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Original Article

Analysis of incidence of traumatic brain injury in blunt trauma patients with Glasgow Coma Scale of 12 or less

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ABSTRACT

Purpose: Early diagnosis of traumatic brain injury (TBI) is important for improving survival and neurologic outcome in trauma victims. The purpose of this study was to assess whether Glasgow Coma Scale (GCS) of 12 or less can predict the presence of TBI and the severity of associated injuries in blunt trauma patients.
Methods: A retrospective cohort study including 303,435 blunt trauma patients who were transferred from the scene to hospital from 1998 to 2013. The data was obtained from the records of the National Trauma Registry maintained by Israel's National Center for Trauma and Emergency Medicine Research, in the Gertner Institute for Epidemiology and Health Policy Research. All blunt trauma patients with GCS 12 or less were included in this study. Data collected in the registry include age, gender, mechanism of injury, GCS, initial blood pressure, presence of TBI and incidence of associated injuries. Patients younger than 14 years old and trauma victims with GCS 13–15 were excluded from the study. Statistical analysis was performed by using Statistical Analysis Software Version 9.2. Statistical tests performed included Chi-square tests. A p-value less than 0.05 was considered statistically significant.
Results: There were 303,435 blunt trauma patients, 8731 (2.9%) of them with GCS of 3–12 that including 6351 (72%) patients with GCS of 3–8 and 2380 (28%) patient with GCS of 9–12. In these 8731 patients with GCS of 3–12, 5372 (61.5%) patients had TBI. There were total 1404 unstable patients in all the blunt trauma patients with GCS of 3–12, 1256 (89%) patients with GCS 3–8, 148 (11%) patients with GCS 9–12. In the 5095 stable blunt trauma patients with GCS 3–8, 32.4% of them had no TBI. The rate in the 2232 stable blunt trauma patients with GCS 9–12 was 50.1%. In the unstable patients with GCS 3–8, 60.5% of them had TBI, and in subgroup of patients with GCS 9–12, only 37.2% suffered from TBI.
Conclusion: The utility of a GCS 12 and less is limited in prediction of brain injury in multiple trauma patients. Significant proportion of trauma victims with low GCS had no TBI and their impaired neurological status is related to severe extra-cranial injuries. The findings of this study showed that using of GCS in initial triage and decision making processes in blunt trauma patients needs to be re-evaluated.

Introduction

Traumatic brain injury (TBI) is a widespread problem, resulting in 50,000 deaths per year only in the United States and affecting 10 million people per year around the world.[1] The appropriate management of such injuries includes prehospital triage protocols which set the destination trauma center for on scene teams, initial stabilization and accurate selection of therapeutic priorities in

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every multiple trauma patient in the trauma bay. One of the most widely used parameters in evaluation of severity of head injury worldwide is the Glasgow Coma Scale (GCS). First published in 1974 it was initially used to assess level of consciousness after head injury.[2] Over the years, the GCS has become an integral part of clinical practice and strong correlation was found with severity and outcome of TBI.[3] Furthermore, this parameter is one of the important criteria of prehospital triage.[4] However, the incidence of trauma patients with a low GCS who actually have no TBI has not been reported. This may impact on the prehospital phase as well as on the decision making process in the trauma room. Transfer takes time, may increase the burden on already busy level I trauma centers and risks en route deterioration from untreated associated injuries which may worsen the outcome if the patient does not reach the nearest appropriate hospital in a timely fashion. This may also affect decisions in the trauma bay, if it is not to taken into account that low GCS may be associated with hypotension, hypoxia, or other systemic factors.

The aim of this study was to examine the incidence of TBI in blunt trauma patients with different levels of GCS in relation to the severity of other injuries.

Methods

We performed a retrospective cohort study involving all blunt trauma patients admitted in hospital from 1998 to 2013.The data was obtained from the records of the National Trauma Registry maintained by Israel's National Center for Trauma and Emergency Medicine Research, in the Gertner Institute for Epidemiology and Health Policy Research. This registry records information concerning all trauma patients hospitalized in 19 hospitals of which six are level I trauma centers and thirteen are level II trauma centers. Data collected in the registry include age, gender, mechanism of injury, GCS, initial blood pressure, presence of TBI and presence of associated injuries. TBI was defined as the presence of any kind of intracranial bleeding (epidural and subdural hematoma, subarachnoid and intraparenchymal hemorrhage). Patients without structural pathology on computerized tomography scan (e.g., brain stem injuries) were excluded from the study.

