The comparison of postmortem blood alcohol concentrations in fatal motor vehicle accidents

การเปรียบเทียบระดับแอลกอฮอล์ในเลือดภายหลังตายในศพที่เสียชีวิตจากอุบัติเหตุจราจร

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Abstract

Objectives: To compare blood alcohol concentrations among different types of fatal motor vehicle accidents and to determine the relationship between blood alcohol concentrations and severity of injury.

Materials and methods: Data from two-hundred motor vehicle accidents autopsied at the Department of Forensic Medicine, Faculty of Medicine Siriraj Hospital during December 2018 to January 2020 were analyzed including demography, injuries, postmortem blood alcohol concentrations (BACs) and types of accident. Injuries were classified into six organ systems, scored into Abbreviated Injury Scale (AIS) and calculated to Injury Severity Score (ISS). Descriptive statistics and Kruskal-Wallis H test and Spearman's correlation were performed among the data.

Results : The vast majority of the cases are male (73.5%) and overall age ranged from 18 to 83 years old (YO) (mean = 39.6 YO). Approximately 47.5% of the cases shows BACs of above 50 mg/dL with median = 222.64 mg/dL. Victims of age ≤ 45 YO contain statistically higher BACs than the others as same as those observed in drivers of either a motorcycle or a car compared to pedestrians or passengers. The motorcycle riders with frontal collision also have significantly higher BACs than those with non-frontal collision. Only frontal-collision motorcycle victims show a positive correlation between BACs and AIS scores for maxillofacial injuries (driver: $r=0.316$, $p<0.01$ and passenger: $r=0.350$, $p<0.05$)

Conclusion: One significant factor that traffic drivers tend to cause accident is a high BAC. This might be consistent with age and sex showing that male adults of middle-age are dominant victims. A motorcycle frontal collision shows higher BACs than the other types and relating to more severe maxillofacial injuries.

Keywords: Postmortem blood alcohol concentration (BAC), motor vehicle accident, Abbreviated Injury Scale (AIS), Injury Severity Score (ISS)

บทคัดย่อ

วัตถุประสงค์: เพื่อเปรียบเทียบระดับแอลกอฮอล์ในเลือดของศพที่เสียชีวิตจากอุบัติเหตุจราจรประเภทต่าง ๆ และศึกษาความสัมพันธ์ของระดับแอลกอฮอล์ในเลือดศพที่เสียชีวิตจากอุบัติเหตุจราจร กับระดับความรุนแรงของการบาดเจ็บ

วัสดุและวิธีการศึกษา: ทำการศึกษาโดยการรวบรวมข้อมูลแบบย้อนหลังของศพที่เสียชีวิตจากอุบัติเหตุจราจร ที่ได้ทำการผ่าศพตรวจ ณ ภาควิชานิติเวชศาสตร์ คณะแพทยศาสตร์ศิริราชพยาบาล มหาวิทยาลัยมหิดล ตั้งแต่วันที่ 1 ธันวาคม 2561 ถึงวันที่ 31 มกราคม 2563 จำนวน 200 ศพ โดยทำการบันทึกข้อมูล ได้แก่ เพศ, อายุ, ระดับแอลกอฮอล์ในเลือดภายหลังตาย และประเภทของอุบัติเหตุจราจร จากนั้นจำแนกลักษณะการบาดเจ็บที่ตรวจพบจากการตรวจศพ ออกเป็นระบบต่าง ๆ ได้แก่ ศีรษะและลำคอ, ใบหน้า, ช่องอก, ช่องท้อง, เชิงกรานและแขนขา และบาดแผลภายนอก โดยในแต่ละระบบทำการให้คะแนนตาม Abbreviated injury scale (AIS) จากนั้นจึงนำข้อมูลที่ได้มาคำนวณ Injury severity score (ISS) ทำการวิเคราะห์ทางสถิติเพื่อเปรียบเทียบระดับแอลกอฮอล์ในเลือดภายหลังตาย กับประเภทของอุบัติเหตุจราจร โดยใช้การทดสอบทางสถิติ ได้แก่ Descriptive statistics และ Kruskal-Wallis H Test และทำการวิเคราะห์หาความสัมพันธ์ระหว่างระดับแอลกอฮอล์ในเลือดภายหลังตาย กับระดับความรุนแรงของการบาดเจ็บ โดยใช้ Spearman’s correlation

