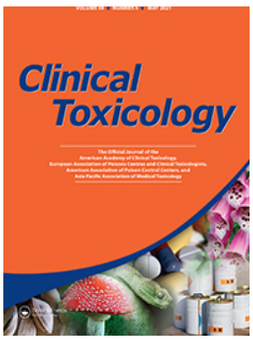

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CLINICAL RESEARCH

Blood phosphatidyl ethanol levels as a tool to detect alcohol misuse in trauma patients

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ABSTRACT

Introduction: There is a strong need for a reliable marker of harmful alcohol consumption to identify injured patients that can benefit from alcohol interventions, and blood phosphatidyl ethanol (PEth) has not previously been tested on this population. This study aims to compare the performance of blood PEth concentration, blood alcohol concentration (BAC) and the Alcohol Use Disorders Identification Test Consumption (AUDIT-C) for the screening of alcohol misuse in trauma patients.

Methods: Prospective cross-sectional study of 238 adult patients presenting in the emergency department with any type of trauma. PEth concentration was determined in whole blood by high-performance liquid chromatography with tandem mass spectrometry. Consent, AUDIT-C score and demographic data were obtained.

Results: The sample consisted of majority male (67.6%), single (46.2%) and employed (66%) patients. The most common type of trauma was traffic collision (63.9%). The mean age was 41.7 years. We found a significant correlation between PEth levels with AUDIT-C score (Spearman's $r = 0.654$; $p < .0001$). PEth had an area under the ROC curve of 0.885 to detect hazardous alcohol consumption (AUDIT-C score $\geq$ 6) and PEth $\geq$23.9 ng/mL cutoff point provided 91.2% of sensitivity and 78.4% of specificity. Twelve patients reported alcohol abstinence, but had quantifiable levels of PEth.

Conclusions: PEth levels and AUDIT-C score had a moderate correlation in our population. PEth was useful to identify 12 cases of underreporting of alcohol consumption habits. PEth shows promising results, but more research is needed to identify the best screening tool for alcohol misuse in trauma patients.

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Trauma; ethanol; phosphatidylethanol; emergency medicine; secondary prevention

Introduction

Trauma is one of the leading causes of death and disability worldwide. It affects predominantly young people and it makes injury the leading cause of death among persons aged 1–44 in the United States. Globally, it is estimated that 5.8 million people die each year due to trauma and tens of millions are left with temporary or permanent disabilities [1]. In 2016, emergency departments in the United States registered 42.2 millions of injury-related visits. The economic burden to society is immense, with approximated 671 billion dollars in medical and work-loss costs associated with all injuries in 2013 [2].

It is clear that alcohol consumption significantly increases the risk of traumatic events [3–5]. The prevalence of trauma patients under the influence of alcohol in the emergency departments vary from 9.5 to 53% on different countries [6,7]. It is estimated that 32.4% of the visits to U. S. Trauma centers are alcohol-related [8]. In 2014, 9,967 people died in crashes involving a driver with blood alcohol concentration (BAC) of 80 mg/dL or higher in the United States [9].

The identification of the trauma patient that abuses alcohol is paramount for secondary prevention. Harmful alcohol consumption is also associated with increased risk of readmission for new trauma [10,11]. Approximately 41% of trauma recidivism is related to alcohol use [12].

Alcohol Screening Brief Intervention and Referral to Treatment (SBIRT) during the hospitalization of the trauma patient can reduce the risk of trauma recidivism by 50% [13–17]. In a cost benefit analysis, SBIRT programs could save USD 3.81 for every USD 1 spent. This could represent an annual saving of 1.82 billion dollars if SBIRT were offered routinely to injured patients throughout United States [18]. Considering this evidence, since 2007, the American College of Surgeons Committee on Trauma demands that all level 1 and 2 trauma centers provide screening of alcohol misuse in all patients admitted and an intervention on those who screen positive.

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Supplemental data for this article can be accessed here.

Currently, there is no standardized screening tool for alcohol misuse in injured patients. The majority of trauma centers uses BAC and others use different questionnaires or combination of both. Using BAC alone is not sufficient. It can lead to a considerable number of false-negatives, due to the short half-life of alcohol [19]. Also, brief interventions in trauma patients who are at-risk drinkers are effective, whether or not they were under the influence of alcohol at the time of the injury [20]. Moreover, using clinical suspicion to identify acute intoxication or alcohol misuse is inaccurate [13].

