Randomized Controlled Trial of a Scoring Aid to Improve Glasgow Coma Scale Scoring by Emergency Medical Services Providers

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Study objective: Emergency medical services (EMS) personnel frequently use the Glasgow Coma Scale (GCS) to assess injured and critically ill patients. This study assesses the accuracy of EMS providers' GCS scoring, as well as the improvement in GCS score assessment with the use of a scoring aid.

Methods: This randomized, controlled study was conducted in the emergency department (ED) of an urban academic trauma center. Emergency medical technicians or paramedics who transported a patient to the ED were randomly assigned one of 9 written scenarios, either with or without a GCS scoring aid. Scenarios were created by consensus of expert attending emergency medicine, EMS, and neurocritical care physicians, with universal consensus agreement on GCS scores. χ^2 And Student's t tests were used to compare groups.

Results: Of 180 participants, 178 completed the study. Overall, 73 of 178 participants (41%) gave a GCS score that matched the expert consensus score. GCS score was correct in 22 of 88 (25%) cases without the scoring aid. GCS was correct in 51 of 90 (57%) cases with the scoring aid. Most (69%) of the total GCS scores fell within 1 point of the expert consensus GCS score. Differences in accuracy were most pronounced in scenarios with a correct GCS score of 12 or below. Subcomponent accuracy was eye 62%, verbal 70%, and motor 51%.

Conclusion: In this study, 60% of EMS participants provided inaccurate GCS score estimates. Use of a GCS scoring aid improved accuracy of EMS GCS score assessments. [Ann Emerg Med. 2015;65:325-329.]

Please see page 326 for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background and Importance

First introduced in 1974, the Glasgow Coma Scale (GCS) is commonly used to describe the level of consciousness in and to predict outcomes of a wide variety of patients, including those in the out-of-hospital setting.[1-3] Out-of-hospital providers use baseline and changes in GCS score assessments to indicate the severity of injuries or illness, and to aid in patient triage.[2,4] In addition to its clinical utility, the GCS is commonly used in research for ascertainment of participant eligibility and as an outcomes assessment or adjustment for baseline severity.[5]

Because the GCS can play a role in the initial and ongoing treatment of the patient, quick and accurate evaluation is necessary. The ability of out-of-hospital providers to accurately score the GCS has not been well reported, yet anecdotally they are often criticized for inaccurate GCS score assessment. There are only limited data characterizing the degree of emergency medical services (EMS) GCS inaccuracy.[6] Furthermore, interrater reliability of GCS scoring is known to be low, including in the out-of-hospital setting.[4,7,8] An aid to facilitate quick recall of the GCS in real time could improve scoring accuracy.[9]

Goals of This Investigation

This study assessed the accuracy of EMS providers' GCS scoring of written scenarios and estimated the potential for a GCS scoring aid to improve accuracy. We hypothesized that providers who were assisted by a GCS scoring table would assess GCS more accurately than those who were not.

MATERIALS AND METHODS

Study Design and Setting

This randomized controlled study of the utility of a GCS scoring table aid was conducted in the emergency department (ED) of an urban, academic Level I trauma center. The University of Cincinnati Institutional Review Board approved the study.

Selection of Participants

Participants were emergency medical technicians or paramedics who had transported a patient to the ED. We enrolled subjects during times of study personnel availability, which included weekdays, nights, and weekends. Providers were permitted to participate only once and had to be older than 18

Editor's Capsule Summary

What is already known on this topic

Emergency medical services (EMS) personnel assessments of Glasgow Coma Scale (GCS) score are often inaccurate.

What question this study addressed

Does the use of a scoring aid improve the accuracy of EMS GCS score assessments?

What this study adds to our knowledge

Among mock written scenarios evaluated by 178 EMS personnel, GCS score accuracy was higher with (57%) than without (25%) a scoring aid.

How this is relevant to clinical practice

This scenario-based study found that GCS scoring accuracy for EMS personnel was low even when assisted by a scoring aid, further undermining the value of this already poor tool for neurologic assessment.

years. The study was approved by the institutional review board, and all participants provided informed consent.

