Article published online: 2023-10-31

Alcohol Consumption and Helmet Use in Patients with Traumatic Brain Injury due to Motorcycle Accident

Consumo de álcool e uso de capacete em pacientes com traumatismo cranioencefálico por acidente de motocicleta

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Arq Bras Neurocir

Abstract

Alcohol consumption is an important risk factor for traumatic brain injury (TBI), and it has a great impact on its incidence and severity. However, studies suggest potential beneficial effects of alcohol during hospitalization and in the prognosis of moderate or severe TBI, with conflicting results. The objective of the present study was to associate alcohol consumption and helmet use in TBI patients, as well as the prognostic variables and patterns of injuries secondary to TBI. We analyzed 109 medical records of patients who suffered TBI due to a motorcycle accident. We evaluated data on alcohol consumption, helmet use, TBI severity, and tomographic findings on admission. The subjects with moderate or severe TBI were evaluated regarding hospitalization, mortality and prognosis variables. Patients who wore a helmet at the time of trauma had lower rates of skull fracture and extradural hematoma (EDH), but an increased incidence of subarachnoid hemorrhage (SAH). Furthermore, patients with moderate or severe TBI who were those under alcohol intoxication had a greater need for Intensive Care Unit (ICU) admission and a tendency to have a lower in-hospital mortality rate and a higher score on the Glasgow Prognostic Score (GPS). Thus, although the consumption

Keywords
► traumatic brain injury
► helmet
► alcohol
► motorcyclist
► prognosis

received
August 24, 2022
accepted
June 21, 2023

DOI https://doi.org/10.1055/s-0043-1776274.
ISSN 0103-5355.

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

of alcohol has an impact on the incidence and severity of TBI at admission, it seems to be related to a lower in-hospital mortality rate and a better prognosis. In addition, helmet use is essential to prevent injuries from direct head-to-shield impact, but no similar reduction in the incidence of injuries caused by indirect forces was observed.

Resumo

O consumo de álcool é um importante fator de risco para o traumatismo cranioencefálico (TCE), e tem grande impacto em sua incidência e gravidade. Entretanto, estudos sugerem potenciais efeitos benéficos do álcool durante a internação e no prognóstico do TCE moderado ou grave, com resultados conflitantes. Neste estudo, objetivou-se associar o consumo de álcool e o uso de capacetes em pacientes com TC, além das variáveis prognósticas e dos padrões de lesões secundárias ao TCE. Analisamos 109 prontuários de pacientes com TCE por acidente de motocicleta. Avaliamos dados relativos ao consumo de álcool, uso do capacete, gravidade do TCE, e achados tomográficos admissionais. Os pacientes com TCE moderado ou grave foram avaliados em termos das variáveis de internação, mortalidade e prognóstico. Os pacientes que utilizavam capacete no momento do trauma apresentaram menores índices de fraturas cranianas e hematoma extradural (HED), e aumento da incidência de hemorragia subaracnóidea (HSA). Além disso, os pacientes com TCE moderado ou grave que haviam consumido álcool apresentaram maior necessidade de internação em Unidade de Tratamento Intensivo (UTI) e tendência a apresentar menor taxa de mortalidade intra-hospitalar e maior pontuação no Escore Prognóstico de Glasgow (EPG). Assim, apesar de o consumo de álcool ter um impacto na incidência e na gravidade do TCE à admissão, ele parece estar relacionado a uma menor taxa de mortalidade intra-hospitalar e a um melhor prognóstico. Além disso, o uso do capacete é fundamental para a prevenção de lesões por contato direto cabeça–anteparo, mas não foi observada similar redução da incidência das lesões por forças indiretas.

Palavras-chave
- traumatismo cranioencefálico
- capacete
- álcool
- motociclista
- prognóstico

Introduction

Traumatic brain injury (TBI) consists of any aggression that causes anatomical or functional injury to the scalp, skull, meninges, or brain. According to the World Health Organization (WHO), this type of trauma is the main determinant of death and sequelae in polytrauma patients.[1] It has a high socioeconomic impact and is responsible for high rates of morbidity, mortality and disability.[2] In Brazil, ~ 100 thousand hospitalizations due to TBI were registered in the Unified Health System (Sistema Único de Saúde, SUS, in Portuguese) in 2020.[3]

The etiology of TBI is diverse and varies according to age group. In children, there is a prevalence of domestic accidents, sports accidents, and falls; among adolescents and young adults, traffic accidents prevail – especially motorcycle accidents –, as well as aggressions, whereas in the elderly, falls and domestic accidents are the main causes.[4] There is still a territorial distribution in Brazil in relation to the etiology of the trauma even in the adult population: the Northeastern region of the country has the second highest number of accidents involving motorcyclists, only behind the Southeastern region.[3]

