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Glasgow Coma Scale Score in Survivors of Explosion With Possible Traumatic Brain Injury in Need of Neurosurgical Intervention

Itamar Ashkenazi, MD; William P. Schecter, MD; Kobi Peleg, PhD; Adi Givon, BA; Oded Olsha, MB, BS; Fernando Turegano-Fuentes, MD; Ricardo Alfici, MD; and the Israeli Trauma Group

IMPORTANCE Head injury following explosions is common. Rapid identification of patients with severe traumatic brain injury (TBI) in need of neurosurgical intervention is complicated in a situation where multiple casualties are admitted following an explosion.

OBJECTIVE To evaluate whether Glasgow Coma Scale (GCS) score or the Simplified Motor Score at presentation would identify patients with severe TBI in need of neurosurgical intervention.

DESIGN, SETTING, AND PARTICIPANTS Analysis of clinical data recorded in the Israel National Trauma Registry of 1081 patients treated following terrorist bombings in the civilian setting between 1998 and 2005. Primary analysis of the data was conducted in 2009, and analysis was completed in 2015.

MAIN OUTCOMES AND MEASURES Proportion of patients with TBI in need of neurosurgical intervention per GCS score or Simplified Motor Score.

RESULTS Of 1081 patients (median age, 29 years [range, 0-90 years]; 38.9% women), 198 (18.3%) were diagnosed as having TBI (48 mild and 150 severe). Severe TBI was diagnosed in 48 of 877 patients (5%) with a GCS score of 15 and in 99 of 171 patients (58%) with GCS scores of 3 to 14 ($P < .001$). In 65 patients with abnormal GCS (38%), no head injury was recorded. Nine of 877 patients (1%) with a GCS score of 15 were in need of a neurosurgical operation, and fewer than 51 of the 171 patients (30%) with GCS scores of 3 to 14 had a neurosurgical operation ($P < .001$). No difference was found between the proportion of patients in need of neurosurgery with GCS scores of 3 to 8 and those with GCS scores of 9 to 14 (30% vs 27%; $P = .83$). When the Simplified Motor Score and GCS were compared with respect to their ability to identify patients in need of neurosurgical interventions, no difference was found between the 2 scores.

CONCLUSIONS AND RELEVANCE Following an explosion in the civilian setting, 65 patients (38%) with GCS scores of 3 to 14 did not experience severe TBI. The proportion of patients with severe TBI and severe TBI in need of a neurosurgical intervention were similar in patients presenting with GCS scores of 3 to 8 and GCS scores of 9 to 14. In this study, GCS and Simplified Motor Score did not help identify patients with severe TBI in need of a neurosurgical intervention.

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Author Affiliations: Department of Surgery, Hillel Yaffe Medical Center, Hadera, Israel (Ashkenazi, Alfici); Department of Surgery, University of California, San Francisco (Schecter); National Center for Trauma and Emergency Medicine Research, Gertner Institute, Tel Hashomer, Israel (Peleg, Givon); Disaster Medicine Department, Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel (Peleg); Department of Surgery, Shaare Zedek Medical Center, Jerusalem, Israel (Olsha); Emergency Surgery Department, Hospital General Universitario Gregorio Marañon, Madrid, Spain (Turegano-Fuentes).

Group Information: The Israeli Trauma Group members are listed at the end of this article.

Corresponding Author: Itamar Ashkenazi, MD, Surgery B Department, Hillel Yaffe Medical Center, PO Box 169, Hadera, Israel 38100 (i_ashkenazi@yahoo.com).

Significant knowledge concerning treatment of traumatic brain injury (TBI) in bomb explosions has been accumulated by the military in the last 2 decades of the war against terror.[1-5] It has been reported to affect 22% of soldiers injured in Iraq and Afghanistan.[1] Of these, injury severity is either moderate or severe in 11%.[6]

In the civilian setting, TBI has been reported to affect 6% to 31% of immediate survivors from explosions resulting in large incidents.[7-12] However, TBI following explosions in the civilian setting differs from TBI experienced in the military setting. Use of body armor by the military means that the abdomen and thorax are relatively more protected from penetrating missiles from the explosion.[13,14] Head and extremity injuries are more common in survivors. It may be that civilians who reach the hospital alive experience associated abdominal and thoracic injuries more commonly than soldiers.