The Alcohol Use Disorders Identification Test (AUDIT) is a traditional self-reported alcohol screening questionnaire that gives an estimated consumption pattern on a weekly/monthly basis of each patient over the last year. It was developed by the World Health Organization and validated in different scenarios, like the trauma care setting [21]. Its shorter version, the AUDIT-C, composed by the first three items from the AUDIT, has similar accuracy in detecting alcohol misuse [22]. The higher the total score of the AUDIT-C, the more likely is that the drinking is affecting the patient's health and safety. Even considering the widespread used of these two questionnaires, they rely on self-report, which have inherent problems like recall bias, social desirability and other factors. Recent studies using laboratory tests of direct ethanol biomarkers supports significant and clear underreporting on self-reported questionnaires [23–25].

In recent years, phosphatidylethanol (PEth), a direct ethanol biomarker, has attracted special attention as a novel method of alcohol misuse screening in blood [26]. PEth is formed only in the presence of ethanol. Therefore, the diagnostic specificity of PEth as an alcohol marker is theoretically 100% [27]. The half-life of PEth in human blood is about 4–6 days, and it can be detected after 28 days of sobriety [28]. The blood concentration of PEth is correlated with the amount of alcohol ingested in the previous 2–4 weeks, making possible the classification of different drinking patterns [29]. PEth has repeatedly outperformed traditional indirect alcohol biomarkers such as carbohydrate-deficient transferrin (%CDT), gamma glutamyl transpeptidase (GGT), and mean corpuscular volume (MCV) to detect alcohol use disorders in different scenarios [30,31]. Also, blood measurements of PEth evidenced underreporting of alcohol use when self-reported questionnaires were used, in different populations [24,26,32,33].

To the best of our knowledge, there is a strong need for a reliable alcohol misuse screening tool to identify injured patients who can benefit from alcohol interventions. Despite its potential advantages in this context, PEth has not been tested on this population. Thus, the aim of this study was to examine the performance of blood PEth concentrations and BAC, compared to the AUDIT-C score, for the screening of alcohol misuse in injured patients.

Materials and methods

Study design

A prospective observational cross-sectional study was conducted from February 2019 to August 2019. The study site was the Emergency Department of a public general hospital in the city of Novo Hamburgo (population: 250,000) in South Brazil. This hospital has 230 beds with about 1000 admissions per month and is responsible for all trauma occurring within the city limits. The study was approved by the Ethics Committee of Feevale University (CAAE 94128918.7.0000.5348)

Participants

Whole-blood samples (1 EDTA containing tube and 1 fluoride containing tube) were collected on the admission of each trauma patient admitted to the emergency department. The researchers approached the patients after the initial medical care, only when patients were without significant pain and fully alert. Each patient was informed of the anonymous nature of the study. We included patients presenting at the Emergency department with any type of trauma and with 18 years old or older. Exclusion criteria were: Inability to give informed written consent, more than 6 h between trauma and blood sampling or decline to participate in the study. The recruitment was performed by the researcher's team 24 h per day, seven days a week during the study period. Written consent, blood samples and AUDIT-C were obtained for all participants.

Variables

Gender, age, partnership status, occupational status and type of trauma were recorded. The severity of trauma was classified by the Injury Severity Score (ISS) in: <8 = minor, 9–15 = Moderate and >16 = Serious [34]. Aditionally, the patients were asked if they consumed any alcohol within 6 h before the trauma and if they had any previous diagnosis of psychiatric disorder.

The AUDIT-C self-report questionnaire was chosen due to its good correlation to the full AUDIT and its brevity [35]. On AUDIT-C questionnaire each question is scored 0–4 and summed for a total score ranging 0–12. An AUDIT-C score of ≥ 3 for women or ≥ 4 for men indicates harmful alcohol use and the need of a brief motivational intervention. The patients were classified according to the AUDIT-C score into two (2) groups: Any level of alcohol misuse (AUDIT-C ≥ 4 men; ≥ 3 women) and social/no alcohol misuse (AUDIT-C < 4 men; <3 women). Additionally, severe alcohol misuse was defined as an AUDIT-C score of 6 or greater for both genders. Abstainers were identified by an AUDIT-C score 0. Additional information on the AUDIT-C questionnaire can be seen in the Supplementary material.