Associated injuries with abbreviated injury score (AIS) 1–2 were defined as mild, and injuries with AIS 3–6 were defined as moderate/severe. Patients with a systolic blood pressure (SBP) $\leq$89 mmHg on admission were defined as hemodynamically unstable. We examined the prevalence of TBI in the blunt trauma population and compared its incidence at different levels of GCS. In this study we concentrated on patients with GCS up to 12 because these patients are considered in the trauma literature as suffering from moderate to severe head injuries.[5]

This study has been approved by the National Center for Trauma and Emergency Medicine Research Institutional Review Board.

Statistical analysis was performed by using Statistical Analysis Software Version 9.2 (SAS Institute Inc., Cary, NC). Statistical tests performed included Chi-square tests. A p-value of less than 0.05 was considered statistically significant.

Results

In the study period, the registry included 303,435 blunt trauma patients, of whom 18,741 (6.2%) were identified as suffering from TBI. There were 8731 (2.9%) trauma victims with GCS of 3–12, and in this group 5372 (61.5%) suffered from TBI. There were 294,704 (97.1%) blunt trauma patients with GCS of 13–15, of whom 13,369 (4.5%) suffered from TBI ($p < 0.0001$), while this group is beyond the scope of this article. Table 1 shows the incidence of TBI according to different levels of GCS.

Table 1
Incidence of TBI according to different levels of GCS.

GCS	TBI		Total (n)
	Yes	No	
3–8	4203 (66.2)	2148 (33.8)	6351
9–12	1169 (49.1)	1211 (50.9)	2380
Total (n)	5372	3359	8731

Data are presented as n (%). $p < 0.0001$. GCS: Glasgow Coma Scale; TBI: Traumatic brain injury.

There were 7269 (2.4%) blunt trauma patients initially hemodynamically unstable, 1140 (15.7%) patients of them had TBI. Table 2 shows the incidence of TBI according to initial systolic blood pressure and GCS. In both the GCS 3–8 and GCS 9–12 groups, unstable trauma patients had a significantly lower incidence of TBI.

Few patients in both the stable and unstable groups had isolated TBI. There were significantly fewer patients with isolated TBI in the unstable than in the stable group. Table 3 shows the relationship of hemodynamic instability in the presence of isolated TBI compared with the presence of TBI and associated injuries according to their severity. The majority of the patients had TBI with severe associated injuries (AIS$\geq$3). ($p < 0.0001$).

According to ICD-9, the severity of TBI is defined according to AIS. The minimal AIS of TBI is 3, which is classified as minor TBI. AIS of 5–6 are classified as moderate to severe TBI. Table 4 showed distribution of the TBI injuries according to AIS and blood pressure.

Among patients with GCS of 3–8 and SBP $\leq$ 89 mmHg, 39.76% of TBI trauma victims associated with injuries had mild TBI compared with 67.5% of trauma patients with GCS of 9–12 ($p < 0.05$).The same correlation was found in stable trauma victims with GCS of 9–12 (73.05% versus 26.95%, $p < 0.05$).

Discussion

Trauma is one of the leading causes of morbidity and mortality around the world. In 2008, about 30 million trauma cases were serious enough to prompt an emergency room visit in the United States.[4] Of those, the TBI category accounted for the highest annual trauma morbidity and mortality.[6] TBI composes 7% of all blunt head trauma injuries in the pediatric population.[7]

TBI has a substantial ongoing health impact: in the USA, an estimated total of 3.17 million people live with neurodisability. Mortality rate for TBI varies between countries. In 2010, population-based mortality due to TBI was 17.1 per 100,000 people according to Centers for Disease Control and Prevention. In China, population-based mortality due to TBI was 13.0 per 100,000 people. There is reduced severe TBI mortality over the past 150 years, on the other hand case fatality rate showed no improvement over the past 25 years.[8]

Prehospital staff carry out initial evaluation and primary care for trauma victims in the field and are responsible for triage to the appropriate health care facility. While improvements in rescue systems and on-scene therapy have led to a reduction in early

Table 2
Incidence of TBI according to initial SBP and GCS.