Among the several risk factors for TBI, the consumption of alcohol has a great impact on its incidence and severity. In relation to traffic accidents, mainly involving motorcycles, alcohol consumption is associated with high driving speed and reduced ability to process information, such as road signs and traffic lights. Although it constitutes a crime under Brazilian legislation, driving under the influence of alcohol remains one of the main factors responsible for the high incidence of accidents with victims, and for ~ 70% of fatal accidents.[1]

Despite the association involving alcohol consumption and the incidence and severity of TBI, some studies[5,6] suggest that alcohol has a beneficial effect on patients with moderate or severe TBI, reducing the incidence of complications and in-hospital mortality. Therefore, the literature is conflicting regarding such associations; hence, cross-sectional studies can enrich knowledge on this field of study.

The first reports of the neuroprotective effects of alcohol after TBI were highlighted in animal and laboratory studies.[7–9] Other studies[10,11] contradict this thesis, and claim that the neuroprotective role of alcohol in TBI needs further clarification.

Thus, there is a need to know the real impact of alcohol during hospitalization and on the prognosis of patients with moderate or severe TBI. Thus, the present study aims to associate alcohol consumption and the use of helmets in TBI patients, as well as the prognostic variables and patterns of injuries secondary to moderate and severe TBI in a subgroup analysis.

Materials and Methods

The present is a descriptive, quantitative, observational, and retrospective study conducted through a review of the medical records of patients with TBI due to motorcycle accidents admitted to a reference emergency hospital in the city of Teresina, state of Piauí, Northeastern Brazil.

The study sample was calculated according to the formula for finite populations:

$$n = \frac{N \cdot \sigma^2 \cdot (Z_{\alpha/2})^2}{(N-1) \cdot E^2 + \sigma^2 \cdot (Z_{\alpha/2})^2}$$

in which “n” is the number of individuals in the sample; “N” is the population size (355 individuals; we performed a survey on the admission of patients with TBI due to motorcycle accidents in 2019 at the hospital where the study was conducted); “Zα/2” is the critical value corresponding to the 95% confidence level (1.96); “σ” is the population standard deviation of the studied variable ($\sigma \approx$ amplitude/4); and “E” is the margin of error (15). The calculation yielded a sample of $\sim$ 98 patients.

The number of patients found exceeded the sample initially stipulated, and we included 109 patients with TBI due to motorcycle accident, aged between 18 and 70 years, who were admitted to a referral emergency hospital in the city of Teresina. Patients who did not report alcohol consumption, helmet use, and for whom there was no data on the Glasgow Coma Scale (GCS) score on admission were excluded from the study, as well as those with associated systemic trauma or who had previous neurological diseases.

The medical records of the patients were evaluated regarding alcohol consumption, helmet use, TBI severity on admission (GCS score), and tomographic findings on admission.

A subgroup of patients with moderate (GCS score between 9 and 12) and severe TBI (GCS score $\leq$ 8, or who had a reduction in the score $\geq$ 3 points during hospitalization) was established for secondary analyses. These were evaluated regarding the need for intensive care unit (ICU) admission, mean length of ICU stay, mean length of hospital stay, and in-hospital mortality rate.

For the prognostic analysis of the subgroup of patients with moderate to severe TBI, a prospective evaluation was performed. The prognosis of these patients was assessed using the Glasgow Prognostic Score (GPS): the patients who were discharged were contacted by telephone between the twelfth and fifteenth months after admission.

Regarding the tomographic findings on admission, the patients were stratified into 4 groups according to the dependent variables: helmet use and alcohol consumption (present or absent for each). This enabled the individual analysis of the correlation of these dependent variables with the need for ICU stay, the mean length of stay in the ICU and hospital, the in-hospital mortality rate, and the mean GPS as independent variables.

The statistical analysis was performed using the SPSS Statistics for Windows (SPSS Inc., Chicago, IL, United States) software, version 17.0. The Chi-squared test (χ^2) was used to test the significance of the association regarding the categorical independent variables (use of helmet at the time of trauma and alcohol consumption before TBI) and categorical dependent variables (tomographic findings on admission, need for ICU on admission). The Student *t*-test was used to assess the significance of the association involving the categorical independent variables (helmet use at the time of trauma and alcohol consumption before TBI) and quantitative dependent variables (length of ICU and hospital stays, in-hospital mortality, and GPS). The significance level was set as $p < 0.05$. Graphs were developed using the Minitab statistical software (Minitab, LLC, State College, PA, United States).