Determination of BAC

Whole-blood samples were collected in tubes with sodium fluoride and stored at $-20\,^{\circ}C$. BAC was determined using a validated headspace gas-chromatography method, with flame ionization detection (HS-GC-FID). Briefly, 250 µL of whole blood was mixed with 750 µL of internal standard (propanol 0.17 g/L) saturated with NaCl, in a 20-mL headspace vial. After incubation at $80\,^{\circ}C$ for 10 min, 1 mL of the

headspace was injected into the gas chromatograph (GC-2010, Shimadzu, Japan), equipped with a ALC1 column (30 m × 0.53 mm, 3 μm Agilent), maintained at 40 °C, with carrier gas flow of 6.4 mL/min and detector temperature of 280 °C. Daily calibration curves and quality control samples were processed in every analytical batch. The method was linear from 2.5 to 500 mg/dL ($r = 0.998$), precise (CV 3.0–8.1%) and accurate (97–104%).

Determination of PEth

In this study, only PEth 16:0/18:1, the most abundant homologue, was quantified. Whole-blood samples for the determination of PEth were collected in EDTA-containing tubes and stored at −80 °C until analysis, to prevent *in vitro* formation or degradation of PEth. PEth was analyzed by liquid chromatography-tandem mass spectrometry (LC-MS/MS), in procedure adapted from Gnann et al. [36].

Briefly, after protein precipitation with isopropanol, PEth was extracted from 0.5 mL of whole blood with n-hexane, at pH 9.0. Phosphatidylpropanol at 0.1 ug/mL was used as internal standard. The organic layer was evaporated and the extract recovered with mobile phase was injected into the chromatography system (Ultimate 3000, Thermo Scientific, USA). Separation was performed on a phenyl (100 × 2.1 mm, 3 μm, Thermo Scientific, USA) column, kept at 30 °C. Mobile phase was a mixture of acetonitrile and ammonium acetate 2 mM (75:25, v/v), eluted at flow rate of 0.4 mL/min. Run time was 5 min. Negative mode eletrospray ionization was used in the mass spectrometer (TSQ Quantum Access MAX, Thermo Scientific, XX). Interface temperature was 400 °C and capillary energy of the ionization source was 4000 V. The mass transition of 701.6 to 281.8 m/z was used for PEth quantification. Calibration curves and quality control samples were processed at every batch of patients samples. The method was linear from 5.0 to 3,000 ng/mL ($r = 0.999$), precise (CV <12%) and accurate (98–109%). The lower limit of detection (LOD) was 1.67 ng/mL.

Data analysis

IBM SPSS 25.0 was used for statistical analysis. Sociodemografic and clinical characteristics were presented as counts, percentages, means or medians. We compared the BAC and blood PEth concentration means between the two AUDIT-C groups (any level of alcohol misuse X no alcohol misuse) using Mann-Whitney U test. Cross-tabulation between blood PEth and AUDIT-C classification was conducted with kappa coefficient to evaluate diagnostic agreement. Furthermore, we analyzed the correlation between blood PEth concentration and AUDIT-C as a continuous variable using Spearman's rank coefficient.

The evaluation of the optimal blood PEth concentration cut-offs for identifying any level of alcohol misuse and severe alcohol misuse was conducted using area under the receiver operated characteristic (ROC) curve analysis. An AUDIT-C score ≥4 in men and ≥3 in women was chosen as reference standard for any level of alcohol misuse and AUDIT-C score ≥ 6 for severe alcohol misuse. A P-value of ≤ 0.05 was considered statistically significant.

Results

During the study period, a total of 327 trauma patients were admitted in the emergency department and 238 patients consented to complete the AUDIT-C and provided blood samples. The patient's characteristics are presented in Table 1. The sample consisted of majority male (67.6%), single (46.2%) and employed (66%) patients. The most common type of trauma was traffic collision (63.9%), and 18.9% of the patients had severe injuries. The mean age was 41.68 years (95% CI 39.3–44 years).

No alcohol misuse was characterized in 174 (73.1%) patients, and any level of alcohol misuse (AUDIT-C ≥ 4 men; ≥3 women) in 64 (26.9%) patients. As a subset of the last group, severe alcohol misuse was detected in 33 (13.9%) patients. The median time between trauma and blood sampling was 50 min. The minimum and maximum time was 20 min and 5 h 48 min, respectively.