Methods of Measurement

Nine standardized brief patient scenarios (Table E1, available online at http://www.annemergmed.com) were modified from 3 widely used EMS textbooks.[10-12] Attending physicians specializing in emergency medicine, EMS, and neurocritical care reviewed the scenarios and provided revisions until there was universal agreement on GCS scores. The scenarios depicted patients with GCS scores corresponding to mild (GCS score 13 to 15), moderate (GCS score 9 to 12), and severe (GCS score 3 to 8) traumatic brain injuries. The test scenarios and expert consensus GCS scores were verified by an independent team of paramedic instructors.

Scenarios with or without the scoring table were placed into sequentially numbered, sealed envelopes for distribution to participants. Each participant was randomly assigned to determine GCS scores on one of the 9 scenarios, with or without the scoring table. No blinding methods were used after randomization. Participants were asked to provide the total GCS score of the patient in the scenario, as well as the eye, verbal, and motor subcomponent scores. The participants' demographic information was collected, including experience, level of training, and EMS practice habits.

Outcome Measures

The primary outcome was the absolute agreement between the participants' assigned GCS scores and the correct GCS score determined by the attending physician review. Secondary outcomes included the frequency of scores falling within 1 point of the correct score, accuracy of subcomponent scores, and accuracy for the different levels of severity.

A sample size of 90 in each group would have 80% power to detect an absolute difference of 15% of the proportion of subjects able to correctly determine the GCS score with or without the GCS scoring aid when α=.05 and conservatively assuming a wide SD.

Data Collection and Processing

The 1:1 randomization sequence was generated with nQuery Adviser (version 7.0; Statistical Solutions, Boston, MA) and designed to ensure equal distribution of the 9 scenarios among those receiving the GCS aid and those not receiving it. Participants' responses were entered into an electronic database (REDCap; Vanderbilt University, Nashville, TN). Out-of-range GCS scores were queried and confirmed. Missing data were minimal and left missing. We compared participant GCS score with expert consensus GCS ratings, using the χ^2 test or Fisher's exact test, as appropriate, to test for differences in proportions and calculated 95% confidence intervals (CIs) for the effect size. We adjusted for multiple comparisons with Sidak's method.

All statistical analyses were conducted with SPSS (version 22.0; IBM Corporation, Armonk, NY). Graphics were created with R (gplots). Differences in means and proportions and 95% CIs were calculated.

RESULTS

Characteristics of Study Subjects

Between April 2013 and June 2013, 261 subjects were screened; 16 declined participation and 65 did not meet inclusion criteria. Of 180 subjects enrolled, 2 participants were excluded because of incomplete GCS scores, leaving 178 cases in the analysis (Figure E1, available online at http://www.annemergmed.com).

Participant characteristics are described in Table 1. Approximately half (52%) were paramedics. Participants were drawn from 41 EMS departments or agencies, which were diverse and included rural, suburban, and urban settings; paid and volunteer staffing models; and annual call volumes ranging from less than 500 to greater than 55,000. The mean length of experience was 12 years (SD 8). Most participants (70%) reported they had been refreshed on GCS material through a course, recertification, or training within the past year, and 56% stated they consistently use some sort of aid in the field to help determine the GCS score. The 2 study arms were well matched in experience and certification levels, and no protocol deviations occurred.

Overall, 73 of 178 participants (41%) gave a GCS score that matched the correct GCS score (Table 2; Figure). Among participants who did not receive the standard GCS scoring table as an aid, the GCS score was correct in 22 of 88 cases (25%) compared with 51 of 90 (57%) for those who did receive the table aid (difference in proportions 32%; 95% CI 18% to 46%).

Table 1. Participant characteristics.

	No Table Aid (n=88)		Table Aid (N=90)		Total (n=178)	
Age, mean (SD), y	37	(10)	36	(9)	36	(9)
Race, No. (%)						
White	72	(81.8)	76	(84.4)	148	(83.1)
Black	15	(17.0)	11	(12.2)	26	(14.5)
American Indian/Alaskan Native	0	(0)	2	(2.2)	2	(1.1)
Other	1	(1.1)	0	(0)	1	(0.6)
Asian/Pacific Islander	0	(0)	1	(1.1)	1	(0.6)
Male, No. (%)	80	(90.9)	77	(85.6)	157	(88.2)
Level of EMS certification, No. (%)						
EMT-basic	44	(50.0)	39	(43.3)	83	(46.9)
EMT-intermediate	2	(2.3)	0	(0)	2	(1.1)
Paramedic	42	(47.7)	51	(56.7)	93	(52.0)
Years of experience, mean (SD)	12	(8)	11	(7)	12	(8)
Refreshed on GCS material within the past year, No. (%)	58	(65.9)	67	(74.4)	125	(70.2)
EMS instructor, No. (%)	6	(6.8)	7	(7.8)	13	(7.8)
Use aid to determine the GCS in the field, No. (%)	54	(61.4)	45	(50.0)	99	(50.0)

