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Reliability of breath alcohol testing with Dräger Alcotest 7410^{Plus} analyzer in a court process

Vjerodostojnost alkotestiranja koncentracije alkohola u izdahu, upotrebom Dräger Alcotest 7410^{Plus} alkometra, kod utvrđivanja alkoholiziranosti u sudskom postupku

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Summary

The aim is to determine the usefulness and reliability of breath alcohol tests performed with Dräger Alcotest 7410^{Plus} analyzer, in comparison to more complex analysis methods of blood and urine alcohol testing. A total of 570 cases were taken from archival court evidence material. In all cases, individuals were driving under the influence of alcohol (DUI), and breath alcohol tests performed with Dräger Alcotest 7410^{Plus} analyzer were positive. After breath alcohol testing, all individuals underwent repeated blood and urine alcohol testing, but this time concentrations were measured by headspace gas chromatography. In all individuals alcohol was in its elimination phase. The results obtained from both experiments were evaluated and compared.

Comparison of breath alcohol concentration and blood alcohol concentration calculated to the time of breath alcotest, showed that 30 of 570 individuals (5.3%) were not within 95% predicament range, according to the linear equation CBAC ± 0.307 = 0.093 + 1.022CBrAC.

Legal classification of being under the influence of alcohol refers to blood alcohol concentration, not breath alcohol concentration. Therefore it is not plausible to define the state of alcohol influence using Dräger Alcotest 7410^{Plus} analyzer.

Key words: Dräger Alcotest 7410^{Plus}, breath alcohol concentration (BrAC), blood alcohol concentration (BAC), forensic toxicology, court process

Sažetak

Mogućnost primjene rezultata alkotesta Dräger 7410^{Plus} kao zamjene za analizom utvrđene koncentracije alkohola u krvi i mokraći. U radu je obrađeno 570 slučajeva koji se temelje na podacima dobivenim iz sudskih spisa gdje je vozaču nakon alkometrom utvrđene prisutnosti alkohola u izdahnutom zraku, upotrebom alkotesta Dräger Alcotest 7410^{Plus}, metodom plinske kromatografije utvrđena koncentracija apsolutnog alkohola u krvi i mokraći. U svim obrađenim slučajevima alkohol se nalazio u fazi eliminacije iz organizma. Analizom utvrđene koncentracije alkohola u krvi retrogradno su preračunate na vrijeme testiranja alkometrom i uspoređene.

Usporedbom rezultata Drägera i analizom utvrđene koncentracije alkohola u krvi preračunate na vrijeme alkotestiranja proizlazi da se 30 od 570 ispitanika (5,3%) ne nalazi unutar granice 95% predikcije jednadžbe pravca CBAC ± 0,307 = 0,093 + 1,022CBrAC

Na osnovi provedenog ispitivanja može se odrediti koncentracijsko područje unutar kojeg bi se s 95%-om vjerojatnošću morala nalaziti koncentracija alkohola u krvi pod pretpostavkom da je krv uzeta na analizu u vrijeme alkotestiranja. Sudskomedicinska klasifikacija stanja alkoholiziranosti odnosi se na

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koncentraciju alkohola u krvi, a ne u izdahu, te stoga na osnovi rezultata alkometra (koncentracije alkohola u izdahu) nije moguće odrediti niti stanje alkoholiziranosti.

Ključne riječi: dräger alkotest 7410^{Plus}, koncentracija alkohola u izdahu, koncentracija alkohola u krvi, sudska toksikologija, sudski postupak

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Introduction

The determination of ethanol in bodily fluids has a long tradition.[1] Volatile substance, such as ethanol (alcohol), has a low molecular weight, is highly soluble in water, and does not bind to plasma proteins, all of which makes it a suitable compound for analysis in bodily fluids and exhaled air. Distribution of ethanol in the body is proportional to water content in the tissue.[2]

Measurements of breath alcohol concentration (BrAC) can be conducted far more easily and are cheaper than determining alcohol concentrations in peripheral venous blood (blood alcohol concentration, BAC) or in urine using chemical methods. With those kinds of laboratory tests it is necessary to have complex equipment and an educated staff, whilst the BrAC can be done in the field by sufficiently trained Police Department operatives.

