Transdermal Alcohol Measurement: A Review of the Literature

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Abstract—The body of scientific literature on transdermal alcohol testing dates back almost 70 years. The first commercial product enabling this knowledge appeared in the 1980s in the form of an alcohol “sweat-patch.” Recently, transdermal alcohol monitoring bracelets have started appearing in the marketplace. Based on published research in this field, one can conclude that measuring alcohol transdermally on a constant basis provides an effective screen for alcohol consumption and a reasonable approximation of the magnitude of that consumption.

Key Words—Transdermal alcohol measurement, Alcohol consumption.

INTRODUCTION

Alcohol testing by transdermal (i.e., through the skin) methods is relatively unknown compared to blood, breath, or urine testing. Over the past several years, products that use transdermal alcohol measurement to screen for alcohol consumption and estimate Blood Alcohol Content have gained prominence in the marketplace.

The purpose of this article is to examine the science of transdermal alcohol testing by summarizing the scientific literature previously published in this field. This literature documents research that dates back almost 70 years, and it provides a solid scientific foundation for the validity of transdermal alcohol testing.

EARLY RESEARCH

The fact that measurable amounts of ingested alcohol are excreted through human skin was first published in 1936 [1], when Nyman and Palmlov estimated that 1% of ingested alcohol is ultimately excreted through the skin. Little additional work was done in this field for 30 years subsequent to their original study; however, a number of papers were published in the 1960s and 1970s that pertained specifically to how the body processes drugs, alcohol, and non-electrolytes in the skin and sweat glands [2]-[5].

FIRST COMMERCIAL PRODUCT

The first concept for a commercial product that utilized transdermal alcohol testing was an alcohol “sweat-patch.” This patch was applied to the user’s skin for a period of several days, where it absorbed liquid sweat excreted through the skin. The patch was then removed and analyzed using separate equipment in order to determine the amount of ethanol that each sweat-patch absorbed. These results were then tied to the consumption of alcoholic beverages.

A significant amount of additional research was performed with the sweat-patch between 1980 and 1984 [6]-[10]. This research concluded that there was a statistically significant linear relationship between the concentration of ethanol in sweat and the average concentration of ethanol in blood (BAC). Results of this testing were also 100% sensitive and specific, meaning the testing clearly differentiated drinkers from non-drinkers and had no false positives [6].

Further sweat-patch development led to simpler methods of quantifying the concentration of ethanol in sweat without using expensive laboratory equipment, such as a gas chromatograph. For example, the patch was placed in a sealed tube, and a fuel-cell-based portable breath tester was used to measure the alcohol concentration in the headspace above the patch. This established a reference point that was then compared to at least three “standard” ethanol solutions, including a zero, to provide an estimate of ethanol concentration. Researchers concluded that the method was sound [8].

BRACELET FORERUNNERS

While sweat-patch research focused on ethanol concentrations in liquid sweat, other research was conducted in the late 1980s that measured the ethanol concentration in vapors formed above the skin.

Research at the Indiana University School of Medicine entailed placing polyethylene bags around the hands of human

\footnote{Blood Alcohol Concentration, or BAC, is the amount of alcohol per fixed unit of blood. It is usually defined as grams of ethanol per deciliter of blood (g/dL) or percent weight of ethanol per volume of blood (<% w/v>). For example, 0.05 g/dL is the same as 0.05 %.}
subjects, measuring ethanol in the “insensible perspiration” that accumulated in the bag, and comparing those measurements to fixed ethanol standards [11]. This study concluded that, “Ethanol gas is readily excreted in insensible perspiration in sufficient quantities to allow reliable estimation of BAC.” The study further concluded that, “Henry’s Law applies to insensible perspiration in the same manner it applies to breath,” suggesting the possibility of a fixed-partition ratio between ethanol concentrations above the skin and BAC. This study was the first published research to note that ethanol concentrations above the skin had clear absorption and elimination phases that corresponded to BAC. In addition, the study noted a distinct, measurable lag between peaks “by as much as 25%.”

Similar research was performed at the University of Toronto, also during the late 1980s. However, this research dispensed with the polyethylene bags and complex laboratory equipment and used a portable ethanol sensor, placed directly above the skin, to measure ethanol vapors excreted by both rats and humans [13], [14]. Like all prior studies, the University of Toronto researchers concluded that there was a very high correlation between ethanol concentration above the skin to both BAC and to BrAC². In addition, the study recorded distinct absorption, peak, and elimination phases in controlled dosage experiments. Finally, these researchers suggested that electrical signals triggered by high skin vapor ethanol concentrations could be used to activate a warning device for problem drinkers or law enforcement, and in fact, their crude device was probably the closest precursor to today’s alcohol monitoring ankle bracelets.