ผลการศึกษา: จากการรวบรวมข้อมูลพบว่ามีศพที่เสียชีวิตจากอุบัติเหตุจราจรทั้งหมด 200 ศพ เป็นเพศชาย 147 ศพ (ร้อยละ73.5) และเพศหญิง 53 ศพ (ร้อยละ 26.5) ศพทั้งหมดมีช่วงอายุระหว่าง 18-83 ปี มีอายุเฉลี่ยเท่ากับ 39.6 ปี พบว่ามี 95 ศพ ที่มีระดับแอลกอฮอล์ในเลือดของศพเกินกว่า 50 mg/dL ซึ่งเกินกว่าที่กฎหมายกำหนด คิดเป็นร้อยละ 47.5 โดยค่า มัธยฐานของระดับแอลกอฮอล์ในเลือดของศพกลุ่มนี้ เท่ากับ 222.64 mg/dL เมื่อเปรียบเทียบค่าเฉลี่ยของระดับแอลกอฮอล์ในเลือดของศพ ระหว่างช่วงอายุของกลุ่มตัวอย่าง พบว่า ศพที่มีอายุไม่เกิน 45 ปี จะมีระดับแอลกอฮอล์ในเลือดที่สูงกว่ากลุ่มที่มีอายุมากกว่า 45 ปี โดยมีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) กลุ่มคนขับยานพาหนะ มีระดับแอลกอฮอล์ในเลือดของศพสูงกว่ากลุ่มคนเดินถนนและคนโดยสารยานพาหนะ โดยมีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) กลุ่มคนขับรถจักรยานยนต์ที่มีการชนทางด้านหน้า มีระดับแอลกอฮอล์ในเลือดของศพที่สูงกว่ากลุ่มคนขับรถจักรยานยนต์ที่มีการชนจากทางด้านอื่น โดยมีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) และระดับแอลกอฮอล์ในเลือดของศพมีความสัมพันธ์กับการบาดเจ็บบริเวณใบหน้า โดยเฉพาะอย่างยิ่งในกลุ่มคนขับรถจักรยานยนต์ที่มีการชนทางด้านหน้า และ กลุ่มคนโดยสารยานพาหนะ ($r=0.316$, $p<0.01$ และ $r=0.350$, $p<0.05$ ตามลำดับ)

สรุปผลการศึกษา: ศพที่เสียชีวิตจากอุบัติเหตุจราจรที่ตรวจพบระดับแอลกอฮอล์ในเลือดเกินกว่าที่กฎหมายกำหนดเกือบครึ่งหนึ่ง โดยพบว่าผู้ขับขี่ยานพาหนะ มีระดับแอลกอฮอล์ในเลือดที่สูงกว่าศพในกลุ่มอื่นๆ เช่น คนเดินถนน หรือผู้โดยสาร นอกจากนี้ ในผู้ตายซึ่งใช้รถจักรยานยนต์ที่ชนทางด้านหน้ามีระดับแอลกอฮอล์ในเลือดที่สัมพันธ์กับความรุนแรงของการบาดเจ็บบริเวณใบหน้า

คำสำคัญ: ระดับแอลกอฮอล์ในเลือดผู้เสียชีวิต, อุบัติเหตุจราจร, ระบบการจัดระดับความรุนแรงของการบาดเจ็บในแต่ละส่วนของร่างกาย, ระบบการคำนวณหาค่าความรุนแรงรวมของการบาดเจ็บ

Introduction

Alcohol use is one of the most common substance found in various forensic cases i.e. traffic accidents, sexual offenses, body assaults or self-inflicts(1). So far, World Health Organization (WHO) reports that Thailand has the 9th highest annual mortality rate in the world that is caused by traffic injuries (32.7 per 100K population) and is ranked the 1st in Asia(2,3). In 2018, motorcycle accident is the leading type that alcohol consumption is believed to play an important role(3). This results in mortality and morbidity that affects a socio-economic structure of the country. Taylor and Rehm (2012) supported this by showing that traffic mortality significantly positively-correlated to blood alcohol concentrations (BACs)(4). So, this study hypothesized that BAC might be an important factor to some specific types and severity of traffic injuries.