Variables	TBI	No TBI	Total (n)
GCS 3–8, SBP$\leq$89 mmHg	760 (60.5)	496 (39.5)	1256
GCS 3–8, SBP>89 mmHg	3443 (67.6)	1652 (32.4)	5095
GCS 9–12, SBP$\leq$89 mmHg	55 (37.2)	93 (62.8)	148
GCS 9–12, SBP>89 mmHg	1114 (49.9)	1118 (50.1)	2232
Total (n)	5372	3359	8731

Data are presented as n (%). $p < 0.0001$. GCS: Glasgow coma scale; TBI: traumatic brain injury; SBP: systolic blood pressure.

Table 3
Relationship of hemodynamic instability in the presence of isolated TBI compared with the presence of TBI and associated injuries according to their severity.

Items	TBI only		TBI with associated injuries (AIS1-2)		TBI with associated injuries (AIS $\geq$ 3)		Total (n)	
SBP (mmHg)	GCS 3-8	GCS 9-12	GCS 3-8	GCS 9-12	GCS 3-8	GCS 9-12	GCS 3-8	GCS 9-12
≤89	91 (7.25)	15 (10.14)	69 (5.49)	5 (3.38)	600 (47.8)	35 (23.70)	1256	148
>89	928 (18.21)	512 (22.94)	705 (13.84)	303 (13.58)	1810 (35.50)	299 (13.40)	5095	2232
Total (n)	1019	527	774	308	2410	334	6351	2380

Data are presented as n (%). GCS: Glasgow coma scale; TBI: traumatic brain injury; SBP: systolic blood pressure; AIS: abbreviated injury score.

Table 4
Distribution of the TBI injuries according to AIS and SBP.

	AIS 3-4			AIS 5-6		
	TBI only	TBI with others	Total (n)	TBI only	TBI with others	Total (n)
GCS 3–8, SBP ≤89 mmHg	25 (27.47)	266 (39.76)	291	66 (72.53)	403 (60.24)	469
GCS 9–12, SBP≤89 mmHg	12 (80.00)	27 (67.50)	39	3 (20.00)	13 (32.50)	16
GCS 3–8, SBP>89 mmHg	421 (45.37)	1238 (49.22)	1659	507 (54.63)	1277 (50.78)	1784
GCS 9–12, SBP>89 mmHg	374 (73.05)	432 (71.76)	806	138 (26.96)	170 (28.24)	308
Total (n)	832	1963	2795	714	1863	2577

Data are presented as n (%). GCS: Glasgow Coma Scale; TBI: traumatic brain injury; SBP: systolic blood pressure.

posttraumatic death, there are important factors which may still impact on mortality, such as evacuation time and correct triage decisions by the transporting team.

According to many prehospital guidelines, one of the important criteria for evacuation to the highest level care is a GCS of 13 or less.[4] Some studies have shown a correlation between low GCS and probability/severity of head injury.[9,10]

Therefore, trauma victims with low GCS will probably have a TBI and require transfer to a neurosurgical facility. However, there are some circumstances, such as low blood pressure, hypercapnia and desaturation of oxygen, which may significantly decrease GCS without the presence of a brain injury. There are also scenarios, such as night time and bad weather conditions, where even a very experienced prehospital team could not be able to diagnose an isolated brain injury and rule out significant and possible life threatening concomitant injuries at the scene. Evacuation from the scene to the neurosurgical facility may be also time-consuming in many countries and catchment areas. Gonzalez et al[11] in their study of 45,763 trauma victims showed that prolonged prehospital emergency medical services response time appears to be associated with a higher mortality rate in rural settings. Demetriades et al[12] in a study of 5792 trauma patients found better survival rates in those transported by private means.