Because of tactical reasons, improvised explosive devices commonly used against soldiers result in only a limited number of military personnel being injured in any 1 event. However, in the civilian setting, terrorist bombings are able to target a concentration of civilians in markets, restaurants, buses, and other public places. These attacks commonly result in dozens of casualties in need of treatment in nearby medical centers.

One of the key clinical issues concerning TBI is the need for rapid identification of patients with severe TBI in need of urgent neurosurgical intervention within the context of a multiple-casualty incident (MCI) following an explosion. We hypothesized that use of the Glasgow Coma Scale (GCS) score on admission would be useful in identifying patients with TBI requiring neurosurgical intervention, defined for the purposes of this study as craniotomy or intracranial pressure monitoring.

Key Points

Question Can the Glasgow Coma Scale (GCS) score or the Simplified Motor Score identify patients with traumatic brain injury in need of neurosurgical intervention following a terrorist explosion in the civilian setting?

Findings This review of 1081 patients in the Israel National Trauma Registry revealed that 30% of patients with GCS scores of 3 to 14 were in need of neurosurgical intervention, and no difference was found between those with GCS scores of 3 to 8 (30%) and those with GCS scores of 9 to 14 (27%). The Simplified Motor Scale did not perform better than the GCS.

Meaning Use of the GCS and the Simplified Motor Scale on admission was not helpful in identifying patients who required urgent neurosurgical intervention.

Methods

Patients included in this study were identified through the Israel National Trauma Registry. Data collected in the Israeli National Trauma Registry are collected without identifiers for the purposes of quality assessment and research. Studies done based on these data are waived from institutional review board approval. Details of the clinical data collected by the Israel National Trauma Registry are described in detail elsewhere.[15] A subset of patients treated following terrorist bombings resulting in MCIs treated in any of the hospitals participating in the registry was identified. The registry data were evaluated for initial GCS score, initial blood pressure, respiratory status, site of intubation, and injuries listed by severity according to *International Classification of Diseases, Ninth Revision (ICD-9)* codes. Severe and mild TBI were defined according to the Barell matrix.[16] The proportion of patients with TBI was compared between patients fully conscious (GCS score of 15) and patients not fully conscious (GCS score of 3-14). The proportion of patients with TBI was further compared between patients with GCS scores of 9 to 14 and those with GCS scores of 3 to 8. Patients with abnormal GCS score rbut no TBI were evaluated for possible reasons for not being fully conscious. Finally, the need for a neurosurgical operation, either intracranial pressure monitoring or craniotomy, was evaluated by GCS category. This analysis was repeated comparing severity of TBI and need for a neurosurgical operation with severity of the motoric component of GCS. Three categories of severity of the motor response were defined according to the Simplified Motor Score (SMS).[17] These 3 categories were compared against the GCS score as follows: obeys commands vs GCS score of 15, localizes pain vs GCS score of 9 to 14, and withdrawal to pain or lesser response vs GCS scores of 3 to 8.

Proportions of patients were compared between subgroups using the Fisher exact probability test. Data analysis was done using a dedicated statistical software program (GraphPad Instat and GraphPad Prism, Graphpad Software Inc).

Results

We identified 1081 survivors of terrorist explosions. More than 75% of these were treated in events where 6 or more patients were hospitalized in hospitals included in the registry. The event with the largest number of hospitalizations occurred in Tel Aviv, where 23 civilians were killed, 120 were injured, and 58 were in need of hospitalization in hospitals included in the registry.

Of 1081 survivors, 661 (61%) experienced injury to an area of the head. One hundred eighty-two (17%) had injuries to the head area only, while 479 (44%) were combined with injuries to the torso and/or extremities. A TBI was recorded in 198 patients (18%), 48 of which were considered mild and 150 of which were considered severe. Sixty-one patients with severe TBI underwent neurosurgical interventions.