Alcohol biomarkers analysis

BAC was detected in 28 (11.8%) patients, ranging from 2.5 to 529.0 mg/dL (mean 20.9 mg/dL; 95% CI 12.1 − 29.8 mg/dL). Blood PEth was detected in 112 (47.05%) patients, ranging from 0.4 to 2,846.5 ng/mL (mean 104.8 ng/mL; 95% CI 61.1 − 148.6 ng/mL).

Of all patients, 10 (4.2%) admitted the intake of alcohol within 6 h before the trauma, which was confirmed with a positive BAC for all of these patients. In addition, BAC was positive in 28 (11.3%) of all patients, showing that 18 (64.3%) of BAC positive patients denied the use of alcohol whitin the 6 h before the trauma.

A total of 77 (32.3%) of all patients declared to be sober for the last 12 months (AUDIT-C = 0). However, differently from their self-report, blood PEth was detected in 12 (15.6%) of these patients. PEth is formed only in the presence of ethanol and it can be detected up to 4 weeks after last ethanol intake [27], suggesting underreporting on the AUDIT-C.

The mean values of the BAC and blood PEth between the AUDIT-C groups are presented in Table 2. BAC and blood PEth values were significantly different ($p < .0001$) between the two AUDIT-C groups (no misuse $n = 174$ *vs.* any level of misuse $n = 64$) using Mann-Whitney U Test (Figure 1).

We also found a significant correlation between blood PEth levels and the AUDIT-C score as continuous variables using Spearman's rho, $r = 0.617$ (95%CI 0.505 − 0.729; $p < .0001$) (Figure 2). Blood PEth had an area under the ROC curve of 0.791 (95%CI 0.722–0.860) to detect any level of alcohol misuse (Figure 3(A)) and 0.885 (95%CI 0.830 − 0.939) to detect severe alcohol misuse (Figure 3(B)), defined by the AUDIT-C.

We defined the optimal cut-off for blood PEth concentrations to detect alcohol misuse using the highest Youden's index (J). A blood PEth cut-off of 18.3 ng/mL provided optimal identification of any alcohol misuse. Using this cut-off,

Table 1. Patient characteristics according to AUDIT-C classification.

Characteristics	Overall ($n = 238$)	Any level of alcohol misuse ($n = 64$)	No alcohol misuse ($n = 174$)	p-value*
Age (years)	41.68	35.77	43.86	.002
Mean (95%CI)	(39–44)	(31–39)	(41–46)	
Gender, *n* (%)				
Female	77 (32.4)	10 (15.6)	67 (38.5)	.001
Male	161 (67.6)	54 (84.5)	107 (61.5)	
Marital Status, *n*(%)				<.0001
Single	110 (46.2)	46 (71.9)	64 (36.8)	
In relationship	98 (41.2)	10 (15.6)	88 (50.6)	
Widowed	16 (6.7)	3 (4.7)	13 (7.5)	
Divorced	14 (5.9)	5 (7.8)	9 (5.2)	
Occupational Status, *n*(%)				
Employed	157 (66)	38 (59.4)	119 (68.4)	.106
Unemployed	76 (31.9)	26 (40.6)	50 (28.7)	
Retired	5 (2.1)	0 (0)	5 (2.9)	
Type of Trauma, *n*(%)				.002
Traffic collision	152 (63.9)	36 (56.3)	116 (66.7)	
Fall from height	33 (13.9)	6 (9.2)	27 (15.5)	
Fall on the same level	28 (11.8)	8 (12.5)	20 (11.5)	
Interpersonal Violence	17 (7.1)	12 (18.8)	5 (2.9)	
Sports injury	5 (2.1)	1 (1.6)	4 (2.3)	
Others	3 (1.2)	1 (1.6)	2 (1.2)	
Injury Severity, *n*(%)				.207
Minor	119 (50)	26 (40.6)	93 (53.4)	
Moderate	74 (31.1)	23 (35.9)	51 (29.3)	
Severe	45 (18.9)	15 (23.4)	30 (17.2)	
Psychiatric Disorder, *n*(%)	23 (9.7)	6(9.4)	17(9.8)	.827

*Difference between Any Level of Alcohol Misuse (AUDIT-$C \geq 4$ men; ≥ 3 women) and No Alcohol Misuse (AUDIT-$C < 4$ men; < 3 women).

Table 2. Alcohol Biomarkers based on AUDIT-C classification.