TRANSDERMAL ALCOHOL BRACELETS

The 1990s ushered in a new era of product development related to transdermal alcohol measurement, including development of the Wrist Transdermal Alcohol Sensor (WrisTAS™), by Giner, Inc., and the Secure Continuous Remote Alcohol Monitor⁰ (SCRAM®) bracelet by Alcohol Monitoring Systems, Inc. (AMS).

Thanks to developmental support the National Institute on Alcohol Abuse and Alcoholism (NIAAA), there has been more published research about the WrisTAS device than the SCRAM Bracelet. In studies using the WrisTAS device [15], [16], it was again found that TAC³ curves and BAC curves were highly correlated in both amplitude and shape, but that the onset of the peak was delayed by 30 to 120 minutes. This research also concluded that sober test subjects never produced a signal that could be interpreted as a drinking curve, and that transdermal ethanol testing showed great promise for assessment of alcohol consumption on a continuous and real-time basis.

Because AMS is privately funded, most of SCRAM’s research to-date has been unpublished. However, research was conducted using prototype SCRAM Bracelets at approximately the same time initial WrisTAS research was published [18]. AMS results were entirely consistent with all published research. Particularly, we concluded that there was sufficient volume of ethanol in insensible perspiration to reliably estimate BAC, measured TAC curves were highly correlated with BrAC curves in both shape and magnitude, and there was distinct delay between peak BrAC and peak TAC. Subsequent research performed through various product development phases also resulted in estimating a TAC:BAC partition ratio⁴ [20].

Beginning in 2002, AMS conducted BETA testing of the SCRAM Bracelet on offenders with the Michigan Department of Corrections (MDOC) [21]. MDOC personnel concluded that, the “SCRAM System clearly meets the primary objective of accurately measuring alcohol consumption.” They also concluded that comparisons between TAC and BrAC measurements were accurate, and that as potential users, they have “been able to obtain confidence in the product’s ability to measure alcohol consumption.”

AMS began actively marketing and selling the SCRAM Bracelet in 2003. As of this writing, the SCRAM System has monitored over 4,000 alcohol offenders. In addition, two independent research studies of the SCRAM Bracelet, conducted by the University of Colorado School of Medicine and the National Highway Transportation Safety Agency (NHTSA) are underway and are scheduled for publication in 2005. Based on the years of research and development, the number of SCRAM alcohol tests performed, and the significant number of offenders monitored, AMS expects the results of these studies to be consistent with all prior published research.

CONCLUSION

Transdermal alcohol measurement has a scientific foundation that dates back almost 70 years. Since that time, researchers have performed significant transdermal alcohol measurement research with very consistent results. Based on the published literature, one must conclude that: (1) ethanol is excreted through the skin in sufficient quantities to estimate BAC; (2) those who have not consumed alcohol do not

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⁰ Breath Alcohol Concentration, or BrAC, is the breath corollary to BAC. It is defined as grams of ethanol per 2100 deciliters of exhaled air. By definition, BrAC = BAC when assuming that 2100 mL of exhaled air contains the same amount of ethanol as 1 mL of blood. Although this 2100:1 ratio, called the partition ratio, varies from person to person, it is generally accepted to be the correct average value for the adult population.

¹ A variety of terms have been used by researchers to refer to the concentration of ethanol in both liquid sweat and insensible perspiration. We will standardize on Transdermal Alcohol Concentration, or TAC, and define TAC to be the measured transdermal ethanol concentration multiplied by a constant that equates it to BAC.

² Breath Alcohol Concentration, or BrAC, is the breath corollary to BAC. It is defined as grams of ethanol per 21000 dL of insensible perspiration. This study concluded that, “Ethanol gas is readily excreted in insensible perspiration in sufficient quantities to allow reliable estimation of BAC.” The study further concluded that, “Henry’s Law applies to insensible perspiration in the same manner it applies to breath,” suggesting the possibility of a fixed-partition ratio between ethanol concentrations above the skin and BAC. This study was the first published research to note that ethanol concentrations above the skin had clear absorption and elimination phases that corresponded to BAC. In addition, the study noted a distinct, measurable lag between peaks “by as much as 25%.”

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produce signals that can be interpreted as an alcohol curve; (3) TAC is highly correlated with BAC in both magnitude and shape of the alcohol curve; and (4) measuring TAC on a constant basis provides an effective screen for alcohol consumption and a reasonable approximation of the magnitude of that consumption.

REFERENCES


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