Overall, 123 of 178 scores (69%) fell within 1 point of the correct GCS score. There was equal likelihood to overestimate (29.2%) and underestimate (29.8%) the total GCS score. More scores were correct within 1 point in the group who received the table aid than the group who did not (82.2% versus 55.7%; difference 26.5%; 95% CI 13.5% to 39.6%). The mean difference between actual and participant-assigned GCS scores for the group without the table was 2.6, and the mean participant-assigned GCS scores for the group with the table was 2.1 (difference of means 0.5; 95% CI –0.3 to 1.3).

The difference in accuracy between the 2 groups was most pronounced in the moderate (GCS score 9 to 12) and severe (GCS score 3 to 8) scenarios (Table 2; Figure). Twelve participants (7%) gave subcomponent scores that are not possible on the scale. Eye component accuracy improved from 43% without the table aid to 80% with the table aid, the verbal from 55% to 86%, and motor from 31% to 70% (Table 2; Figure).

LIMITATIONS

Scoring a written scenario in a controlled environment and assigning a GCS score during the immediate evaluation and treatment phase of an acutely ill or injured patient are inherently

Table 2. Scoring of patient scenarios by EMS providers.*

	Total (n=178)		No Table Aid (n=88)		Table Aid (n=90)			95% CI	
	No.	%	No.	%	No.	%	% Difference	Lower	Upper
All GCS scenarios									
Total	73	(41.0)	22	(25.0)	51	(56.7)	31.9	18.3	45.6
Eye	110	(61.8)	38	(43.2)	72	(80.0)	37.3	24.1	50.5
Verbal	125	(70.2)	48	(54.5)	77	(85.6)	31.6	19.0	44.3
Motor	90	(50.6)	27	(30.7)	63	(70.0)	39.7	26.2	53.1
Mild TBI scenarios (GCS score 13–15)									
Total	32	(54.2)	13	(44.8)	19	(63.3)	14.3	−6.1	34.6
Eye	41	(69.5)	16	(55.2)	25	(83.3)	18.5	−6.5	43.5
Verbal	47	(79.7)	21	(72.4)	26	(86.7)	28.2	5.7	50.6
Motor	44	(74.6)	17	(58.6)	27	(90.0)	29.3	6.1	52.5
Moderate TBI scenarios (GCS score 9–12)									
Total	17	(28.8)	3	(10.3)	14	(46.7)	31.4	10.5	52.3
Eye	37	(62.7)	12	(41.4)	25	(83.3)	34.9	13.1	56.8
Verbal	41	(69.5)	15	(51.7)	26	(86.7)	36.3	15.3	57.3
Motor	21	(35.6)	6	(20.7)	15	(50.0)	40.0	17.4	62.6
Severe TBI scenarios (GCS score 3–8)									
Total	24	(40.0)	6	(20.0)	18	(60.0)	40.0	16.9	63.1
Eye	32	(53.3)	10	(33.3)	22	(73.3)	42.0	19.6	64.3
Verbal	37	(61.7)	12	(40.0)	25	(83.3)	43.3	21.3	65.4
Motor	25	(41.7)	4	(13.3)	21	(70.0)	56.7	36.2	77.1

TBI, Traumatic brain injury.

*Results are presented as the proportion of absolutely correctly assigned composite and component GCS scores and further stratified by mild, moderate, and severe TBI scenarios.

different. Although we have mirrored previously used methodologies,[9,13] our approach may overestimate accuracy because the EMS providers are not subject to the task saturation of clinical care. Conversely, it is possible that the information gained from examining a live patient is more useful than that presented in a written scenario, which could improve the accuracy of GCS estimates.

