Original Article

Access this article online
Website: www.ijciis.org
DOI: 10.4103/ijciis.ijciis_20_21
Quick Response Code:

The impact of alcohol intoxication on early Glasgow Coma Scale-Pupil reactivity score in patients with traumatic brain injury: A prospective observational study

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ABSTRACT

Background: A simple arithmetic combination of the Glasgow Coma Scale (GCS) score and pupillary response, the GCS-Pupil (GCS-P), extends the information provided about the patient outcome to an extent comparable to that obtained using more complex methods. The objective of the study was to compare the changes in the GCS-P score of patients with traumatic brain injury (TBI) under alcohol intoxication and nontoxication over time.

Methods: A prospective observational study was done in a hospital at the Level I trauma center. The patients admitted to the emergency department (ED) with TBI were the study participants. They were grouped into intoxicated and nonintoxicated based on blood alcohol concentration (BAC). BAC of 0.08% and above was considered intoxication. GCS-P score in the ED and the best day 1 GCS-P score were the outcome variables. For nonnormally distributed quantitative parameters, medians and interquartile range were compared between study groups using Mann–Whitney *U*-test. $P < 0.05$ was considered statistically significant.

Results: A total of 216 patients were included in the final analysis. There was no statistically significant difference between BAC in GCS-P score at different follow-up periods, GCS-P score (ED), and GCS-P score (best day 1).

Conclusion: This prospective observational study showed a low GCS-P score for alcohol-intoxicated patients compared to nonintoxicated patients, which was not statistically significant. There was no significant difference in emergency GCS-P score and best day 1 score between alcohol-intoxicated and nonintoxicated patients.

Key Words: Alcoholic intoxication, blood alcohol content, brain injuries, Glasgow Coma Scale, traumatic

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INTRODUCTION

Alcohol intoxication has been present in 35%–50% of traumatic brain injury (TBI) patients admitted in the hospitals.[1] Evidence showed that a blood alcohol concentration (BAC) of 0.08% causes motor and cognitive impairment.[2,3] The Glasgow Coma Scale (GCS) is widely used for this purpose to observe a patient's responsiveness or consciousness level.[4-6] The GCS

Cite this article as: Thamminaina A, Prasad KJ, Abhilash T, Moorthy DG, Rajesh K. The impact of alcohol intoxication on early Glasgow Coma Scale-Pupil reactivity score in patients with traumatic brain injury: A prospective observational study. Int J Crit Illn Inj Sci 2022;12:28-32.

Received: 17.02.2021; Revision: 17.05.2021;
Accepted: 20.05.2021; Published: 24.03.2022.

score, along with the information about pupil reaction, conveys to the physician most of the clinical predictive information in head-injured patients.[7] To the best of our knowledge, there was no literature available on the usage of GCS-Pupil (GCS-P) score to assess the clinical condition of alcohol-intoxicated patients with TBI.

Hence, the objective of the present study was to compare the changes in the GCS-P and Abbreviated Injury Score (AIS) score of patients with TBI under alcohol intoxication and nonintoxication over time.

METHODS

This prospective observational study was conducted at the RL Jalappa Hospital and Research Centre, a Level I trauma center, a teaching hospital of Sri Devaraj URS Medical College, a constituent unit of Sri Devaraj URS Academy of Higher Education and Research, Tamaka, Kolar, Karnataka, India. The data collection was done from May 2020 to December 2020. This study was approved by the Institutional Review Board/Ethics Committee at Sri Devaraj URS Medical College (Approval number SDUMC/KLR/IEC/65/2020-21; approval date May 27, 2020). A surrogate consent was permitted in the present study as the patients admitted to the emergency department (ED) were not able to give informed consent.

The patients included in the study were of (1) age >18 years presented to the ED and admitted to the neurosurgery intensive care unit (NSICU) with TBI and (2) patients who had suffered from head injury under alcohol influence. The patients excluded were patients who lost follow-up due to the following reason(s): (1) discharged against medical advice, (2) underwent inter-hospital transfer for any reason, (3) patients succumbed in the ED following head injury, and (4) patients with a head injury for more than 24 h on arrival to the ED.