	Any level of alcohol misuse ($n = 64$)	No alcohol misuse ($n = 174$)	p-value
BAC (mg/dL) Mean (95%CI)	67.2 (38.9 – 95.6)	3.9 (0.0 – 8.1)	<.0001
PEth (ng/mL) Mean (95%CI)	297.9 (149.6 – 446.1)	33.8 (16.3 – 51.5)	<.0001

BAC: Blood Alcohol Concentration; PEth: Phosphatidylethanol.

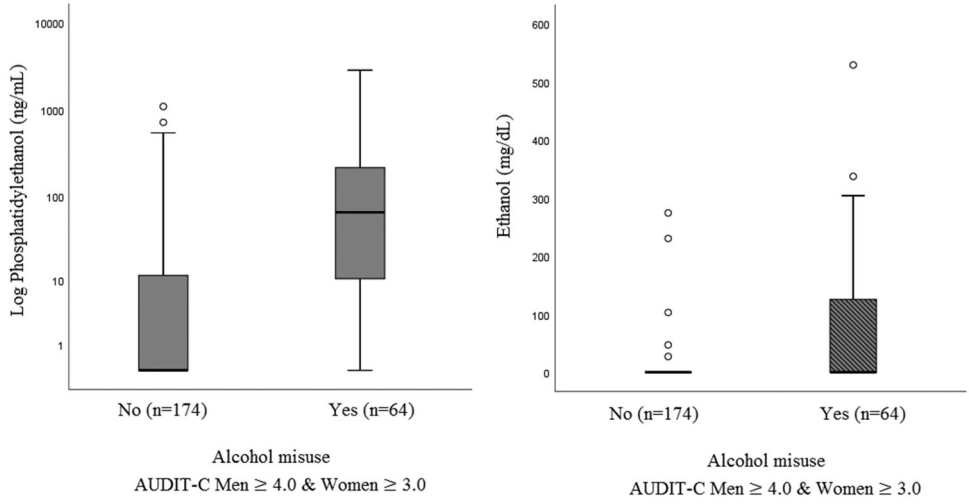

Figure 1. Box plot of PEth concentration (left) and Ethanol concentration (right) by AUDIT-C classification. Mann- Whitney ($p < .0001$).

sensitivity was 73.4%, specificity was 80.6%, the positive predictive value (PPV) was 79% and the negative predictive value (NPV) was 75%. To identify severe alcohol misuse, the optimal PEth cut-off was 23.9 ng/mL. Alternative cut-offs with their sensitivity, specificity, PPV and NPV are presented in Table 3.

Using these optimal cut-offs for blood PEth levels, the agreement to the self-report AUDIT-C was tested with Kappa statistics. PEth was positive ($\geq$ 18.3 ng/mL) among 73.4% of patients defined as "any alcohol misuse", presenting a significant ($p < .0001$), but only moderate agreement with a Kappa coefficient of 0.490 (95% CI 0.373−0.607). Using the blood PEth cut-off of 23.9 ng/mL, PEth was positive among 91.2% of patients with "Severe Alcohol Misuse" according to AUDIT-C ($\geq$6), with a Kappa agreement of 0.463 (95% CI 0.344−0.582 CI; $p < .0001$).