However, autopsy findings in traffic cases are presented in several parts of the body with varied severities that might depend on types and mechanisms of incident, speed while the accident occurs, and BACs. To draw how the accident occurs, thorough scene investigation and autopsy findings may help analyze types and mechanisms at some point in conjunction with other evidences. Nevertheless, if data from scene and autopsy is limited as well as no firm evidences, BAC may be useful to determine a cause of accident in the legal process when combining with other circumferential evidences. Previous studies have compared BACs in traffic accidents with other causes of injuries such as falls(5) or with other manners(6) but there is no deep study of BACs in different types of traffic accidents and also in correlation with injury severity. Thus, this study aims to analyze BACs in fatal motor vehicle accidents and correlate BACs with types and severity of injuries to obtain useful data for the diagnosis of types and mechanisms of injuries in traffic accidents.

Materials and methods

Population

Retrospective study was performed from the autopsy reports and data of traffic fatalities done at the Department of Forensic Medicine, Faculty of Medicine Siriraj Hospital during December 2018 to January 2020. Inclusion criteria include:

1. Thai citizens of age above 18 YO
2. Containing complete evidences such as police investigation data, autopsy data or CCTV footage that are enough to identify types and mechanisms of the accidents
3. Postmortem interval < 3 hours

The exclusion criteria include:

1. Showing any sign of decomposition
2. Blood cannot be retrieved

Factors involving in the study

Data from each individual includes demography (i.e. sex and age), BAC, types of passenger or a pedestrian, types of vehicle, and collision directions in motorcycle accidents which is categorized into frontal against non-frontal types was extracted from reports and database. Injuries were graded and classified into six regions of the body including head and neck, face, chest, abdomen, pelvis and extremities and external wounds according to the Abbreviated injury scale (AIS) with the rating scale ranging from 1 to 6, and were calculated to Injury severity score (ISS) which is based upon the most three severe AIS as the following equation(7,8): ISS = (AIS1)2 + (AIS2)2 + (AIS3)2.

Statistical analysis

SPSS Statistic for Windows ver.19 was used to analyze the abovementioned factors by means of descriptive statistics. Pairwise comparison between BACs of each types and mechanisms was carried out by Kruskal-Wallis H test. Correlation between BACs and injury severity was performed by bivariate correlation and Spearman's correlation.

Ethical approval

Institutional Reviewing Board of the Faculty of Medicine Siriraj Hospital was granted the approval to this study as No. Si 190/2020.

Results

The total number of cases suit to the criteria is 200 which comprises of 147 males (73.5%) and 53 females (26.5%). The ages range from 18 to 83 YO (mean = 39.6). Of total, BACs are found in 106 cases (53%) whereby 95 contain BAC over 50 mg/dL (47.5%). The distribution curve of BACs > 50 mg/dL is presented in **Fig.1** which shows mean and median as 216.66 and 222.64 mg/dL, respectively.