Sampling method

The sampling method used was convenience sampling. Four hundred patients with road traffic accidents were reported in the ED from May 2020 to December 2020. Among them, 23 were excluded as they were below 18 years, 41 were discharged against medical advice, 70 patients do not have any kind of TBI, 20 succumbed in the ED during resuscitation, and 30 patients were those with head injury for more than 24 h on arrival to the ED as inter-hospital transfer. BAC was measured by a bedside breath alcohol analyzer (True Sense AT-002 Portable digital breath alcohol tester with automated flow detector having BAC display range 0%–0.2% BAC or 0–2 g/L). Immediately, and those who were having a concentration of 0.08% and above were grouped into alcohol-intoxicated, and those having BAC below 0.08% were grouped into nonintoxicated. Patients were recruited in each group conveniently, until the sample size was obtained.

Data collection tools and clinical examination

The data collected for this study include demographic data, including the initial ED GCS-P score as recorded by the ED physician at the arrival time, ED records including vital signs, laboratory parameters, admission neurological examination, and the initial computed tomography (CT) scan of the head. The severity of the overall injuries was graded using the AIS. Testing for BAC (considering BAC of 0.08% and above to be intoxication)[8] was part of the management protocol for head trauma admissions to the NSICU. BAC was measured by a bedside breath alcohol analyzer in the ED on arrival. The ED GCS-P score was obtained before sedation for intubation, and in all the participants, it was obtained free from sedation, as circumstances permitted. Finally, after admission to the NSICU, the GCS-P score was recorded on 4-h bases. Best day 1 GCS-P, which is the highest GCS-P score recorded in the first 24 h, was selected for analysis and compared with the ED GCS-P score at the arrival time. This study was conducted and reported according to STROBE guidelines.

Statistical methods

The sample size was estimated based on a similar study done by Shahin *et al.*[5] in Houston, Texas. With an assumed accuracy of 50% and a confidence level of 95%, the sample size was calculated using the below formula.

$$n = \frac{Z^2_{1-a/2}\,pq}{d^2}$$

$$n = \frac{Z^2_{1-a/2}\,p(1-p)}{d^2}$$

$$n = \frac{(1.96)^2 \times 50 \times 50}{(7)^2}$$

$$n = \frac{1.96 \times 1.96 \times 50 \times 50}{49} = 196 \pm 20$$

In addition, considering a nonresponsive rate of about twenty patients, the estimated sample size was 216 patients. The data of patients who were not able to complete the study were not included in the final analysis. GCS-P was considered the primary outcome variable, and AIS was considered a secondary outcome variable. Age, gender, patent airway, respiratory rate, SPO_2, blood pressure, pulse rate, and number of unreactive pupils were considered as secondary outcome variables. BAC (alcohol-intoxicated and nonintoxicated) was considered as a primary explanatory variable. P <0.05 was considered statistically significant. CoGuide Statistics software, Version 1.0, BDSS corporation. Bangaluru, India was used for statistical analysis.[9]

RESULTS

Two hundred and sixteen patients were included in the final analysis, with 108 patients in each group: intoxicated and nonintoxicated. One hundred and forty-nine patients were aged below 60 years (61 intoxicated and 88 nonintoxicated) and 67 patients older than 60 years (47 intoxicated and 20 nonintoxicated). There were 128 males (72 intoxicated and 56 nonintoxicated) and 88 females (36 intoxicated and 52 nonintoxicated) in the study. There was a statistically significant difference between the two groups in baseline parameters such as age (in years) and gender ($P < 0.05$) [Table 1].

There was a statistically significant difference between BAC in clinical and laboratory parameters such as airway patency, respiratory rate, SPO_2, blood pressure, pulse rate, and AIS ($P < 0.05$). AIS was more than 2 for 82 nonintoxicated patients (75.93%) compared to 57 intoxicated patients (52.78%). There was no statistically significant difference between BAC in clinical and laboratory parameters such as GCS, eye response, motor response, and change in GCS-P (ED vs. best day 1 GCS-P) ($P > 0.05$). There was a statistically significant difference between BAC in the verbal response of GCS ($P < 0.05$). The difference in BAC between pupillary reaction, intubation in the ED or ICU, and ED CT normal was found to be insignificant with $P = 0.097$, 0.178, and 0.174, respectively [Table 2].

There was no statistically significant difference between BAC in GCS-P score at different follow-up periods, GCS-P score (ED), and GCS-P score (best day 1). GCS-P score every 4 h was assessed and was not significant among groups (R1 GCS-P score, R2 GCS-P score, R3 GCS-P score, R4 GCS-P score, R5 GCS-P score, and R6 GCS-P score) ($P > 0.05$) [Table 3].

There was no statistically significant difference between BAC in GCS-P score (ED vs. best day 1 GCS-P) ($P > 0.05$) [Table 4].

