motor component of the Glasgow Coma Scale (mGCS) to the prehospital total GCS (tGCS) as a prehospital risk adjustment measure for trauma patients. Prehosp Emerg Care. 2014 Jan-Mar;18(1):68-75. doi: 10.3109/10903127.2013.844870. PMID: 24329032.

18. Healey C, Osler TM, Rogers FB, et al. Improving the Glasgow Coma Scale score: motor score alone is a better predictor. J Trauma. 2003 Apr;54(4):671-8; discussion 8-80. doi: 10.1097/01.ta.0000058130.30490.5d. PMID: 12707528.

19. Ross SE, Leipold C, Terregino C, et al. Efficacy of the motor component of the Glasgow Coma Scale in trauma triage. J Trauma. 1998 Jul;45(1):42-4. PMID: 9680010.

20. Gill M, Windemuth R, Steele R, et al. A comparison of the Glasgow Coma Scale score to simplified alternative scores for the prediction of traumatic brain injury outcomes. Ann Emerg Med. 2005 Jan;45(1):37-42. PMID: 15635308.

21. Cook NR. Statistical evaluation of prognostic versus diagnostic models: beyond the ROC curve. Clin Chem. 2008 Jan;54(1):17-23. doi: 10.1373/clinchem.2007.096529. PMID: 18024533.

22. Menegazzi JJ, Davis EA, Sucov AN, et al. Reliability of the Glasgow Coma Scale when used by emergency physicians and paramedics. J Trauma. 1993 Jan;34(1):46-8. PMID: 8437195.

23. Gill MR, Reiley DG, Green SM. Interrater reliability of Glasgow Coma Scale scores in the emergency department. Ann Emerg Med. 2004 Feb;43(2):215-23. doi: 10.1016/S019606440300814X. PMID: 14747811.

24. National Emergency Medical Services Workforce Data Definitions. (Prepared by the American Institutes for Research through contract DTNH22-080F-00122.). Washington, DC: National Highway Traffic Safety Administration; February 2013. www.nhtsa.gov/staticfiles/nti/pdf/811720.pdf. Accessed October 7, 2016.

25. Badjatia N, Carney N, Crocco TJ, et al. Guidelines for prehospital management of traumatic brain injury 2nd edition. Prehosp Emerg Care. 2008;12 Suppl 1:S1-52. doi: 10.1080/10903120701732052. PMID: 18203044.

26. Bazzoli GJ, Madura KJ, Cooper GF, et al. Progress in the development of trauma systems in the United States. Results of a national survey. Jama. 1995 Feb 1;273(5):395-401. PMID: 7823385.

27. Hayden JA, van der Windt DA, Cartwright JL, et al. Assessing bias in studies of prognostic factors. Ann Intern Med. 2013 Feb 19;158(4):280-6. doi: 10.7326/0003-4819-158-4-201302190-00009. PMID: 23420236.

28. Whiting PF, Rutjes AW, Westwood ME, et al. QUADAS-2: a revised tool for the quality assessment of diagnostic accuracy studies. Ann Intern Med. 2011 Oct 18;155(8):529-36. doi: 10.7326/0003-4819-155-8-201110180-00009. PMID: 22007046.

29. Methods Guide for Effectiveness and Comparative Effectiveness Reviews. AHRQ Publication No. 10(14)-EHC063-EF. Rockville, MD: Agency for Healthcare Research and Quality; January 2014. www.effectivehealthcare.ahrq.gov. Accessed December 22, 2015. PMID: 21433403.

30. Acker SN, Ross JT, Partrick DA, et al. Glasgow motor scale alone is equivalent to Glasgow Coma Scale at identifying children at risk for serious traumatic brain injury. J Trauma Acute Care Surg. 2014 Aug;77(2):304-9. doi: 10.1097/TA.0000000000000300. PMID: 25058258.

31. Al-Salamah MA, McDowell I, Stiell IG, et al. Initial emergency department trauma scores from the OPALS study: the case for the motor score in blunt trauma. Acad Emerg Med. 2004 Aug;11(8):834-42. PMID: 15289188.