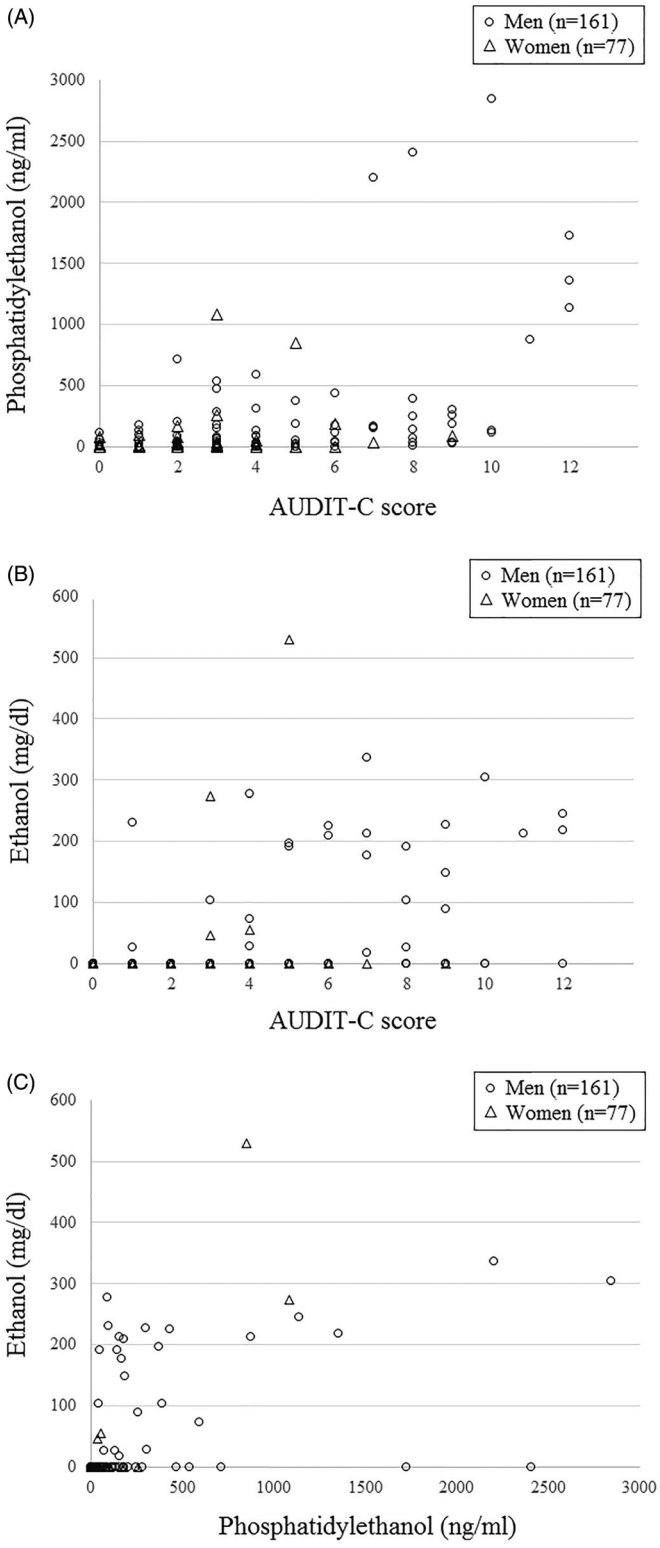

Figure 2. Scatter plot of PEth concentration (A) and Ethanol concentration (B) by AUDIT-C scores and PEth by Ethanol concentrations (C).