DISCUSSION

This study compared the GCS-P score in TBI patients comprising those with alcohol intoxication and those without alcohol intoxication hospitalized at a Level I trauma center. TBIs are a common cause of admission to EDs and subsequent morbidity and mortality. Evidence showed that alcohol played a significant role in the incidence of head injuries.[2]

There was no significant improvement of ED GCS-P score, best day 1 GCS-P score, and every 4-h GCS-P score in the alcohol-intoxicated group and nonintoxicated group. Furthermore, patients with alcohol intoxication had less severe AIS than nonintoxicated ones.

To the best knowledge of the authors, this is the first study that used a GCS-P score for the comparison of TBI patients in the ED who were alcohol-intoxicated. A simple arithmetic combination of the GCS score and pupillary response, the GCS-P, extends the information provided about the patient outcome to an extent comparable to that obtained using more complex methods.[10]

Around 66.67% of males who were admitted to the ED were alcohol-intoxicated. A similar study done by Shahin *et al.*[5] showed that 88% of the male patients were alcohol-intoxicated. Studies by Bombardier *et al.*[11] and Peng *et al.*[12] showed that a high percentage of males were intoxicated, 66.4% and 88.4%, respectively, in their studies.

There was no significant difference in GCS-P score (ED) and GCS-P (best day 1) in intoxicated and nonintoxicated patients even though there was a slightly improved GCS-P score for nonintoxicated patients. This result was contrary to the findings of the studies by Shahin *et al.*[5] and Brickley and Shepherd,[13] where there was a decrease in GCS score for the intoxicated group. Moreover, Shahin *et al.*[5] reported that there was an improvement in GCS score over time and was statistically significant ($P < 0.001$) in their study. This can be due to the overall effect of verbal and motor response in the GCS score in alcohol-intoxicated patients, which can overestimate the ED GCS score. The present study used GCS-P, which incorporates the pupillary score. Studies by Rundhaug *et al.*[14] and Alexander *et al.*[15] showed a decrease in the GCS score with higher BAC levels in TBI patients.

There is conflicting evidence about the effects of alcohol on GCS scores in patients with head injuries. Lange *et al.*[16] examined the impact of blood alcohol levels on GCS scores following TBI. They found that overall, acute alcohol intoxication did not significantly affect GCS scores, even in patients with high blood alcohol levels. Similarly, a study by Stuke *et al.*[17] found that alcohol did not result in a clinically significant reduction in GCS in young-to-middle-aged trauma patients. Similar results were found in our present study in which both GCS scores were

Table 1: Comparison of baseline parameter between blood alcohol concentration ($n = 216$)

Parameter	BAC		*P*
	Intoxicated ($n = 108$), *n* (%)	Nonintoxicated ($n = 108$), *n* (%)	
Age group (years)			
<60	61 (56.48)	88 (81.48)	<0.001
≥60	47 (43.52)	20 (18.52)	
Gender			
Male	72 (66.67)	56 (51.85)	0.027
Female	36 (33.33)	52 (48.15)	

BAC: Blood alcohol concentration

Table 2: Comparison of clinical and laboratory parameter between blood alcohol concentration ($n = 216$)

Parameter	BAC		*P*
	Intoxicated ($n = 108$), *n* (%)	Nonintoxicated ($n = 108$), *n* (%)	
Patent airway			0.014
Yes	64 (59.26)	81 (75)	
No	44 (40.74)	27 (25)	
Respiratory rate			
Tachypnea	44 (40.74)	77 (71.3)	<0.001†
Normal	64 (59.26)	31 (28.7)	
%Spo2			
Above 90	64 (59.26)	26 (24.07)	<0.001†
Below 90	44 (40.74)	82 (75.93)	
Blood pressure			
Normal	83 (76.85)	44 (40.74)	<0.001†
Hypotension	25 (23.15)	64 (59.26)	
Pulse rate			
Normal	92 (85.19)	29 (26.85)	<0.001†
Abnormal	16 (14.81)	79 (73.15)	
GCS/15, median (IQR)	11 (8-13.75)	12 (11-13)	0.197‡
Eye response	3 (2-4)	3 (3-3)	0.853‡
Verbal response	3 (2-5)	4 (3-5)	0.001‡
Motor response	5 (4-5)	5 (5-5)	0.301‡
Pupillary reaction	98 (90.74)	104 (96.3)	0.097†
Number of pupils unreactive			
0	79 (73.15)	61 (56.48)	0.002†
1	21 (19.44)	44 (40.74)	
2	8 (7.41)	3 (2.78)	
Change in GCS-P (ED vs. best day 1 GCS-P), median (IQR)	1 (1-2)	1 (1-2)	0.448‡
AIS			
<2	51 (47.22)	26 (24.07)	<0.001†
>2	57 (52.78)	82 (75.93)	
Mechanism: High velocity	108 (100)	108 (100)	†
Intubation in ED or in ICU	36 (33.33)	27 (25)	0.178†
ED CT normal	35 (32.41)	26 (24.07)	0.174†
Survival	98 (90.74)	98 (90.74)	1.000†