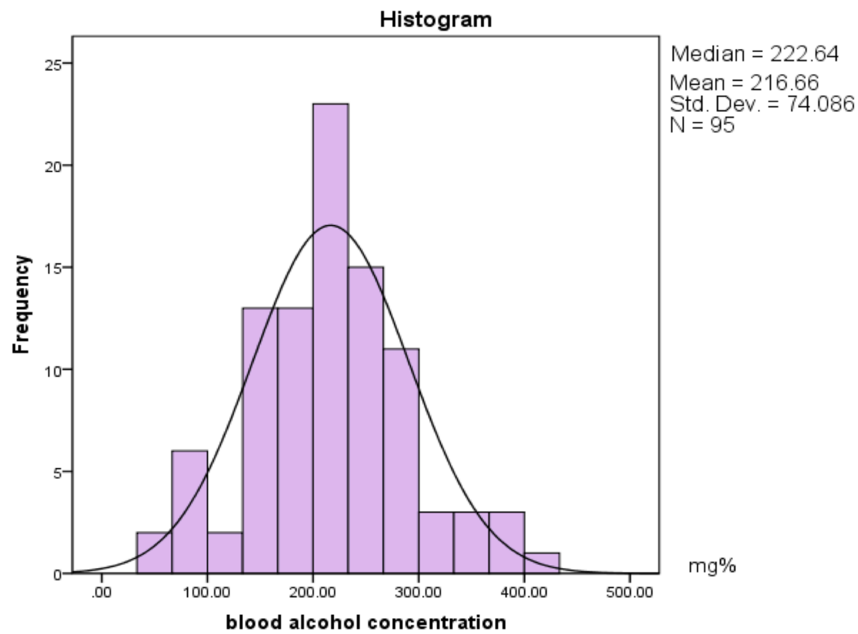

Fig.1 Distribution of a number of the cases containing BAC > 50 mg/dL

BAC may have different degrees of a risk of accident in different behaviors, so they are categorized into four groups by the victims' activities, i.e. motorcycle drivers, car drivers, passengers of any type of vehicle, and pedestrians and the results are shown in **Table 1.**

Table 1 BACs categorized by victims' activities

Victim's activity	n	BAC range	% of victims with BAC >50 mg/dL	Median of BAC in victims with BAC >50 mg/dL
Motorcycle driver	86	0 - 351.35	62.79	218.38
Car driver	24	0 - 357.17	54.17	227.68
Passenger	34	0 - 260.28	17.65	152.92
Pedestrian	56	0 - 420.48	39.29	239.14

Categorizing the cases into 4 age groups, i.e. 18-30, 31-45, 46-60 and >60 YO, it is found that the first two groups (age < 45 YO, 135 individuals, 67.5%) show significantly higher BACs than the rest (65 individuals, 32.5%) ($p<0.05$) as in **Fig.2.**