Determining BrAC has a long tradition in clinical medicine, in alcohol related research, and especially in law enforcement practice as an indirect and non-invasive way of estimating an individual's BAC.[3-6]

Our study was conducted due to a daily demand for forensic, toxicological rulings on the absolute BAC that is to be used on several legal levels: (i) rulings on BAC of drivers on trial for suspected DUI resulting in a car accident, (ii) misdemeanour offences, (iii) in City and County Courts for criminal offences and civil lawsuits.

Forensic toxicologists are expected to retrogradely calculate BAC corresponding to the exact time of a traffic accident using only the BrAC, determined with Dräger's analyzer as the input data.

According to the Croatian Traffic Security Law ("Official Gazette" no. 105/2004), if a car accident does not include serious material damage or human victims (severely wounded or death casualties), the responding policemen are *not* obliged to escort any involved individual to be medically examined, or their bodily fluids tested for absolute alcohol concentration, regardless the potentially positive BrAC determined with Dräger Alcotest 7410^{plus} breath analyzer at the scene of the accident.

Material and Methods

A total of 570 cases were taken from archival court evidence material. In all cases individuals had been driving under the influence of alcohol (DUI). If a driver was tested positive for BrAC, as determined with Dräger Alcotest 7410^{Plus} analyzer, blood and urine were then taken for further analyses by headspace gas chromatography. Blood and urine alcohol concentration ratios in all individuals pointed that alcohol was in its elimination phase at the time BrAC was measured.

From the measured BAC and the time blood samples had been taken (C_t), past BAC (C_{BAC}) was retrogradely calculated to correspond to the time BrAC was measured using Dräger's analyzer. We used Widmark's equation:

$$C_{BAC} = C_t + ß\ t \qquad \text{[Eq. 1]}$$

where β represents an alcohol elimination factor of 0.15 g/kg/h, and it equals the time, in hours, elapsed between blood and breath samplings.

Statistics

All statistical analyses were performed with SPSS software (7.0 for Windows, SPSS Inc, Chicago, USA) and MedCalc software (Version 9.2, Frank Schoonjans, Mariakerke, Belgium). Statistical probability was $p < 0.05$ for all tests.

Breath alcohol concentration (C_{BrAC}), measured BAC (C_t) and retrogradely calculated BAC (C_{BAC}) are variables both determined and compared through their arithmetical means, standard deviations, and minimum and maximum values. Regression equation was used for statistical analyses:

$$C_{BAC} \pm S.E.(C_{BAC}) = b_0 + b_1 C_{BrAC}, \qquad \text{[Eq. 2]}$$

where C_{BAC} = calculated blood alcohol concentration, $S.E.(C_{BAC})$ standard error, b_0 (0.093) and b_1(1.022) = regression coefficients and C_{BrAC} = breath alcohol concentration determined by Dräger Alcotest 7410^{Plus} analyzer. Using equation 2 all BACs (C_{BACi}) were determined from all measured BrAC-s (C_{BrACi}).

A 95% confidence range was set as follows:

$$C_{BACi} = 1.96\ S.E.\ (C_{BACi})$$

Results

Blood samples were always taken after breath tests had been performed. The relationship between blood and urine alcohol concentrations showed that all individuals were in the alcohol elimination phase at the time of sampling and at the time the accident occurred. Median time between breath testing and blood sampling was 50 minutes (ranging from 0 to 1020 minutes). Table 1 shows mean values of measured BrAC, BAC and calculated BAC.