The GCS score was 15 in 877 patients (81%), 9 to 14 in 30 patients (3%), and 3 to 8 in 141 patients (13.0%). The GCS score was not recorded in 33 patients (3%). The relationship of TBI to GCS is shown in **Figure 1**. Patients with severe TBI accounted for only 5% of patients with GCS scores of 15 compared with 58% in those with GCS scores of 3 to 14 ($P < .001$). Of 171 patients with an abnormal GCS score on presentation,

Figure 1. Proportion of Patients With Traumatic Brain Injury According to Glasgow Coma Scale Score Category

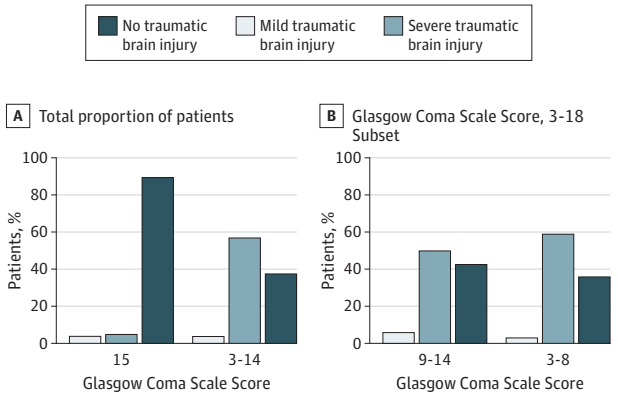
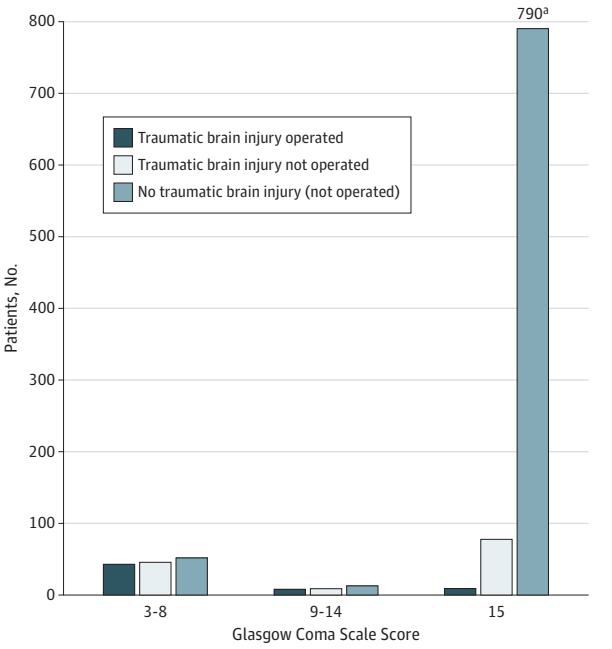


Table. Patients Without TBI But With Abnormal GCS Score on Presentation

Reasons for Abnormal GCS Score on Presentation	No.
Agonal, declared dead soon after arrival	7
Intubated on site or during transport	26
Other severe injuries with or without hemodynamic decompensation	27
No significant injury recorded	5

Abbreviations: GCS, Glasgow Coma Scale; TBI, traumatic brain injury.

Figure 2. Number of Patients in Need of Operation for Traumatic Brain Injury in Each Glasgow Coma Scale Score Category



[a] Number of patients with Glasgow Coma Scale score of 15 and no traumatic brain injury.

99 patients (58%) had severe TBI. In 65 patients (38%) with an abnormal GCS score, no head injury was recorded. Only 5 of the 65 patients without TBI but with an abnormal GCS score had no significant injury to explain the abnormal GCS score (**Table**). Stratification of patients according to GCS score revealed that GCS severity was not helpful in differentiating between those with severe TBI and those without.