Results

The study included 109 patients with TBI due to a motorcycle accident; 93 (85.3%) of them were not wearing a helmet, and 63 (57.8%) were drunk at the time of the accident. The subgroup of patients with moderate to severe TBI who could be followed for 12 to 15 months was composed of 39 patients, 23 of whom were intoxicated at the time of the accident.

When evaluating the impact of these variables alone on the tomographic findings on admission, we observed that head-to-shield direct-impact injuries corresponding to fractures ($p = 0.025$) and extradural hematoma (EDH; $p = 0.042$) presented the highest rates among patients who did not wear a helmet (►**Table 1** and Graph 1A).

When comparing the presence of bruises in motorcycle accidents according to the use or not of helmets, we found that subjects who were negligent had a higher rate of EDH than of acute subdural hematoma (SDH), at a proportion of 1:0.7. In patients who were wearing helmets during the TBI, this proportion was reduced to 1:3 (►**Table 1** and Graph 1A). In addition, a higher incidence of subarachnoid hemorrhage (SAH) was observed in patients who were wearing a helmet at the time of trauma ($p = 0.033$)

Regarding alcohol consumption, intoxicated patients had proportionally higher rates of tomographic findings on admission in all categories, except for EDHs, when compared with those who were not intoxicated (Graph 1B). We could identify a trend, despite the lack of statistical relevance in the data presented ($p > 0.05$).

Regarding the data on hospitalization and prognosis of patients with moderate or severe TBI, the group who was intoxicated had a higher severity index in relation to the greater need for ICU admission among the group of patients who were not using a helmet (65.2% versus 62.5% respectively; Graph 2A). However, they had a lower in-hospital mortality rate (34.7% versus 43.7% respectively; Graph 2D) and a higher GPS (2.7 versus 2.5 respectively; Graph 2E). It is worth mentioning the lack of statistical relevance in the data presented ($p > 0.05$).

Table 1 Correlation regarding tomographic findings on admission, helmet use, and alcohol consumption before a TBI

Variables	Helmet (+); N = 16–n (%)	Helmet (-); N = 93–n (%)	OR (*p*-value)	Alcohol (+); N = 63–n (%)	Alcohol (-); N = 46–n (%)	OR (*p*-value)
Skull fracture	7 (43.8%)	67 (72%)	0.3 (0.025)	44 (69.8%)	30 (65.2%)	1.2 (0.610)
Contusion	7 (43.8%)	43 (46.2%)	0.9 (0.854)	31 (49.2%)	19 (41.3%)	1.8 (0.414)
EDH	2 (12.5%)	36 (38.7%)	0.2 (0.042)	19 (30.2%)	19 (41.3%)	0.6 (0.228)
ASDH	6 (37.5%)	25 (26.9%)	1.6 (0.384)	19 (30.2%)	12 (26.1%)	1.2 (0.642)
SAH	10 (62.5%)	32 (34.4%)	3.1 (0.033)	26 (41.3%)	16 (34.8%)	1.3 (0.492)
Diffuse brain edema	1 (6.3%)	6 (6.5%)	0.9 (0.976)	5 (7.9%)	2 (4.3%)	1.8 (0.450)
Pneumocephalus	2 (12.5%)	14 (15.1%)	0.8 (0.790)	10 (15.9%)	6 (13.0%)	1.25 (0.680)

Abbreviations: ASDH, acute subdural hematoma; EDH, extradural hematoma; OR, odds ratio; SAH, subarachnoid hemorrhage; TBI, traumatic brain injury.
Notes: " + " indicates the presence of the variable at the time of the trauma; "-" indicates absence of the variable at the time of trauma; statistical significance was set at $p < 0.05$.

Table 2 Correlation regarding hospitalization, prognosis data of motorcyclists with moderate or severe TBI, and alcohol consumption before a TBI

Variables	Alcohol (+) N = 23	ALcohol (-) N = 16	OR	*p*-value
Need for admission – n (%)	15 (65.2%)	10 (62.5%)	1.1	0.866
Average length of stay (days):				
ICU (N = 25) – mean ± standard deviation	11.9 ± 14.5	6.6 ± 5.03		0.277
Hospital	15.8 ± 18.49	9.3 ± 8.25		0.197
In-hospital mortality rate (%)	34.8%	43.8%	0.6	0.583
Glasgow Prognostic Score (*N* = 29) – mean ± standard deviation	2.70 ± 1.89 (*N* = 17)	2.5 ± 1.88 (*N* = 12)		0.775

Abbreviations: ICU, Intensive Care Unit; OR, odds ratio; TBI, traumatic brain injury.
Notes: " + " indicates the presence of the variable at the time of the trauma; "-" indicates absence of the variable at the time of trauma; statistical significance was set at $p < 0.05$.