After inputing the date derived from testing 570 individual cases into Eq. 2, a simple equation describing the relationship between C_{BrAC} and C_{BAC} is suggested:

$$C_{BAC} \pm 0.307 = 0.093 + 1.022\ C_{BrAC}. \qquad \text{[Eq. 3]}$$

Figure 1 shows that 30 of 570 individuals do not fit within the 95% equation prediction range

Table 1. Mean blood and breath alcohol concentrations (g/kg)
Tablica 1. Prosječna koncentracija alkohola u krvi i izdahu (g/kg)

	Mean ± SD *Prosjek ± SD*
BrAC measured with Dräger Alcotest 7410^{Plus} analyzer *BrAC mjereno Dräger Alcotest 7410^{Plus} analizatorom*	1.17 ± 0.73
BAC measured by headspace gas chromatography method *BAC mjereno kromatografskom metodom*	1.14 ± 0.79
BAC calculated using Eq. 1 *BAC izračunato primjenom jednadžbe 1.*	1.29 ± 0.80
BAC calculated using Eq. 2 *BAC izračunato primjenom jednadžbe 2.*	1.29 ± 0.74

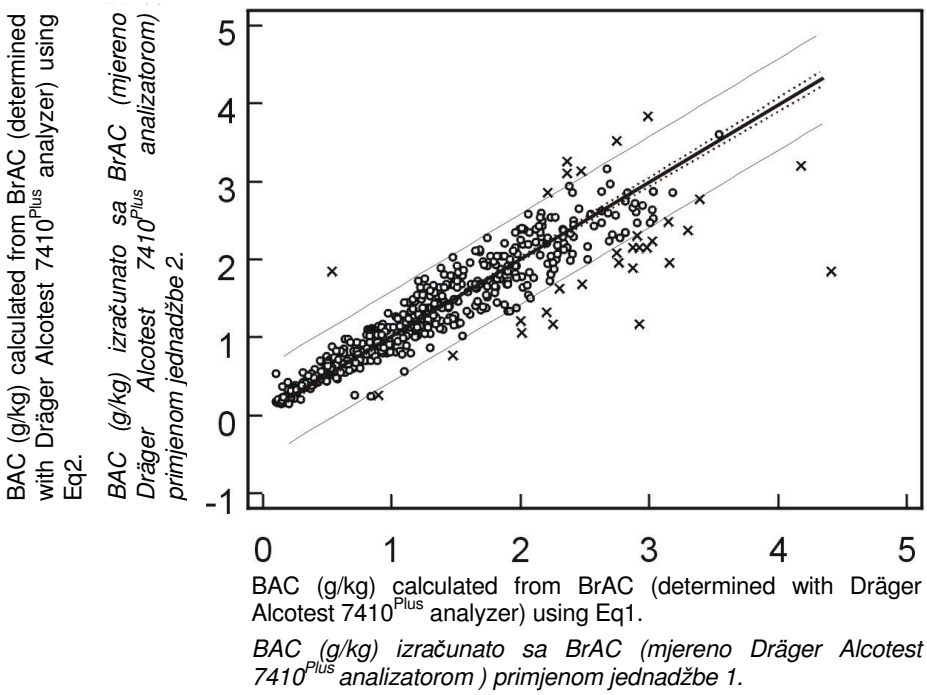

Figure 1. Scatter plot of 570 retrogradely calculated BACs (g/kg) at the time of breath analyses; calculated with equations 1 and 2 using Dräger Alcotest 7410^{Plus} analyzer measurements. Symbol "o" denominates results that fit within 95% prediction range, symbol "×" denominates results that are outside. Regression line calculated from Eq. 3 is shown in bold, while broken lines determine its 95% reliability of prediction.

Slika 1. Grafički prikaz raspršenosti 570 retrogradno izračunati BAC (g/kg) za vrijeme analize izdaha, izračunato jednadžbom 1 i 2 primjenom analizatora Dräger Alcotest 7410^{Plus} Simbol "o" označuje rezultate koji odgovaraju 95% predviđenog raspona, simbol "x" označava vanjske rezultate. Linija regresije izračunata u jednadžbi 3 prikazana je deblje otisnuto, dok isprekidane crte određuju 95% predviđene vjerodostojnosti.