Sixty-one patients, all with severe TBI, were in need of a neurosurgical surgical intervention (**Figure 2**). Nine were fully conscious on admission, while 51 had a GCS score of 3 to 14. Glasgow Coma Scale score was unknown in 1 patient. The 9 patients who were fully conscious on admission but in need of a neurosurgical intervention represent 1% of 877 patients with a GCS score of 15. In contrast, 51 of 171 patients with a GCS score of 3 to 14 (30%) required a neurosurgical intervention (9 operated out of 877 patients with a GCS score of 15 compared with 51 operated out of 171 patients with a GCS score of 3-14; $P < .001$). No difference was found between the proportion of patients in need of neurosurgery with a GCS score of 3 to 8 and those with a GCS score 9 to 14 (30% vs 27%; $P = .83$).

Repeated analysis was done using SMS. Motor response was not recorded in 52 patients (4.8%). Three categories defined by SMS were compared with 3 categories defined by GCS (**Figure 3**). Except for patients localizing pain, no difference was found between the SMS and GCS score in identifying patients with severe TBI when patients obeying commands were compared with patients with a GCS score of 15 or when patients withdrawing from pain or lesser response were compared with patients with GCS scores of 3 to 8 (53 with severe TBI out of 892 patients classified by SMS as obeys commands compared with 48 with severe TBI out of 877 patients with GCS 15; $P = .68$; 64 with severe TBI out of 112 patients classified by SMS as withdrawing to pain or lesser response compared with 84 with severe TBI out of 141 patients with GCS score 3 to 8; $P = .70$). Of patients localizing pain, 20 (80%) had severe TBI. In comparison, severe TBI was diagnosed in only 15 patients (50%) with GCS scores of 9 to 14 (20 with severe TBI out of 25 patients classified by SMS as localizes pain compared with 15 with severe TBI out of 30 patients with a GCS score of 9 to 14; $P = .03$). Although localization of pain was best at discriminating between patients with severe TBI and patients without TBI, only 25 patients (2.3%) included in this study fit in this category. When the SMS and GCS score were compared with respect to their ability to identify patients in need of neurosurgical interventions, no difference was found between the 3 pairs of categories: obeys commands vs GCS score of 15 (13 operated out of 53 patients with severe TBI classified by SMS as obeys commands compared with 9 operated out of 48 patients with severe TBI and a GCS score of 15; $P = .63$); localizes pain vs GCS score of 9 to 14 (13 operated out of 20 patients with severe TBI classified by SMS as localizes pain compared with 8 operated out of 15 patients with severe TBI and a GCS score of 9-14; $P = .51$); and withdrawal to pain or less response vs GCS score 3 to 8 (31 operated out of 64 patients with severe TBI classified by SMS as withdrawing to pain or lesser response compared with 43 operated out of 84 patients with severe TBI and a GCS score of 3-8; $P = .87$).

Discussion

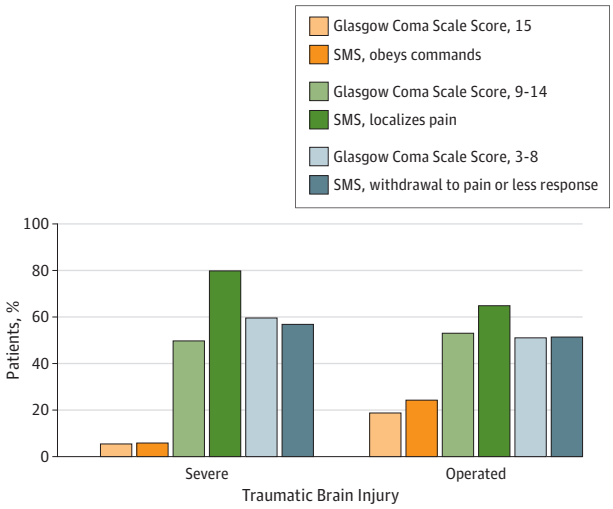
Terrorist bomb explosions in the civilian setting commonly result in MCIs in which many patients are transferred to nearby hospitals. To have an effect on survival, priority should be given to the diagnosis and treatment of life-threatening injuries. Traumatic brain injury is a common injury following explosion.[1-12] Urgent resuscitation, correction of coagulopathy, and early neurosurgical intervention may improve outcome in patients with severe TBI.[18] In a situation where many patients are treated simultaneously in the emergency department, identification of patients with severe TBI is challenging. The situation is further complicated by the possibility that many patients with severe TBI end up being transferred to the nearest hospitals, which may not have a neurosurgery service.[19]