The issue what is the most appropriate destination for each trauma victim is still debated. Despite the tendency to transfer trauma victim to the highest level of trauma center, direct transportation to level I trauma centers may not always result in a lower mortality rate. Fatovich et al[13] in a study of 3083 trauma patients did not find a difference in mortality rate in patients transferred to designated trauma centers rather than directly to a tertiary hospital in Australia. In 2014, Billeter et al[14] examined 750 blunt trauma victims found that stops at nontrauma centers or secondary transfers for severely injured patients did not affect their outcome. Secondary transfer to the highest level of care from other hospitals is often unnecessary. Sorensen et al[15] in his study of 7793 patients showed that 24% of adult and 49% of pediatric trauma victims transferred were eventually designated as over triaged. Similar findings were reported by Ciesla et al[16] who demonstrated that 39% of 2189 secondarily transferred patients were over triaged. Moreover, Sugerman et al[17] in a study of 53,930 severely injured trauma victims showed lower mortality rates when patients were initially transported to the nearest hospital with appropriated surgical facilities, even when they were found to be suffering from severe TBI. The actual percentage of patients with low GCS who have no TBI is not clear.

Only a single study showed that 9% of 1643 trauma victims with GCS 8 or less had no significant TBI, but the diagnostic value of GCS ≤8 for severe TBI in patients with multiple injuries had low sensitivity.[7] In the current study we found that only 23% of stable trauma patients with a GCS of 9–12 and 18% of stable victims with a GCS of 3–8 suffered from isolated TBI. In unstable trauma victims the proportion was even lower, with only 7% of trauma patients with a GCS of 3–8 having isolated TBI.

Leitgeb et al[18] in a study on 767 trauma patients found that concomitant injuries have a significant effect on the mortality of patients with moderate TBI. The GCS value in emergency room is also one of the parameters which impact on the decision making process. For example, according to advanced trauma life support guidelines, in trauma victims with GCS of 3–8, in case their SBP can be temporarily corrected, every effort should be made to get a head computerized tomography scan prior taking the patient to thoracotomy or laparotomy.[19] In some situations, it may increase incidence of secondary brain insults due to incomplete hemodynamic and/or respiratory resuscitation. Knowledge of the actual incidence of TBI in patients with different levels of GCS and, which would enable improved estimation of the risk of having a head injury, may help in establishing therapeutic priorities. In our study we found that almost 40% of unstable patients with GCS of 3–8 and 62.8% of the patients with GCS of 9–12 had no TBI at all. Moreover, 86% of the unstable trauma victims with GCS of 9–12 suffered from TBI together with severe associated injuries (AIS≥3) or had severe injuries and no TBI at all. These findings question the appropriateness of using a GCS of 12 or less as a single triage parameter to determine the most appropriate medical facility to which the trauma victim should be evacuated.

In this study we did not analyze the exact size of intracranial hemorrhage. Such information is not included in our database. We assume that some of the patients diagnosed with TBI had small hematomas which do not explain lower GCS and therefore the real incidence of clinically significant TBI is even lower. Among patients with GCS of 3–8 and SBP ≤89 mmHg, 39.76% of TBI trauma victims with associated injuries had mild TBI compared with 67.5% of trauma patients with GCS of 9–12 ($p < 0.05$). The same correlation was found in stable trauma victims with GCS of 9–12 (73.05%

versus 26.95%, $p < 0.05$). Therefore, that even in patients with TBI, a significant amount of trauma victims suffered from minor TBI and more severe associated injuries.

In this study, 42% of unstable blunt trauma patients with a GCS 12 or less had severe injuries but no TBI. Only 12.7% of unstable trauma victims with GCS of 3–8 as well as 13.5% of trauma patients with GCS of 9–12 had isolated TBI or TBI with mild associated injuries. Most of the unstable patients had no TBI or TBI with severe associated injuries. The findings of this study suggest that the utility of a GCS of 12 or less as predictor of brain injury in multiple trauma patients is limited. In summary, the relevance of the GSC score in the severely injured patients is questionable due to the decline in conscious state brought about by injuries other than the possible neurological insult. The importance of low GCS values in decision making processes in blunt trauma patients needs to be reevaluated.

Conflict of interest

The authors certify that there is no relationship exists between a commercial party and material contained in this material that might represent a potential conflict of interest. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.cjtee.2018.01.004.

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