32. Brown JB, Forsythe RM, Stassen NA, et al. Evidence-based improvement of the National Trauma Triage Protocol: the Glasgow Coma Scale versus Glasgow Coma Scale motor subscale. J Trauma Acute Care Surg. 2014 Jul;77(1):95-102; discussion 1-2. doi: 10.1097/TA.0000000000000280. PMID: 24977762.

33. Caterino JM, Raubenolt A. The prehospital Simplified Motor Score is as accurate as the prehospital Glasgow Coma Scale: analysis of a statewide trauma registry. Emerg Med J. 2012 Jun;29(6):492-6. doi: 10.1136/emj.2010.110437. PMID: 21795294.

34. Caterino JM, Raubenolt A, Cudnik MT. Modification of Glasgow Coma Scale criteria for injured elders. Emerg Med J. 2011 Oct;18(10):1014-21. doi: 10.1111/j.1553-2712.2011.01164.x. PMID: 21951715.

35. Cicero MX, Cross KP. Predictive value of initial Glasgow Coma Scale score in pediatric trauma patients. Pediatr Emerg Care. 2013 Jan;29(1):43-8. doi: 10.1097/PEC.0b013e31827b52bf. PMID: 23283262.

36. Corrigan JD, Kreider S, Cuthbert J, et al. Components of traumatic brain injury severity indices. J Neurotrauma. 2014 Jun;31(11):1000-7. doi: 10.1089/neu.2013.3145. PMID: 24521197.

37. Davis DP, Serrano JA, Vilke GM, et al. The predictive value of field versus arrival Glasgow Coma Scale score and TRISS calculations in moderate-to-severe traumatic brain injury. J Trauma. 2006 May;60(5):985-90. PMID: 16688059.

38. Eken C, Kartal M, Bacanli A, et al. Comparison of the Full Outline of UnResponsiveness score coma scale and the Glasgow Coma Scale in an emergency setting population. Eur J Emerg Med. 2009 Feb;16(1):29-36. doi: 10.1097/MEJ.0b013e32830346ab. PMID: 19106717.

39. Gill M, Steele R, Windemuth R, et al. A comparison of five simplified scales to the out-of-hospital Glasgow Coma Scale for the prediction of traumatic brain injury outcomes. Acad Emerg Med. 2006 Sep;13(9):968-73. PMID: 16894005.

40. Haukoos JS, Gill MR, Rabon RE, et al. Validation of the Simplified Motor Score for the prediction of brain injury outcomes after trauma. Ann Emerg Med. 2007 Jul;50(1):18-24. PMID: 17113193.

41. Holmes JF, Palchak MJ, MacFarlane T, et al. Performance of the pediatric Glasgow Coma Scale in children with blunt head trauma. Acad Emerg Med. 2005 Sep;12(9):814-9. PMID: 16141014.

42. Johnson DL, Krishnamurthy S. Send severely head-injured children to a pediatric trauma center. Pediatr Neurosurg. 1996 Dec;25(6):309-14. PMID: 9348151.

43. Kupas DF, Melnychuk EM, Young AJ. Glasgow Coma Scale Motor Component ("patient does not follow commands") performs similarly to Total Glasgow Coma Scale in predicting severe injury in trauma patients. Ann Emerg Med. 2016:1-7. doi: 10.1016/j.annemergmed.2016.06.017. PMID: 27436703.

44. Leijdesdorff HA, van Dijck JT, Krijnen P, et al. Injury pattern, hospital triage, and mortality of 1250 patients with severe traumatic brain injury caused by road traffic accidents. J Neurotrauma. 2014 Mar 1;31(5):459-65. doi: 10.1089/neu.2013.3111. PMID: 24093437.

45. Majdan M, Steyerberg EW, Nieboer D, et al. Glasgow Coma Scale motor score and pupillary reaction to predict six-month mortality in patients with traumatic brain injury: comparison of field and admission assessment. J Neurotrauma. 2015 Jan 15;32(2):101-8. doi: 10.1089/neu.2014.3438. PMID: 25227136.