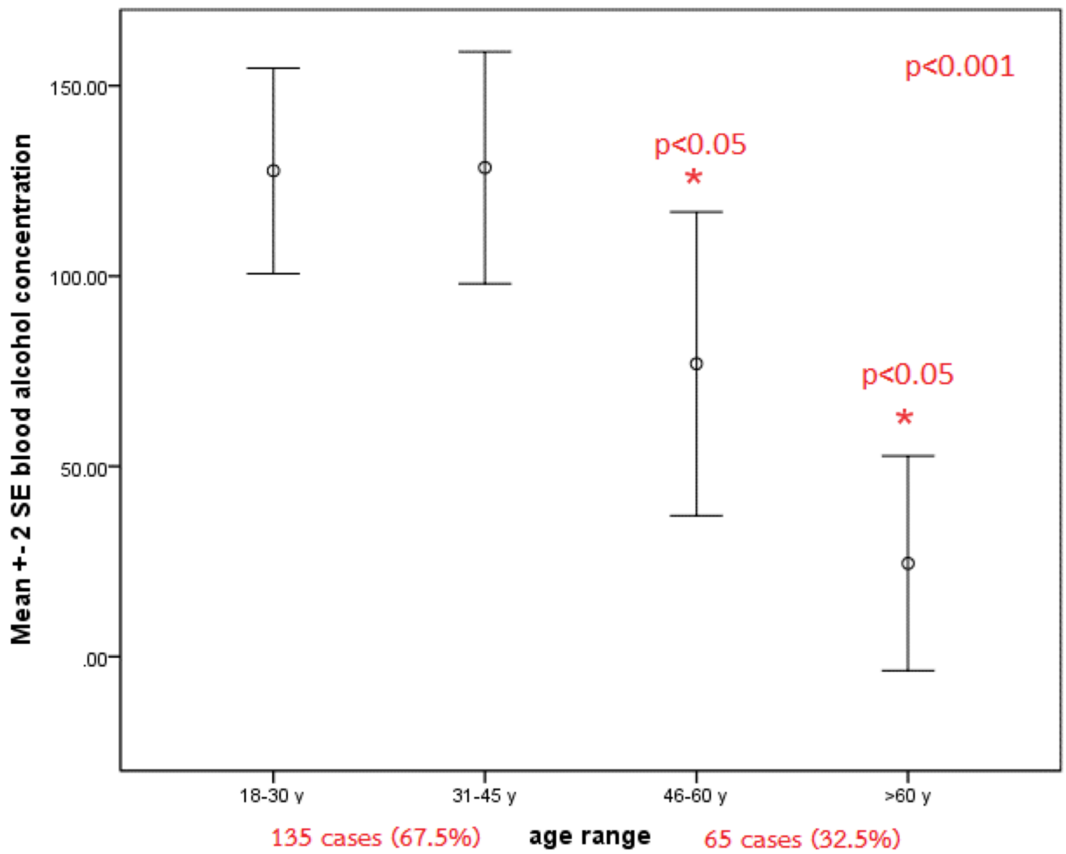

Fig.2 Means of BACs in four age groups

When dividing cases into 3 groups regarding their activities during accidents, i.e. drivers, passengers and pedestrians, significant difference is found among all groups ($p<0.001$) similar to pairwise comparison between groups ($p<0.05$) as shown in Fig.3 that the highest mean of BAC belongs to the drivers following by the pedestrians and the passengers, respectively. The former two groups have BAC means greater than 50 mg/dL while that of the latter is the other way around.

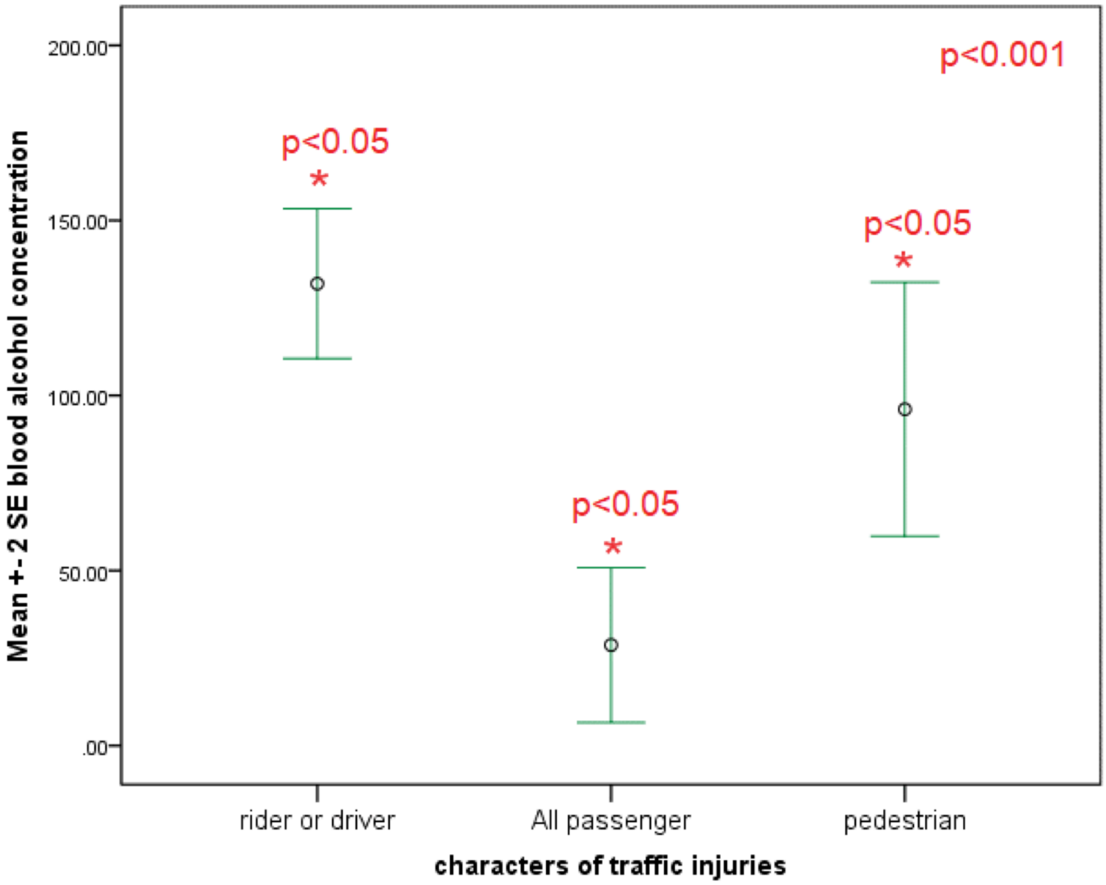

Fig.3 Comparison of BACs among three groups: Drivers, Passengers and Pedestrians from left to right