Discussion

Measuring BrAC became daily routine in Croatia, especially since the new Traffic Security Law became valid. In 2004 BAC tolerance level for drivers was fixed at 0.00 g/kg. Many legal disputes arose from the fact that drivers tested positive for BrAC were not taken in for further medical examination, e.g. blood and urine sampling, which would have defined actual alcohol levels in their bodily fluids. In the case when alcohol concentration is determined solely from breath, retrograde toxicological determining of BAC at the time of accident is not possible. Any conclusion thereafter would not be safe not reliable enough to hold up in court.[7]

Legal systems that use breath alcohol for detecting drinking drivers do not attempt to relate the breath level to the blood, but make the offence solely that of having exceeded a certain level in the breath itself.[8]

In fact, to safely determine BAC at the time of accident, one must know the exact BAC at the time BrAC was measured, and also, which pharmacokinetic phase the alcohol was in at the time the accident happened. Common alcotesting gives BrAC, not BAC. According to those tests, it is not possible to determine in which pharmacokinetic phase the alcohol is in. It is known from literature that there is a relationship between BrAC and BAC, but a conversion factor is needed to correctly convert BAC from BrAC. Unfortunately the said factor is variable depending on many elements such as: (i) actual BAC, (ii) time elapsed between alcohol consumption and sampling, (iii) pharmacokinetic phase, (iv) concentration of ethanol in the drink, (v) atmospheric pressure and humidity, etc.[9,10]

The cellular composition of blood also influences BrAC to BAC conversion, so the conversion factor of 1:2100 is valid for 47% blood hematocrite. Physiological hematocrite levels for men are between 42-52%, and for women 37-47%. Lower hematocrite gives falsely higher BrAC, and the error ranges from -2 to +5%. An elevation in body temperature of 10ºC results in 7% higher BrAC. Physical activity and hyperventilation can lower BrAC levels 11-25%. Lower atmospheric temperature changes the levels of water that condenses in expired air, and can also give falsely lower BrAC.[3,4,9-11]

Theoretically, it is possible to determine the conversion factor if testing conditions are standardized, but daily field circumstances substantially differ from standard laboratory conditions. As the complex field variations and circumstances in which the breath alcohol levels are measured are not known to a toxicologist, his task of determining the BAC at the time of testing or the accident, is virtually impossible.

Testing the BrAC does not define its pharmacokinetic phase in the body. If blood and urine alcohol concentrations have not been measured, the alcohol pharmacokinetical phase at the time of an accident is suggested only by the defendant's (possibly false) testimony about the time, the kind and the quantity of alcohol consumed. If the defendant is exercising his or her legal right to remain silent, even this opportunity to recommend the BAC levels fails.

Using the Dräger Alcotest 7410^{plus} breath analyzer on drivers involved in car accidents, we tried to find an acceptable correlation between their BrAC and BAC.

The only element that can somewhat be tested in practice, and that strongly influences the alcohol conversion factor, is the pharmacokinetic phase the alcohol is in. Therefore, we delt with the archival court cases that had alcohol in the elimination phase at the time of the accident and alcotesting.

Conclusion

The use of results obtained with an alcometer, without confirmation of alcohol levels through blood and urine testing, is not acceptable in court processes, even if the breath is tested shortly after the traffic accident or any other legal offence.

Comparing the BrAC and BAC, no unique correlation factor, which would possibly determine BAC using solely BrAC, has been found.

Using the Dräger's alcometer and the measured BrAC, it is not possible to conclude whether alcohol was in the resorption or elimination phase. Because of that fact, it is not possible to retrogradly calculate BAC at the time of accident using solely BrAC.

Through this study we were able to suggest the concentration range within which the BAC would be, with 95% confidence, if the blood had been sampled at the exact time of breath testing.

Kovačić and Mrčela, in their paper from 1998, describe examples from court practise which show that a wrong estimation, and therefore a wrong ruling, is possible if solely the alcometer results are taken into consideration.[12]

Pavlic et al. show that the application of alcohol elimination rates on the basis of such BrAC values would lead to invalid results.[13]

Legal classification of being under the influence of alcohol refers to blood alcohol concentration, not breath alcohol concentration. In conclusion, it is not plausible to define the state of alcohol influence nor to make an expert toxicological decision using only

the results obtained with Dräger Alcotest 7410^{Plus} breath analyzer. Doing so would be turning away from profession and entering the area of assumption.

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