Discussion

The present study aimed to evaluate the association regarding alcohol consumption and helmet use with prognostic variables and injury patterns secondary to TBI on admission; moreover, we performed a prospective subgroup analysis of patients with moderate to severe TBI to evaluate the prognosis.

As observed, 93 patients (85.3%) were not wearing a helmet and 63 patients (57.8%) were intoxicated at the time of the accident. These data reflect the urgency of public policies aimed at raising awareness among the population, in addition to more effective inspection and punishment measures for those who fail to comply with these norms already established in Brazilian legislation.

In the present study, intoxicated patients had a higher rate of tomographic findings associated with greater severity on admission. Similarly, in a study[12] performed in Los Angeles with 479 seriously-injured patients, a higher incidence of severe TBI and lower GCS scores were observed in patients with high blood alcohol levels on admission.

When comparing the presence of bruises in motorcycle accidents according to helmet use, we observed that patients who were negligent presented a higher proportion of EDH in relation to acute subdural hematoma (ASDH). There is a statistical ($p = 0.042$) association between helmet use and a lower incidence of EDH, which can alter the ratio of hematomas (EDH and SDH), which have different injury mechanisms. In addition, there was an increase in the incidence of SAH in patients wearing a helmet at the time of the trauma ($p = 0.033$).

Thus, helmet use has been shown to be associated with a reduction in the incidence and severity of TBI in the motorcyclist population. It is believed that the reduction in morbidity and mortality when using the helmet correctly is due to the absorption and redistribution of kinetic forces during the impact. However, according to the study by Richter et al., in which the mechanisms of brain trauma in motorcyclists wearing helmets were evaluated, injuries caused by the effect of indirect forces (acceleration, deceleration, and rotation) continue to be a problem. This finding reflects the inversion of the EDH and SAH/ASDH ratio.[13]

In an epidemiological study[14] performed in Cambodia, the authors also observed a reversal in the proportion of bruises related to helmet use or neglect. In this study, only 13% of the patients used a helmet during the trauma. As observed, the most common tomographic diagnosis was skull fracture. The ratio of ASDH to EDH was of 1:1.05.

Agrawal and Dawar[15] reported a strong association between tentorial hematomas and helmet use (89%). Thus, they suggested that although the helmet offers protection against direct brain injury, indirect transmission of rotational forces is still present. Gupta et al.[16] reported a lower rate of EDH in patients wearing helmets. However, patients with and without helmets presented similar rates of other types of intracranial hemorrhage, as well as fractures.

Regarding alcohol consumption, it is noteworthy that intoxicated patients had a higher incidence of all pathological tomographic findings on admission, except for EDHs. A correlation is suggested with the tendency of motorcyclists to drive at higher speeds (mechanism of inertial trauma) and to display greater neglect regarding helmet use (mechanism of trauma by direct contact) when intoxicated. However, such data were not statistically significant ($p > 0.05$).

Regarding the data on hospitalization and prognosis of the patients with moderate to severe TBI, antagonistic results regarding severity and outcome were observed in the present study. Although the intoxicated group of patients presented a higher severity index (with greater need for ICU admission, for example), they presented a lower in-hospital mortality rate, and a higher GPS. It is important to report the longer length of stay in the ICU and in the hospital among the intoxicated patients; their lower in-hospital mortality rate made hospital stay longer, but this was not statistically significant ($p > 0.05$).

The increase in interest in the role of alcohol and its repercussions on TBI outcome was based on laboratory results and animal studies,[8,9] which have demonstrated a lower mortality rate, better motor function, reduced size of intracranial lesions, and reduced cognitive dysfunction with alcohol consumption before the lesion.

However, the mechanism of this protective effect remains unclear. The binding of ethanol to N-methyl-D-aspartate receptors and the inhibition of the excitotoxicity pathway are presumed to be responsible for the neuroprotective effects of alcohol. The increase in postinjury hyperglycolysis and the reduction in the levels of catecholamines and inflammatory mediators have also been suggested as beneficial effects of alcohol intoxication in TBI.[7,17–19] Studies[7,18,20] have reported that the critical period for the benefits of alcohol in TBI occurs up to one hour after the injury.