46. Nesiama JA, Pirallo RG, Lerner EB, et al. Does a prehospital Glasgow Coma Scale score predict pediatric outcomes? Pediatr Emerg Care. 2012 Oct;28(10):1027-32. doi: 10.1097/PEC.0b013e31826cac31. PMID: 23023472.

47. Reisner A, Chen X, Kumar K, et al. Prehospital heart rate and blood pressure increase the positive predictive value of the Glasgow Coma Scale for high-mortality traumatic brain injury. J Neurotrauma. 2014 May 15;31(10):906-13. doi: 10.1089/neu.2013.3128. PMID: 24372334.

48. Thompson DO, Hurtado TR, Liao MM, et al. Validation of the Simplified Motor Score in the out-of-hospital setting for the prediction of outcomes after traumatic brain injury. Ann Emerg Med. 2011 Nov;58(5):417-25. doi: 10.1016/j.annemergmed.2011.05.033. PMID: 21803448.

49. Van de Voorde P, Sabbe M, Rizopoulos D, et al. Assessing the level of consciousness in children: a plea for the Glasgow coma motor subscore. Resuscitation. 2008 Feb;76(2):175-9. doi: 10.1016/j.resuscitation.2007.07.007. PMID: 17728046.

50. Arbabi S, Jurkovich GJ, Wahl WL, et al. A comparison of prehospital and hospital data in trauma patients. J Trauma. 2004 May;56(5):1029-32. PMID: 15179242.

51. Bledsoe BE, Casey MJ, Feldman J, et al. Glasgow Coma Scale scoring is often inaccurate. Prehospital Disaster Med. 2015 Feb;30(1):46-53. doi: 10.1017/S1049023X14001289. PMID: 25489727.

52. Dinh MM, Oliver M, Bein K, et al. Level of agreement between prehospital and emergency department vital signs in trauma patients. Emerg Med Australas. 2013 Oct;25(5):457-63. doi: 10.1111/1742-6723.12126. PMID: 24099376.

53. Feldman A, Hart KW, Lindsell CJ, et al. Randomized controlled trial of a scoring aid to improve Glasgow Coma Scale scoring by emergency medical services providers. Ann Emergency Med. 2015;65(3):325-9.e2. PMID: 25199613.

54. Heim C, Schoettker P, Gilliard N, et al. Knowledge of Glasgow Coma Scale by air-rescue physicians. Scand J Trauma Resusc Emerg Med. 2009;17:39. doi: 10.1186/1757-7241-17-39. PMID: 19723331.

55. Kerby JD, MacLennan PA, Burton JN, et al. Agreement between prehospital and emergency department Glasgow Coma Scores. J Trauma. 2007 Nov;63(5):1026-31. PMID: 17993947.

56. Lane PL, Baez AA, Brabson T, et al. Effectiveness of a Glasgow Coma Scale instructional video for EMS providers. Prehospital Disaster Med. 2002 Jul-Sep;17(3):142-6. PMID: 12627917.

57. Takahashi C, Okudera H, Origasa H, et al. A simple and useful coma scale for patients with neurologic emergencies: the emergency coma scale. Am J Emerg Med. 2011 Feb;29(2):196-202. doi: 10.1016/j.ajem.2009.09.018. PMID: 20825789.

Full Report

This executive summary is part of the following document: Chou R, Totten AM, Pappas M, Carney N, Dandy S, Grusing S, Fu R, Wasson N, Newgard C. Glasgow Coma Scale for Field Triage of Trauma: A Systematic Review. Comparative Effectiveness Review No.182. (Prepared by the Pacific Northwest Evidence-based Practice Center under Contract No. 290-2015-00009-I.) AHRQ Publication No.16(17)-EHC041-EF. Rockville, MD: Agency for Healthcare Research and Quality; January 2017. www.effectivehealthcare.ahrq.gov/reports/final.cfm.

AHRQ Pub. No.16(17)-EHC041-1-EF
January 2017
www.ahrq.gov