

Concurrent Measurements of Arterial and Venous Blood Alcohol Concentrations and Breath Alcohol Concentrations Using the Alcotest 7110 MK III Evidential

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ABSTRACT

By adopting the Act Amending the Traffic Road Act dated 27 April 1998, the German Bundestag also introduced breath alcohol concentration thresholds as a criterion for traffic offences in Germany. An expert opinion of the Federal Ministry of Health of 1992 reads that, in terms of time, the breath alcohol concentration does not follow the venous blood alcohol concentration but the arterial blood alcohol concentration. Tests were performed in 5 subjects, who drank 0.5 – 0.8 g ethanol/kg of body weight over a period of 20 minutes. An IV cannula was inserted in the crook of the elbow of one arm, whereas the arteria radialis of other arm was punctured by using the Seldinger technique. Forty minutes following the end of drinking breath alcohol concentrations were measured at intervals of 10-15 minutes by using the calibrated Alcotest 7110 Evidential MK III. Between two breath alcohol tests concurrent venous and arterial blood samples were drawn from the catheters, discarding the first 5 mL of blood each. A total of 101 concurrent readings were obtained for breath alcohol, blood alcohol and arterial blood concentrations. The regression equation is $y = 2.10 x + 0.03$ ($R^2 = 0.96$) for the correlation between venous blood alcohol concentration and breath alcohol concentration and $y = 2.11 x + 0.03$ ($R^2 = 0.95$) for the correlation between arterial blood alcohol concentration and breath alcohol concentration. Hence, the differences are rather minor as is also confirmed by examinations of Jones et. al. However, as measurements started 40 minutes after the end of drinking, the earlier resorption phase was not completely covered. Nonetheless, the expert opinion of the Federal Health Office suggesting that the breath alcohol concentration follows the arterial, instead of the venous, blood alcohol concentration must be considered questionable in terms of a general introduction of breath alcohol concentration measurements in Germany.

Keywords: breath alcohol concentration, arterial blood alcohol concentration, venous blood alcohol concentration

INTRODUCTION

By adopting the Act Amending the Traffic Road Act dated 27 April 1998, the German Bundestag also introduced breath alcohol concentration thresholds as a criterion for traffic offences in Germany; limit values for criminal prosecution are under discussion. An expert opinion of the Federal Ministry of Health of 1992 [1] reads that, in terms of time, the breath alcohol concentration does not follow the venous blood alcohol concentration but the arterial blood alcohol concentration. As the arterial blood alcohol concentration describes the alcohol concentration in the brain and hence the impairment by alcohol in road traffic, it seems to be more suited than the venous blood alcohol concentration, which is usually measured. Statements in the opinion of the Federal Ministry of Health are based on examinations by Martin et al. in 1988 [2]. These authors used the Alcolinger Automatic Breath Analyser (Etzlinger, Switzerland) to measure breath alcohol concentrations. The breathalyser Alcotest

7110 Evidential MK III (Dräger, Germany) is the only device approved in Germany for establishing breath alcohol concentration values usable in court proceedings. Hence, the task was to identify the extent of arteriovenous differences and differences between the concurrent arterial and venous ethanol values. Theoretical examinations of Wehner et al. [3] describe a great variance of the venoalveolar ethanol concentration quotient. In an experimental study on arteriovenous differences in 2003 and 2004 Jones et al. [4, 5] revealed the dependence of arteriovenous differences on the ethanol kinetics.

MATERIALS AND METHODS

Subjects

All 5 subjects (1 women and 4 men) between 35 and 66 years of age declared to be healthy. Their histories were not indicative of any lung dysfunction due to asthma or any other diseases of the respiratory system. Body-plethysmographical and spirometrical examinations did not reveal any pathological findings. The extent of habituation to alcohol was different among the subjects; the subjects were not under the influence of medical drugs during the examinations. Radial artery and ulnar artery occlusion was excluded in both arms by using the Allen test.

Breath and blood alcohol concentration measurements

Breath alcohol concentrations were determined by means of the calibrated Alcotest 7110 Evidential MK III device approved by the Federal Physical-Technical Institute (*PTB*). This device establishes one final value out of two measured values (infrared measurement and electrochemical ethanol determination). Blood alcohol concentrations of both arterial and venous blood samples were determined under due consideration of the relevant expert opinion of the Federal Ministry of Health and the Decision of the German Federal High Court of Justice (*BGH*) dated 28 June 1990 (4 StR 297/90) as well as of the recommendations of Iffland and Daldrup [6]. Two ADH values and two GC values were determined in serum for each sample. Then, these values were used to calculate the arithmetic mean. The analytical mean value is indicated without being rounded with an accuracy of two digits after the decimal place in grams of ethanol per 1000 g of blood.