Re-division of the cases into five novel categories, i.e. motorcycle riders, car drivers, motorcycle passengers, car passengers and pedestrians, their BAC means are still significantly different ($p<0.001$) that the motorcycle riders, the car drivers and the pedestrians show the BAC means within 100-150 mg/dL and are significantly different ($p<0.05$) to the passengers of either a motorcycle or a car which show BAC means below 50 mg/dL as shown in **Fig.4.** However, among the former three categories, the BAC means are statistically unremarkable ($p>0.05$) whereas the latter two act similarly.

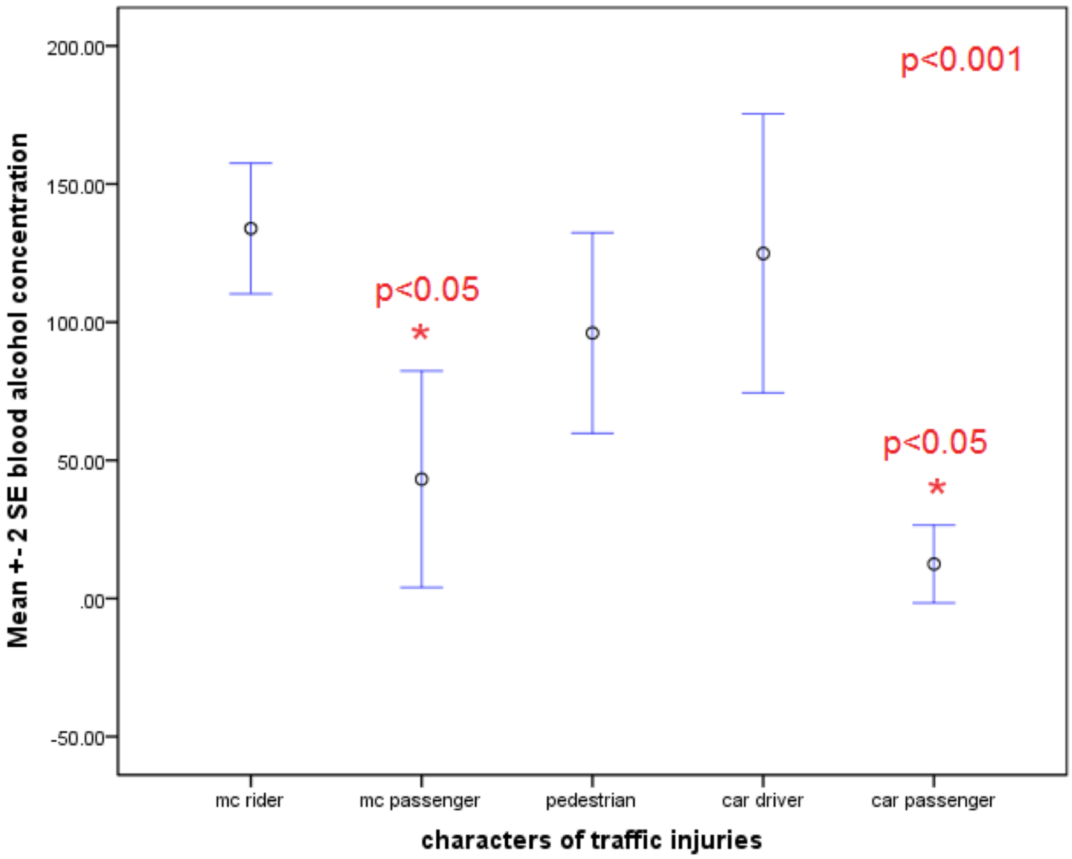

Fig.4 Comparison of BACs among five groups: Motorcycle riders, Motorcycle passengers, Pedestrians, Car drivers, and Car passengers from left to right

Considering that motorcycle riders are the majority population in the study, this subset is divided into two groups according to the collision directions which are frontal and non-frontal collisions and the former is subsequently divided into two subgroups depending on the objects to which they, vehicles and objects. Comparison of BACs among those three groups in conjunction with the car drivers shows significantly different as shown in Fig.5, however, pairwise comparison shows statistically different ($p<0.05$) only between the frontal collision riders to objects and the non-frontal collision riders.