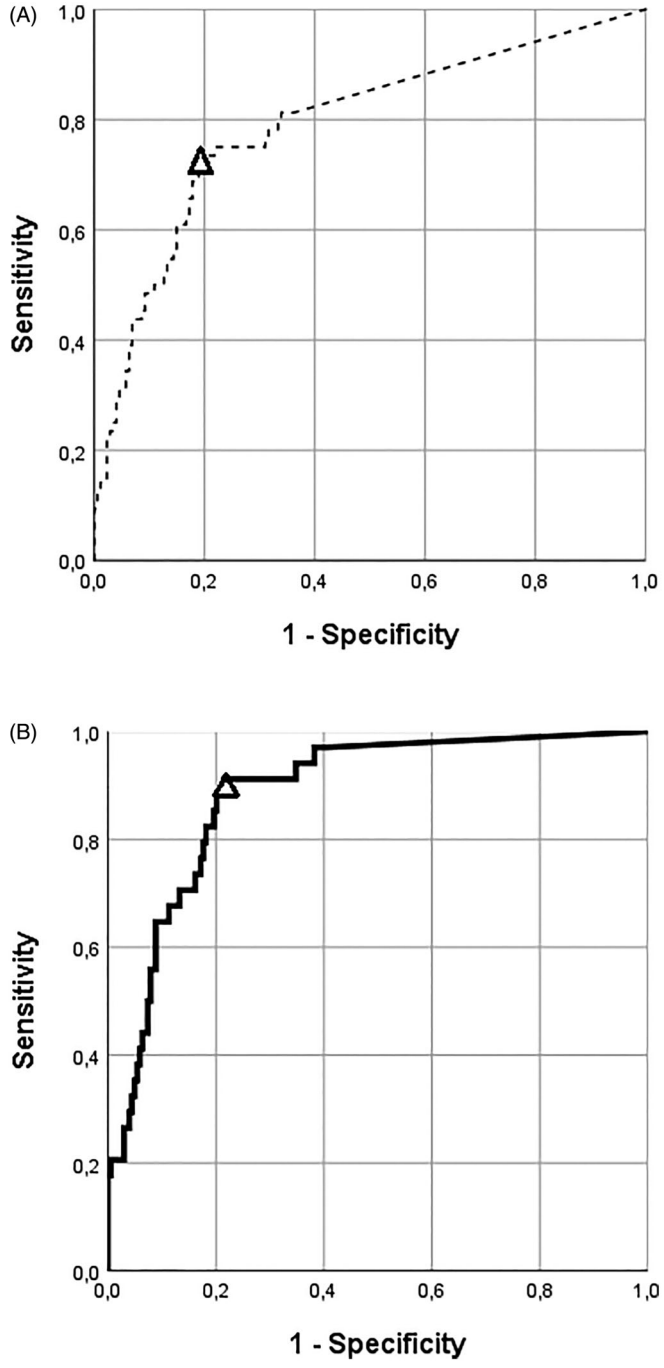

Figure 3. Receiver-operating characteristic (ROC) curves for PEth predicting any alcohol misuse (A) and severe alcohol misuse (B) by AUDIT-C. The triangle marks the optimal PEth cut-off of 18.3 ng/mL (A) and 23.9 ng/mL (B).

Discussion

To the best of our knowledge, this is the first study to examine blood PEth levels to screen for alcohol misuse in trauma patients presenting at the emergency department, with minor to severe injuries. The AUDIT-C questionnaire is a validated tool to estimate alcohol consumption pattern on a weekly/monthly basis over a year. While PEth concentration gives a more precise consumption assessment of the last month. Besides its limitation, the comparison of the two is valid in the context of screening for alcohol misuse in trauma patients that can benefit of brief motivational interventions. Similar to findings reported in other populations, this study shows a strong positive correlation of blood PEth to the AUDIT-C self-report, with mean levels significantly different between AUDIT-C classification groups.

Using AUDIT-C as a reference classification method, following the Youden's index (J), blood PEth cut-off levels of 18.3 ng/mL and 23.9 ng/mL were the best to identify "any

Table 3. PEth cut-off points to detect any alcohol misuse and severe alcohol misuse.

PEth (ng/mL)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
	Any alcohol misuse (AUDIT-$C \geq 4$ men; ≥ 3 women)			
6.7	76.6	69.0	71.1	74.6
15.1	75.0	71.9	72.7	74.2
18.3*	73.4	80.6	79.0	75.0
21.8	70.3	81.0	78.7	73.1
30.0	64.0	82.8	78.8	69.6
	Severe alcohol misuse (AUDIT-$C \geq 6$)			
6.7	94.1	65.2	73.0	91.7
23.9*	91.2	78.4	80.8	89.9
30.5	88.2	79.9	81.4	87.1
34.9	82.4	81.9	81.9	82.3

PPV: Positive Predictive Value; NPV: Negative Predictive Value; PEth: Phosphatidylethanol.
*Blood PEth concentration cut-off with the highest Youden's index (J).

alcohol misuse" (AUDIT-$C \geq 4$ men; $\geq$3women) and "severe alcohol misuse" (AUDIT-$C \geq 6$), respectively. In addition, blood PEth levels were also useful to identify 12 cases of clear underreporting on the AUDIT-C.

PEth is a promising biomarker for assessing ethanol consumption in different populations. It has outperformed the traditional indirect alcohol biomarkers and it's not affected by age, sex, comorbities or other confounders [26,30,31]. PEth formation in blood can occur post sampling, when the patient has a positive BAC. We minimized this by storing the samples at $-80\,^{\circ}C$. Apart from the in-vitro formation of PEth in the presence of ethanol, there are no other sources of false-positives described in the literature.

PEth blood levels were positively correlated to AUDIT or AUDIT-C scores in other populations, like healthy volunteers, young adults, binge drinkers, critically-ill patients, and emergency room patients with clinical complaints. Spearman's rho ranging from 0.397 to 0.745 were found [23–25,37]. In agreement with these studies, we found a significant Spearman's rho of 0.617 in trauma patients.