We did not record whether subjects sought help in scoring the scenarios either from another EMS provider or from their personal GCS scoring aids, although no such activity was witnessed. Use of a scoring aid in the group not given one as part of the study would bias toward improved accuracy, and failure to use the aid provided would cause the opposite. In either case, the actual effect sizes would be greater than we observed.

Although we identified a deficiency in GCS scoring by EMS providers, we are unable to speculate about the reasons such a deficiency exists. Use of a scoring aid does improve accuracy, but discovery of other potential causes—and solutions—would be useful.

DISCUSSION

These results suggest that GCS score assessment with a scoring table improves the accuracy of EMS providers' GCS scoring of patients, using written scenarios. However, even with use of a GCS table, accuracy of GCS scoring by EMS providers was low.

The GCS has been criticized as somewhat complex, and the fundamental utility and appropriateness of GCS scores in emergency medicine, and out-of-hospital care by proxy, have been challenged.[14] We agree that GCS is imperfect and we support calls for a better tool. However, despite these criticisms,[14] GCS is still the tool that has been universally adopted in clinical care. Until the GCS can be replaced, *accurate* scoring using the GCS should be emphasized. The inability of EMS providers to accurately assess an injured patient and communicate the findings is a problem regardless of the tool used.

Our data empirically quantify the inaccuracy, offering providers information that should be useful in interpreting an out-of-hospital GCS score. Clinically, a 1-point discrepancy in the GCS score may be acceptable, and when a scoring table aid was made available to providers, 82% of scores were within 1 point of the correct score. In other situations, even a 1-point error may prompt inappropriate field triage to a trauma center, exclusion from a clinical trial, or consideration of a procedure (ie, intubation). Providers were just as likely to overestimate and underestimate scores, and the magnitude of the difference was frequently enough to change the assigned category in the mild/moderate/severe classification scheme (Figure).