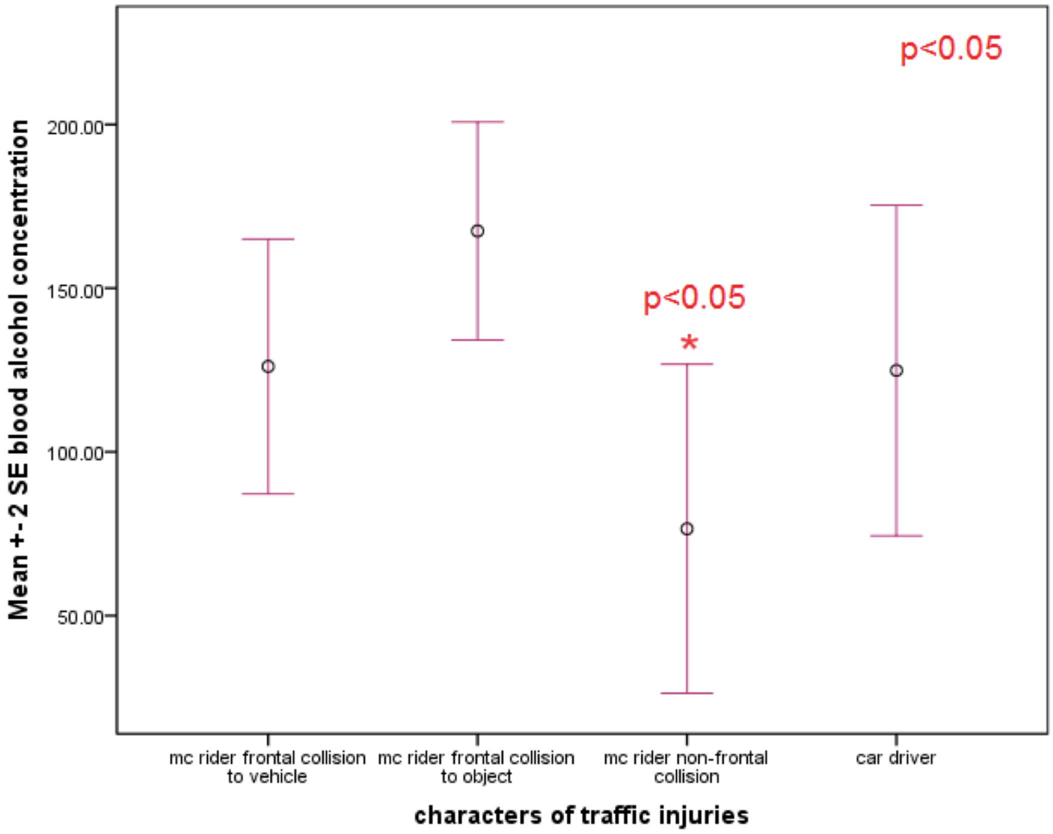

Fig.5 Comparison of BACs among four groups: Motorcycle rider with frontal collision to vehicles, to objects, with non-frontal collision and Car drivers from left to right

Correlation of BACs and severity of injury shows that there is no statistically significant correlation between BACs and ISS ($p>0.05$) in all mechanisms however they correlate with AIS in some mechanisms as shown in **Table 2.**

Table 2 Correlation of BACs to AIS of each body region in different mechanisms of accident

Mechanism	Pairwise correlation	p-value	r	% of death caused by AIS
Motorcycle driver with frontal collision	BAC vs AIS (Face)	0.009	0.316	53.73
Car driver	BAC vs AIS (pelvis and extremities)	0.032	0.438	12.5
Passenger	BAC vs AIS (Face)	0.043	0.350	44.12

The motorcycle drivers with frontal collision and the passengers show statistically significant correlation between BACs and the AIS of maxillofacial region (r= 0.316, p-value = 0.009 and R = 0.35, p-value = 0.043, respectively), also most of the causes of death in both groups involve head and neck (53.73 and 44.12%, respectively). In addition, the car drivers contain BACs which correlate significantly to the AIS of pelvis and extremities (r = 0.438, p-value = 0.032), however, though the severity of pelvis or extremity is high, the major cases with causes of death resulted from these regions are on the opposite direction (12.5%).