Test procedure

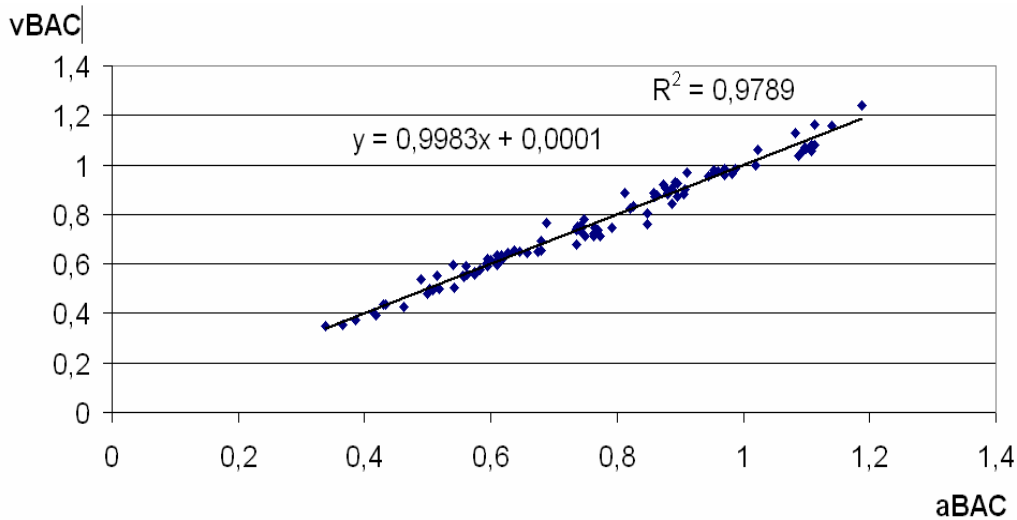
The subjects had breakfast at home and then came to the institute. Prior to the commencement of tests, they were checked for soberness using the breathalyser. Thereafter, the subjects were administered ad libitum 0.5 to 0.8 g of ethanol per kilogram of body weight in form of additive-free alcohol (69.9% v/v) in orange juice. The time of drinking was 20 minutes. An IV cannula was inserted in the crook of the elbow of one arm, whereas the arteria radialis of the other arm was punctured by using the Seldinger technique. Forty minutes following the end of drinking breath alcohol concentrations were measured at intervals of 10-15 minutes by using the calibrated Alcotest 7110 Evidential MK III. Between two breath alcohol tests concurrent venous and arterial blood samples were drawn from the catheters, discarding the first 5 mL of blood each. The subjects were under permanent medical care. During the test the subjects did not take any food or drink.

RESULTS

A total of 101 concurrent readings were obtained for breath alcohol, blood alcohol and arterial blood concentrations. No test was suspended for queasiness.

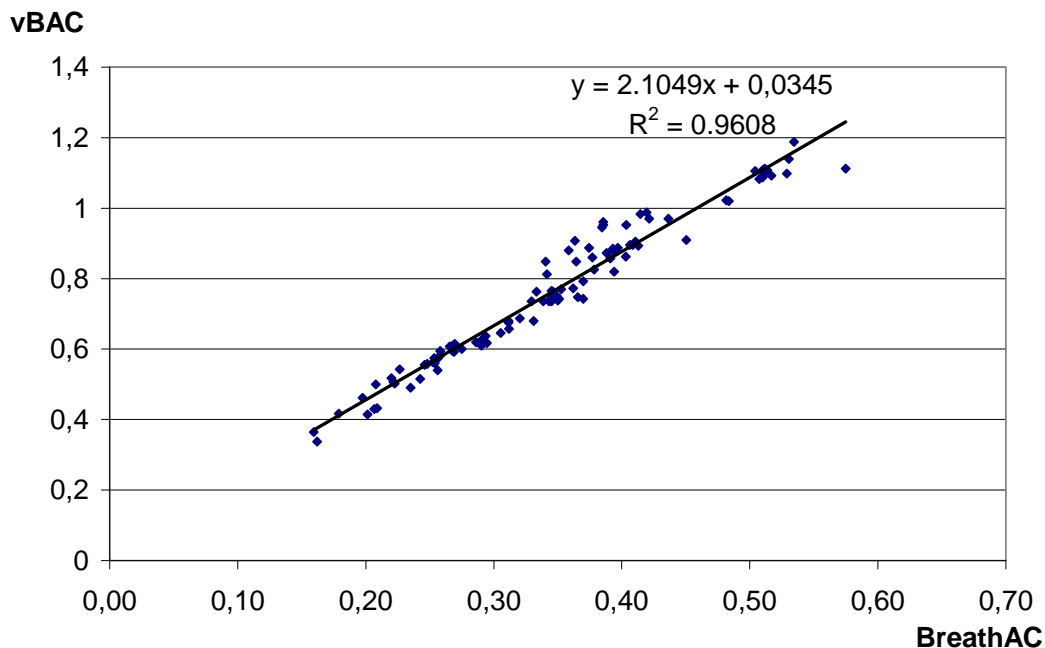
Figure 1 shows the concurrent pairs of arterial and venous blood alcohol concentration values. The regression equation is $y = 0.99x + 0.0001$, $R^2 = 0.97$.