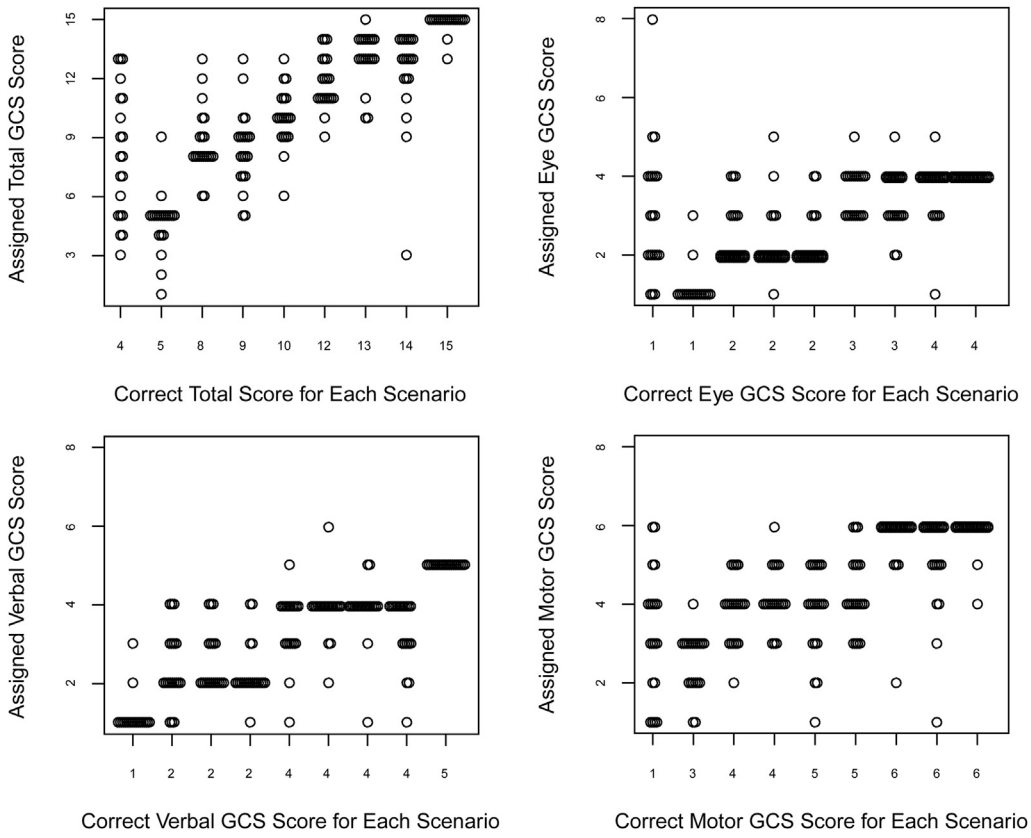

Figure. Dot plot of assigned composite and component GCS scores for each scenario. Each circle represents the score assigned by a single respondent.

Although our findings of inaccuracy when relying on memory alone are, unfortunately, not unique,[9] we show that having a scoring table aid readily available more than doubles (25% to 57%) the number of accurate scores. To our knowledge, this is the first intervention shown to improve GCS scoring accuracy. In accordance with our observations, EMS providers should be given GCS scoring cards, with real-time use strongly encouraged.

Some health care providers have advocated abandonment of the full GCS and suggest simplifications or using only the motor component.[15-18] In our sample, the motor score was the least reliable of the subcomponents. Proposed alternatives to the GCS that simplify assessment of consciousness include the FOUR score and the Emergency Coma Scale.[19,20] However, these scoring methods may also suffer from accuracy limitations because the eye and motor components are similar to those of the GCS. Additionally, many of the articles that compare GCS with a newer tool of mental status assessment rely on retrospectively recorded out-of-hospital GCS values as the criterion standard.[18,19] Our results do not support abandoning the full GCS in favor of these alternatives.

Our findings provide the key insights about the inaccuracy of GCS scoring by EMS and support the need for improved tools for evaluating out-of-hospital patients with neurologic emergencies. Until a new method of evaluating altered mental status in the setting of trauma is developed, validated, and adopted, use of a GCS scoring aid may help to improve the accuracy of the EMS GCS score assessments.

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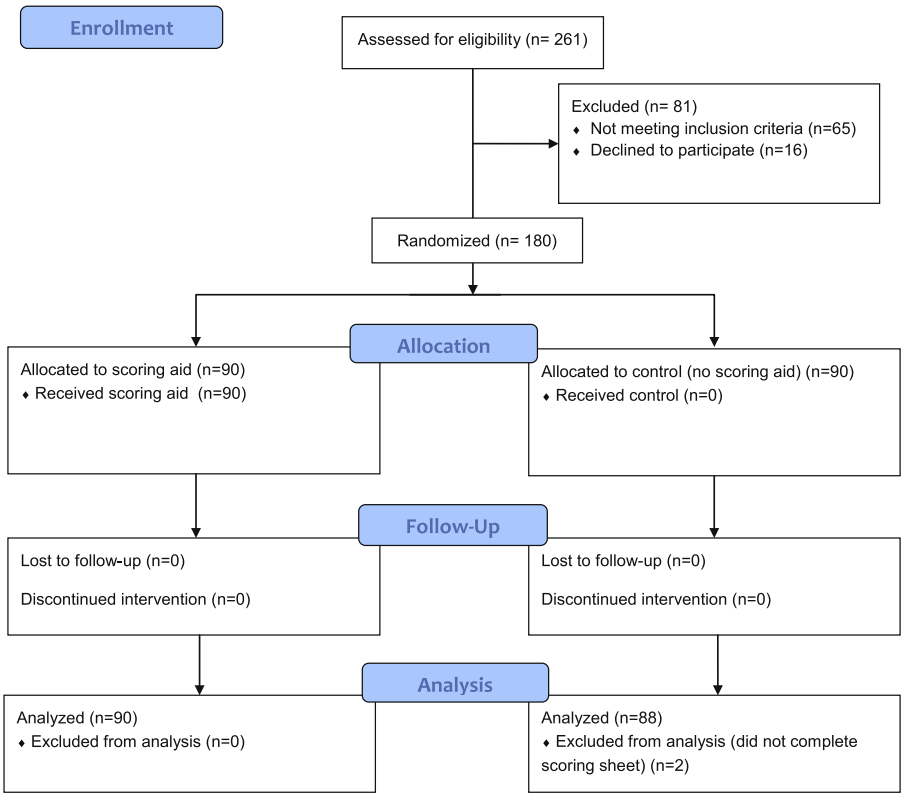

Figure E1. CONSORT flow diagram of subjects.