The main finding of this study is that slightly less than one-third of the patients with GCS scores of 3 to 14 were in need of a neurosurgical intervention. No difference was found in the proportion of patients in need of a neurosurgical intervention between those with GCS scores of 3 to 8 and those with GCS scores of 9 to 14. For patients with GCS scores of 15, only a small number required neurosurgical intervention. Nevertheless, because 15% of the patients who underwent neurosurgical intervention arrived fully conscious at the emergency department, a GCS score of 15 cannot be used to rule out severe TBI in need of neurosurgery.

The practical implication of this study is that the GCS score is not useful in differentiating patients experiencing severe TBI from those who do not. Furthermore, the GCS score cannot differentiate between those patients with severe TBI who need neurosurgical interventions and those with severe TBI who do not. The GCS score is an assessment of the effects of the injury but does not provide anatomic information critical to the decision to operate. Furthermore, the GCS is complex, and accurate scoring is user dependent. The GCS score may be low owing to mechanisms other than head injury such as associated injuries, drugs, and analgesia. These limitations should be taken into consideration, especially in hospitals without a neurosurgical capability that need to prioritize transfer of patients with possible head injury within the context of an MCI following a terrorist explosion. Although computed tomography is the most predictive examination for identification of those in need of a neurosurgical intervention, it may be a limited resource. Therefore, there is a need for the development of clinical screening tools that will help prioritize patients suspected of having TBI who are likely to be in need of neurosurgical interventions.

In this study, we evaluated the reliability of the SMS in identifying both patients with severe TBI and patients with TBI in need of neurosurgery. Some authors have cast doubt on the reliability of the GCS score as the initial form of evaluation of TBI, whether it is done in the prehospital phase or in hospital.[20,21] Evaluating patients with SMS is easier than with the GCS. In the setup of an MCI, a situation in which not all medical professionals are experienced in the evaluation of trauma patients, simplifying the evaluation of the mental status could in theory improve triage of patients for neurosurgical evaluation and treatment. Nevertheless, in this study, SMS did not perform better than GCS.

Figure 3. Reliability of Glasgow Coma Scale Score and Simplified Motor Score (SMS) in Identifying Severe Traumatic Brain Injury and Need of Neurosurgery



Bars represent percentage of patients in the specific category who had either severe traumatic brain injury or were in need of neurosurgical operation.

This study has several limitations. The data used in this analysis come from a national trauma registry. It may be subject to data entry and coding errors. The analysis was done retrospectively. A major limitation of this study is that the population of patients described in the registry does not include patients who were discharged from the emergency department without admission to the hospital. We assume that these patients had a GCS score of 15 and no significant head injury. Thus, the proportion of patients with severe TBI with a GCS score 15 on presentation is probably even lower than what is presented in this study. We assume that the other findings described were not affected. Another limitation of this study is that it is based on patients treated in several hospitals by a number of different neurosurgeons who may have had varying thresholds for intracranial pressure monitoring insertion or craniotomies performed in patients included in this study. A third limitation is the observation that 7 of the 65 patients with an abnormal GCS score and no proof of head injury were declared dead soon after arrival. We cannot rule out severe TBI in these patients. Nevertheless, for the purposes of this study, even if these patients did have TBI, they could not be saved at presentation. Low GCS score in these 7 patients did not help identify the need of a neurosurgical intervention.