Evidence of the Benefits of Alcohol in Moderate or Severe TBI

In 2009, the largest retrospective clinical study[6] to date on the relationship between alcohol and TBI was conducted; the authors that high serum levels of alcohol are independently associated with greater survival in patients with severe TBI. After this first study, the authors expanded the results and concluded that alcohol is also an independent factor for greater survival in patients with moderate TBI.[21]

Talving et al.[22] compared groups of patients with low and high blood alcohol levels, and they concluded that, in TBI patients, blood alcohol levels do not appear to be associated with the severity of the injury according to the GCS on admission, nor with the occurrence of major morbidities. However, hospital mortality was significantly lower in patients with high blood alcohol levels.

In a study conducted in Los Angeles,[12] the authors divided TBI patients according to blood alcohol levels into non-alcohol, low-alcohol, and high-alcohol groups; they reported an increase in the length of hospital stay in the low-alcohol group, but the high-alcohol group presented significantly better survival than the non-alcohol group.

In a retrospective study, Raj et al.[23] included TBI patients treated in the ICU of a large center, and they reported that low levels of alcohol on admission independently reduced the risk of long-term mortality when compared no alcohol or high levels of alcohol on admission. In addition, a trend toward better neurological evolution was observed in patients with some level of alcohol in their blood.[23]

On the contrary, Lin et al.[24] compared the in-hospital mortality rate of patients with blunt TBI with different blood alcohol concentrations, and they concluded that patients with moderate to high concentrations presented a lower mortality rate than those with low alcohol concentrations.

Studies have also demonstrated systemic benefits in patients with alcohol intoxication before a TBI. Lustenberger et al.[25] concluded that alcohol intoxication is associated with a lower incidence of early coagulopathy and in-hospital mortality. In addition, in a retrospective study,[4] the authors observed a significant decrease in the rate of pneumonia in intoxicated patients with moderate to severe TBI. However, Salim et al.[6] related alcohol to an increase in the rate of sepsis and in the indication for tracheostomy in intoxicated patients with severe TBI.

Does Alcohol Really Have a Neuroprotective Effect?

In a study[26] performed in a population of motorcyclists, the authors observed an increase in mortality of up to 4 times in the population who consumed alcohol before the TBI. Another study[27] on the impact of substance abuse, including alcohol, on the mortality of patients with severe TB found that the use of amphetamine was associated with lower in-hospital mortality; however, alcohol consumption did not affect mortality. Shandro et al.[11] did not report an association between alcohol consumption and mortality in patients with moderate or severe TBI.

Furthermore, in a study[28] performed with 137,950 alcohol-positive and 262,618 alcohol-negative patients, no statistically significant differences were found in the mortality rate between the two groups after a TBI.

In a retrospective study with patients included in the United States National Trauma Data Bank (NTDB), Pandit et al.[10] concluded that alcohol consumption is an independent predictor of mortality in patients with TBI, and it is associated with higher complication rates.

Conclusion

The negligence regarding helmet use and alcohol consumption by motorcyclists is a serious health problem. Both variables play a role in the incidence and severity of TBI. Helmet use prevents brain injuries from direct contact, especially fractures and EDHs, but its role in relation to injuries caused by acceleration, deceleration or rotation is yet to be established. In the present study, we could not statistically correlate alcohol consumption before the TBI with any specific tomographic findings. In addition, alcohol consumption before a TBI seems to be related to a lower in-hospital mortality rate and better prognosis. However, further studies with a definition of risk are needed to reinforce these findings, but they. presents ethical difficulties, since it is not possible to guide groups to stop wearing helmets or drinking alcoholic beverages.

Limitations of the Study

The present study did not take into account variables that may interfere with tomographic findings, such as the helmet buckling condition at the time of the trauma. In addition, we found an association trend without statistical significance in the results regarding mortality and TBI prognosis when related to alcohol intake. Furthermore, in the prognostic evaluation of patients who were discharged from the hospital, we were unable to contact 10 patients, which represents 25.6% of the total sample, a fact that may interfere with the results herein reported. Association biases may be typical in studies with a retrospective design, such as in relation to patients with a better prognosis possibly having received better care in an ICU environment. The conduction of cohort studies to define risk is hampered by ethical issues, as it is not possible to guide groups to drink alcohol or not wear a helmet.

Funding
The authors declare that they have not received funding from any source for the conduction of the present study.

Conflict of Interests
The authors have no conflict of interests to declare.

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