†χ^2, ‡Mann-Whitney *U*-test. GCS: Glasgow Coma Scale, GCS-P: GCS-Pupil, IQR: Interquartile range, ICU: Intensive care unit, CT: Computed tomography, BAC: Blood alcohol concentration, ED: Emergency department, AIS: Abbreviated Injury Score

Table 3: Comparison of median Glasgow Coma Scale-Pupil between the blood alcohol concentration over time ($n = 216$)

Parameter	BAC, median (IQR)		Mann-Whitney U-test (*P*)
	Intoxicated	Nonintoxicated	
GCS-P score ED	11 (8-13.75)	12 (10-13)	0.538
GCS-P (best day 1)	12 (8-15)	13 (12-14)	0.368
R1 GCS-P score	11 (8-13.75)	12 (10-13)	0.443
R2 GCS-P score	11.5 (8-14)	12 (11-13)	0.458
R3 GCS-P score	12 (8-15)	12 (11-13)	0.408
R4 GCS-P score	12 (7-15)	12 (12-14)	0.377
R5 GCS-P score	12 (7-15)	13 (12-14)	0.348
R6 GCS-P score	12 (8-15)	13 (12-14)	0.424

GCS-P: Glasgow Coma Scale-Pupil, IQR: Interquartile range, BAC: Blood alcohol concentration, ED: Emergency department

not showing a significant difference in alcohol-intoxicated patients. Ten-year retrospective analysis of patients with TBI showed <1 point difference in GCS between those intoxicated and nonintoxicated, but a 1.4-point difference in patients with severe TBI was observed.[18] A limitation of their study was that BAC was measured selectively and they did not report the percentage of patients from the total cohort who had a measurement of BAC.

Analysis of AIS of the present study revealed that patients with alcohol intoxication had less severe AIS. However, studies by Peng *et al.*[12] and Demetriades *et al.*[19] showed a high AIS score for intoxicated patients. A study that compared the pattern and severity of TBI in patients who were intoxicated with alcohol showed an increased severity of TBI.[20,21]

Health-care professionals can encounter various difficulties when carrying out neurological assessments of intoxicated patients. GCS verbal score of the present study was found to be low and significant when compared to nonintoxicated. In a study by Kelly *et al.*,[22] the verbal part of the alcohol-intoxicated GCS had inappropriately low GCS scores. This can be due to associated cognitive impairment, which can affect the linguistic ability of intoxicated patients.[23]

Strengths and limitations

This is the first of its kind study, in which the GCS-P score was used to assess the neurological outcome, and the GCS-P score was measured and analyzed in all the participants every 4 h. The limitations of the study were that the potential confounders were not assessed, and calibration of examiners was not done before the study.

CONCLUSION

This prospective observational study revealed that there was a low GCS-P score for alcohol-intoxicated patients

Table 4: Comparison of Glasgow Coma Scale-Pupil reactivity score between the blood alcohol concentration ($n = 216$)

Parameter	BAC, change in GCS-P (ED vs. best day 1 GCS-P)		*P*
	Intoxicated ($n = 108$), *n* (%)	Nonintoxicated ($n = 108$), *n* (%)	
Significant	34 (31.48)	45 (41.67)	0.120
Insignificant	74 (68.52)	63 (58.33)	

GCS-P: Glasgow Coma Scale-Pupil, BAC: Blood alcohol concentration, ED: Emergency department

who were admitted to the ED and were not statistically significant. There was no significant difference between alcohol-intoxicated and nonintoxicated patients on emergency GCS-P score and best day 1 score. The more severe injury was seen in patients who were nonintoxicated compared to intoxicated.

Research quality and ethics statement

This study was approved by the Institutional Review Board/Ethics Committee at Sri Devaraj URS Medical College (Approval number SDUMC/KLR/IEC/65/2020-21; approval date May 27, 2020). The authors followed the applicable EQUATOR Network (http://www.equator-network.org/) guidelines, notably the STROBE guideline, during the conduct of this research project.

Acknowledgment

We acknowledge the technical support in data entry, analysis, and manuscript editing by Evidencian Research Associates.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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