Fig. 1: Simple linear regression of concurrent arterial blood alcohol and venous blood alcohol concentration readings.



The regression equation is $y = 2.10x + 0.03$ ($R^2 = 0.96$) for the correlation between venous blood alcohol concentration and breath alcohol concentration (Fig. 2) and $y = 2.11x + 0.03$ ($R^2 = 0.95$) for the correlation between arterial blood alcohol concentration and breath alcohol concentration (Fig. 3).

Fig. 2: Simple linear regression of concurrent venous blood alcohol concentration and breath alcohol concentration readings.



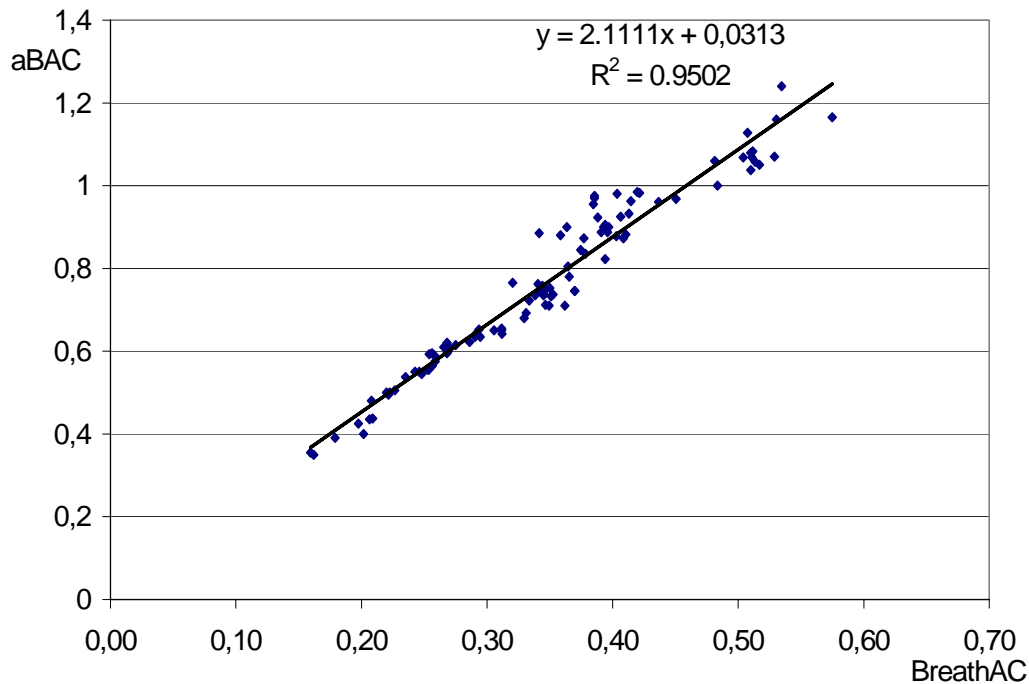


Fig. 3: Simple linear regression of concurrent arterial blood alcohol and breath alcohol concentration readings.

DISCUSSION

The arteriovenous differences established are lower than expected. Both the arterial and the venous blood alcohol concentrations show a good correlation with the breath alcohol concentration. Hence, the statement in the expert opinion of the Federal Ministry of Health in 1992 [1] suggesting that the breath alcohol concentration follows the arterial, instead of the venous, blood alcohol concentration must be rejected. Also the examinations of Jones [5] et al. are in contradiction to the opinion of the Federal Ministry of Health. These authors established a zero arteriovenous difference about 90 minutes after the end of drinking, taking a negative path in the further course. The critical aspect of our examinations is that concurrent readings were obtained 40 minutes after the end of drinking, and hence the earlier resorption phase was not completely covered. Jones et al. [4] performing similar examinations with the Datamaster breathalyser also found out that the arteriovenous differences occurring in the early resorption rapidly decreased in the further course.

Concurrent arterial, venous and breath alcohol concentration results obtained with the only breathalyser approved for court proceedings in Germany, the Evidential 7110 MK III (Dräger, Germany), have not been published to date. Nonetheless, breath alcohol concentrations measured with this device have been admitted under the traffic offence law since 1998. However, they have not yet been introduced for criminal prosecution, and should be critically reviewed.

References

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