Conclusions

Following an explosion in the civilian setting, almost 40% of patients with GCS scores of 3 to 14 did not have severe TBI. The

proportion of patients with severe TBI and severe TBI in need of a neurosurgical intervention were similar in patients presenting with GCS scores of 3 to 8 and GCS scores of 9 to 14. The results of this study do not support the hypothesis that GCS score on admission is useful in identifying patients with TBI requiring neurosurgical intervention. Because computed tomography is a limited resource, there is a need to develop clinical screening tools that will help identify and prioritize patients suspected of having TBI in need of neurosurgical intervention.

ARTICLE INFORMATION

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The Israeli Trauma Group includes Hany Bahouth, MD; Alexander Becker, MD; Michael Ben Ely, MD; Alexander Braslavsky, MD; Igor Jeroukhimov, MD; Milad Qarawany, MD; Boris Kessel, MD; Yoram Klein, MD; Guy Lin, MD; Ofer Merin, MD; Miklosh Bala, MD; Youri Mnouskin, MD, PhD; Avraham I. Rivkind, MD; Gad Shaked, MD; Dror Soffer, MD; Michael Stein, MD; Michael Weiss, MD.

Affiliations of The Israeli Trauma Group: Trauma and Emergency Surgery Division of General Surgery, Rambam Health Care Campus, Haifa, Israel (Bahouth); Department of Surgery, HaEmek Medical Center, Afula, Ruth and Bruce Rappaport Medical School, Technion, Haifa, Israel (Becker); Wolfson Medical Center, Holon, Israel (Ben Ely); Trauma Unit, Ziv Medical Center, Zfat, Israel (Braslavsky); Assaf Harofeh Medical Center, Tel Aviv University, Tel Aviv, Israel (Jeroukhimov); Trauma Unit, Poriya Medical Center, Tiberias, Israel (Qarawany); Trauma Unit, Hillel Yaffe Medical Center, Hadera, Israel (Kessel); Bruce Rappaport Medical School, Technion, Haifa, Israel (Kessel); Divison of Acute Care Surgery and Trauma, Chaim Sheba Medical Center, Tel Hashomer, Israel (Klein); Kaplan Medical Center, Rehovot, Israel (Lin); Shaare Zedek Medical Center, Hebrew University, Jerusalem, Israel (Merin); Hadassah Medical Center, Jerusalem, Israel (Bala, Rivkind); Surgery Department, Barzilai Medical Center, Ashkelon, Israel (Mnouskin); Trauma Unit, Soroka Medical Center, Beer-Sheva, Israel (Shaked); The Yitzhak Rabin Trauma Division, Division of Surgery, Tel Aviv Sourasky Medical Center, Tel Aviv, Israel (Soffer); Trauma Unit, Rabin Medical Center-Beilinson Hospital, Petah Tikva, Israel (Stein); Trauma Unit, Galilee Medical Center, Nahariya, Israel (Weiss).

Author Contributions: Dr Ashkenazi had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Ashkenazi, Turegano-Fuentes, Alfici, Bahouth, Becker, Ben Ely, Qarawany, Merin, Bala, Rivkind, Soffer.
Acquisition, analysis, or interpretation of data: Ashkenazi, Schecter, Peleg, Givon, Olsha, Braslavsky, Jeroukhimov, Kessel, Klein, Lin, Mnouskin, Shaked, Stein, Weiss.
Drafting of the manuscript: Ashkenazi, Olsha, Bahouth, Becker, Qarawany, Kessel, Merin, Rivkind, Shaked.
Critical revision of the manuscript for important intellectual content: Ashkenazi, Schecter, Peleg, Givon, Olsha, Turegano-Fuentes, Alfici, Ben Ely, Braslavsky, Jeroukhimov, Kessel, Klein, Lin, Bala, Mnouskin, Rivkind, Soffer, Stein, Weiss.
Statistical analysis: Ashkenazi, Peleg, Givon, Olsha, Kessel, Rivkind.
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Administrative, technical, or material support: Olsha, Kessel, Lin, Bala, Rivkind, Shaked, Soffer.
Study supervision: Peleg, Givon, Turegano-Fuentes, Alfici, Braslavsky, Jeroukhimov, Kessel, Rivkind, Soffer, Weiss.

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