Table E1. Patient scenarios randomly provided to on-duty EMS providers for GCS scoring, with the correct component and composite scores for each.

		Eye	Verbal	Motor	Total
Mild TBI					
1	You respond to the scene of a 50-y-old man who was injured in a bicycle accident. A car pulled in front of him, forcing him off the road, and he fell in a grassy median. He is sitting up, inspecting his helmet, and is only complaining of road rash to his arms and legs. He is giving the police a description of the car involved and limps to the ambulance to have his wounds dressed.	4	5	6	15
2	You respond to an 18-y-old man involved in a single-car MVC, in which he struck a tree. There is moderate damage to the car, and he is sitting on the curb. When you ask him the date, he has slurred speech and states, "December 12, 2002" (it is actually February 14, 2013). When you ask him to show you 2 fingers, he giggles and flips you off with both hands. You note a strong odor of alcohol on his breath and possible track marks on his arms.	4	4	6	14
3	You respond to a 28-y-old woman struck in the head by a canoe oar. She was pulled from the river by bystanders, who state she was unconscious. She was wearing a life jacket. She awakens when you ask whether she is okay and asks what happened over and over again. She shows you 2 fingers on each hand when you ask her to do so.	3	4	6	13
Moderate TBI					
4	You respond to a 16-y-old woman who was a pedestrian struck by a car and find her lying in the street. She has a boggy hematoma to the right side of her scalp and abrasions to her arms and legs. Her pupils are equal, round, and reactive to light. She opens her eyes when you call her name but she is confused. She knows her name and the year, but not the date or month. When you ask her to show you 2 fingers, she looks confused and does nothing. When you attempt to insert an IV line in her right arm, she quickly pulls away, swats at you with her left hand, and says, "Stop it!"	3	4	5	12
5	You respond to a 24-y-old male assault victim who was struck in the side of his head with a baseball bat during a bar fight. You find him breathing but unconscious. When you perform a sternal rub, he opens his eyes and tries to pull away, and stops when you stop stimulating him. When you constantly sternally rub him, he will talk to you and thinks the year is 1963 when asked (it is 2013).	2	4	4	10
6	You respond to a call for a "man down" by the railroad tracks and find a disheveled 45-y-old man facedown and parallel to the tracks. As you approach, he is moaning but you cannot understand what he is trying to say. He will not answer questions or follow commands. His breathing is normal, he is covered in blood, and he has obvious deformities to his right arm and leg. When you apply a sternal rub, he reaches for your hand and briefly opens his eyes; his pupils are equal.	2	2	5	9
Severe TBI					
7	You respond to a 22-y-old woman who was pushed down the stairs during a fight with her boyfriend. She fell down 12 wooden steps and landed on the cement basement floor. She is bleeding from the nose and mouth and has an obvious deformity to her left wrist. She will briefly open her eyes to a sternal rub, and her pupils are normal-sized and sluggishly reactive to light. She tries to pull away when you pinch her shoulder and mumbles something you cannot understand, but settles when you stop applying stimulation.	2	2	4	8
8	You respond to a motorcycle accident in which an unhelmeted rider hit a car that unexpectedly pulled out of a parking lot. He is found lying supine in the road 20 feet from the site of impact. Initially, you notice that he has irregular, snoring respirations and has obvious trauma to his head, face, and right leg. He is unresponsive and does not open his eyes to a deep sternal rub. You pull his eyelids open and discover that his left pupil is 2 mm larger than his right. Other than noisy respirations, he makes no sounds at any time. When you apply a sternal rub, his arms pull into his chest and his legs straighten out.	1	1	3	5
9	You respond to an 18-y-old man who fell out of a tree and landed on his head. He is briskly bleeding from his scalp but has no other obvious injuries. His only response to a deep sternal rub is to moan and groan. On your secondary examination, you find that his pupils are equal, dilated, and sluggishly reactive to light. There are several empty beer bottles at the base of the tree, and there is a strong odor of alcohol on his breath.	1	2	1	4