Estimation of the Level of Arterial Blood Alcohol by Analysis of Breath: Investigation of a New More Accurate Technique than Current Methods

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A special medico legal problem is the determination of the level of alcohol intoxication.

The determination of alcohol concentration (g/L or g/kg) in venous blood involves an inherent non-systematic error due to variable absorption, distribution and elimination in the tissues drained by the particular sampling vein and its use can be disputed. Venous blood ethanol content is lower than arterial content during the initial uptake phase whereas the reverse is true during elimination. The concentration of ethanol in arterial blood correlates closely with the brain ethanol level and is therefore regarded as a better parameter to quantify pharmacological effects and drunkenness. However, it is not practical and possible to take arterial samples on a regular basis.

Ethanol in blood is nearly exclusively dissolved in its water content. Ethanol produces a partial pressure, which is the driving force for the distribution of it into the extra vascular components. The partial pressure of ethanol in arterial blood transfers ethanol into the brain water and the partial pressure of ethanol in brain water determines the level of intoxication, probably in a similar way as anaesthetic drugs. However, if ethanol concentration in arterial blood is used to determine level of intoxication it should be compensated for the content of water in blood.

The partial pressure of ethanol in the water phase of arterial blood is by definition in equilibrium with the partial pressure of ethanol in the alveoli and a breath test should therefore provide a more accurate determination of the level of ethanol intoxication. However, the current methods for ethanol breath test rely on techniques, which introduce several errors to the measurements. These tests require a prolonged exhalation against a flow resistance, which causes an exchange of ethanol between the gas phase and airway tissues. Together with the dead space volume and the slow response of the analysers (time-constants of approximately 1 s), it contributes to a continuously increase in the breath ethanol concentration during exhalation. The current technique is furthermore temperature dependent and sensitive to breathing pattern manipulations. These errors have challenged the validity of the breath tests during jurisdiction.

A new infrared analyser measures ethanol concentration in freely exhaled air in a cuvette with low airflow resistance. Measurement of ethanol concentration at three different wavelengths and of water and carbon dioxide concentrations is performed at a frequency of 33/second. Exhaled alveolar gas is always saturated by water vapour at lung temperature. Water vapour can therefore be used as an internal standard for the alveolar ethanol concentration, which directly reflects arterial blood alcohol concentration. At lung temperatures other than 37ºC, this internal standardization reduces the error in the measurement of ethanol concentration from 7 %ºC to <1%ºC.

Documentation of this new method and the results from arterial, venous, and breath analysis verifying the accuracy of this technique will be presented.