Currently, there are no well established blood PEth cut-off values reported in the literature and we recommend caution using our suggested cut-offs in clinical practice. Types of self-report questionnaires used as reference standards to evaluate alcohol intake vary across studies. In a study with 80 reproductive-aged women, a blood PEth cut-off of 50 ng/mL had 93% of sensitivity and 83% of specificity to detect an average of >2 drinks/day in the prior 2 weeks [38]. To detect at least 4 drinks/day in patients with chronic liver disease, a blood PEth cut-off of 80 ng/L was 89% sensitive and 82% specific [32]. In two studies with healthy volunteers, a blood PEth cut-off of 6.3 ng/mL and 10 ng/mL were strongly correlated to light drinking habits or abstinence [24,33]. In a study with 74 male patients with clinical complaints presenting at an emergency department and using AUDIT ($\geq$8) as reference standard, a cut-off of 159 ng/mL produced an area under the ROC curve of 0.672. The sensitivity and specificity was not reported. Also, it is not clear if the researchers measured total PEth or a specific homologue [23].

A study with similar design with ours, compared the blood PEth (16:0/18:1 homologue) levels and the AUDIT-C classification in 122 patients from a mixed cohort of critically ill patients, alcohol detoxification patients and healthy volunteers. They found an area under the ROC curve of 0.948 for any alcohol misuse and 0.913 for severe alcohol misuse. Interestingly, this study reported a much higher optimal cut-off than ours and those previously reported [32,38]. The suggested cut off levels was a blood PEth levels higher than 250 ng/mL to detect any alcohol misuse with 80.6% sensitivity and 91.7% specificity, and higher than 400 ng/mL to detect severe alcohol misuse, with 83.6% sensitivity and 89.2% specificity [39]. In a further publication, the authors discussed that higher cut-points could be a reflection of the more severe alcohol phenotype that occurs in the intensive care unit (ICU) setting [40].

Alcohol misuse is frequent in injured patients admitted to emergency departments [6,7]. These trauma patients have a higher risk of readmission for a new trauma [12]. The stay in the emergency department is considered an excellent "learning moment" to break this cycle of trauma recidivism [17]. In SBIRT programs, AUDIT and AUDIT-C are frequently used screening tools to identify alcohol misuse patients to undergo alcohol interventions. Using direct alcohol biomarkers, previous studies found significant underreporting of alcohol use in different self-report questionnaires [26]. With the use of blood PEth, Schröck et al. [24] identified two cases of clear underreporting when using AUDIT-C, in a study with 300 healthy volunteers. In a study with patients presenting at the emergency department with clinical complaints, Kip et al. [23] found that 38% of patients reporting abstinence in the last year had detectable blood PEth levels. On our study, participants were aware of the anonymous nature of the study. Nevertheless, 15.58% of the abstainers (AUDIT-$C = 0$) had detectable blood PEth concentrations, corroborating the findings of underreporting in the emergency department population and the need of better alcohol misuse screening tools.

In addition, our data also showed a significant sub notification of the self-report on recent alcohol intake, as 64% of BAC positive patients denied the consumption of alcohol within the 6 h before the trauma. As reported by MacLeod and Hungerford [8] the threshold for a positive BAC screening result in trauma centers vary considerably across studies, from >0 to >100 mg/dL. In the present study we considered the cut-off of 2.5 mg/dL, the LOQ of the method, adequate as the results were confronted to the question of drinking within 6 h before the trauma. In this context any amount of alcohol detected can discredit a negative answer.

Our findings have several limitations. We had a modest sample size that affects precision of our results. Another limitation is the reliance on self-reported alcohol consumption as a reference standard, which is subject to social desirability and recall bias. Underestimation of alcohol consumption by AUDIT-C could cause underestimation of PEth specificity. We did not measured %CDT or other direct alcohol metabolites, therefore it remains inconclusive whether PEth value or self-report is the best tool for the screening of alcohol misuse. Future research with combination of PEth value, along with other promising direct alcohol biomarkers (e.g., ethyl glucuronide, ethyl sulfate) could provide additional objective data [26].

In conclusion, our results indicate that blood PEth levels are positively correlated to the AUDIT-C score in the studied population. This study corroborates the findings of underreporting on self-reported alcohol consumption questionnaires. The use of blood PEth levels might provide additional and objective evidence in the screening of alcohol misuse in trauma patients. Future studies with PEth and other direct alcohol biomarkers in injured patients area needed to identify the best alcohol screening tool and to provide interventions to reduce the burden of trauma recidivism.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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