Discussion

In Thai traffic law, BAC above 50 mg/dL is illegal and this study is observed that approximately 47.5 % of the fatal victims from traffic accidents contain BACs above the legal threshold. This finding is comparable to Kassasbeh et al. (2011) (65%)(9) and might indicating that about half of more of the dead victims from traffic accidents contain illegal BACs that might potentially increase a risk.

Moreover, mean and median of the BACs in those whose BACs are above the legal threshold (50 mg/dL) are 216.66 and 222.64 mg/dL, respectively, that are not only illegal but they are also over the drunkness level (150 mg/dL)(10) and may lead to loss of vehicle control or body balance and increase the risk of traffic accident.

Obviously, means of BACs from drivers and pedestrians are higher than that from passengers. As shown in Fig.3 and 4, the formers contain means of BAC between 100-150 mg/dL which potentially affects a driving ability and a control of body motion and balance (10) leading to an increase risk of traffic accident. Data in Table 1 represents a wide range of BACs that overlap with one another however when focusing the victims with BAC above 50 mg/dL of each group (motorcycle drivers, car drivers, passengers and pedestrians) the major number of victims are from only the drivers of motorcycles and cars (62.79 and 54.17 %, respectively) with the medians of 218.38 and 227.68 mg/dL, respectively. There are minority of victims from the passengers and pedestrians who contain BAC above 50 mg/dL (17.65 and 39.29 %, respectively) nonetheless the median of those who have illegal BACs are 152.92 and 239.14 mg/dL, respectively. This data shows that BACs of the passengers are lowest even ones who contain high BACs also reveal the median below 200 mg/dL. There is no doubt why most of the victims may lose their abilities to control the vehicles or to have a full awareness while walking on the road(10).

Similarly, it is found that the motorcycle drivers with frontal collision contain higher BACs than the motorcycle drivers with other colliding direction (BAC ranging from 100-200 against 50-100 mg/dL). And the BAC factor might primarily dominate a frontal-collision motorcycle accident while the other collision directions might be caused by a wider variety of factors, for instance, a road condition, the other vehicle, etc.

By looking at age, the younger dead victims are found to have higher BACs than the elder. This data is correspondent to WHO that people younger than 30 YO show significantly higher risk to traffic accidents than the older(2).

In this study, BACs relate to severity of injuries of some body region in some mechanism of accident. Facial injury is one region where BAC correlates to AIS in the motorcycle drivers with frontal collision and passengers of all types of vehicle. Those two groups also show their major causes of death from head and neck. There are some reasons support this, first, the former contains the highest BAC and second, a frontal collision tends to cause injuries to the anterior parts of the body of the drivers and the face is the most prone region. While the passengers dying from head and neck injuries might be caused by a throwing mechanism that their bodies fly away from the vehicles and hit on ground without ability to protect themselves due to high BAC. However, BAC correlates to AIS of pelvis and extremities in the car drivers but leads to only 12.5% of the cause of death. It is possible that there are more severe injuries in other body regions leading to the cause of death so AIS of pelvis and extremities does not best represent the severity of body injury.

Conclusion

BAC is one of the most important factors causing traffic accidents since about half of the victims contain BAC over the legal limit. The younger age group show higher BAC than the elder similar to the drivers that contain higher levels than the pedestrians and passengers. This is obvious in the motorcycle drivers with frontal collision in comparison to the other collision directions suggesting that alcohol depresses their ability to control the vehicle. This also correlates to facial injury severity that resulting in the cause of death occurring around head and neck.

Acknowledgement

We would like to thank the Department of Forensic Medicine for facilitating data accession and to the colleagues who supported in many ways. UB would like to pay his gratitude to his parents for their strong support though this project.

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