HISTORY AND HIGHLIGHTS OF ALCOHOL-LEGISLATION IN SWEDEN; TRIBUTE TO ERIK M.P. WIDMARK AND ROGER K. BONNICHSEN

Rune Andrasson and A. W. Jones
The Information Center for Traffic safety, Stockholm, and Department of Alcohol Toxicology, National Laboratory of Forensic Chemistry, University Hospital, Linkping, Sweden.

Summary. This article traces developments in Swedish legislation dealing with driving under the influence of alcohol (DUI). We pay homage to two men of achievement in forensic alcohol studies, namely, Professor Erik M.P. Widmark and Professor Roger K. Bonnichsen. These scientists developed methods for quantitative determination of alcohol in body fluids that become widely used in research, forensic science, and clinical practice. Punishable limits of alcohol concentration in blood were introduced in Sweden in 1941. In July 1989, Breath-alcohol analysis was approved as a substantive test of alcohol load in the organism.

Introduction

Before most countries fully appreciated the role of alcohol in accidents and deaths on the highway, the Swedish parliament enacted legislation allowing the policy to take specimens of blood for forensic purposes. This 1934 law paved the way for introducing statutory limits of alcohol in the blood of motorists. A two-tier system with punishable limits of 0.8 and 1.5 mg/g appeared in 1941. The 0.8 mg/g limit was lowered to 0.5 mg/g in 1957. These milestones in alcohol-traffic legislation owe much to the research efforts of Professor Erik M.P. Widmark. He developed an accurate and precise micromethod for quantitative determination of alcohol in biological specimens and also published pioneer work on the pharmacokinetics of alcohol.

In the 1950s Widmark's chemical oxidation method of blood-alcohol analysis was replaced by a method based on enzymatic oxidation. This new technique involved the reaction of ethanol with an enzyme called alcohol dehydrogenase (ADH). This development was a direct result of the biochemical research of Professors Roger K. Bonnichsen and Hugo Theorell working at the Karolinska Institute. The enzymatic, or ADH method as it became known, furnished a more sensitive and specific way to determine ethanol in blood compared with Widmark's wet-chemical oxidation procedure. In 1985, computer-aided headspace gas chromatography became the official method of forensic alcohol analysis in Sweden (Jones and Schuberth 1989).

Early recognition of the role played by drugs other than alcohol in causing traffic accidents (1951 law) and the introduction of random road-side breath testing (1977 law) are other examples of legislation aimed at curbing the impaired driver.
Drinking and driving in Sweden

Sweden is about the same size as California or twice that of the United Kingdom. But this Nordic country is sparsely populated with only 8.4 million inhabitants in a land area of 159,000 square miles. The year-by-year development in the number of blood specimens submitted for alcohol analysis from suspected drunk drivers has remained remarkably constant, between 19,000-22,000, for the past 23 years. The total consumption of alcohol in Sweden, the number of motor vehicles registered, the number of driver's licenses issued as well as the sales of petrol have all increased during this period. The number of drinking drivers, as judged by the number of blood specimens submitted for alcohol analysis, probably reflects the available police resources and activity in this field. The dark figures are certainly enormous.

An evaluation of the results obtained during random roadside breath testing showed that only 2 out of every 1000 drivers tested (0.2%) had a blood-alcohol concentration over the legal limit of 0.5 mg/g. This compares with 2-5% in several other European countries where the statutory limits for motorists are higher. The average blood alcohol concentration among DUI offenders in Sweden is 1.7 mg/g and ranges from below 0.5 to 4.50 mg/g. Most DUI suspects with a BAC above 1.5 mg/g obviously have problems with their drinking. It is generally accepted that 40-50% of male offenders in Sweden are alcoholics and therefore in need of medical treatment; 6% of DUI offenders are women (Jones et al. 1989). In 1989, the Swedish government approved the use of breath-alcohol analysis for substantive testing. Today both BrAC and BAC are accepted by the courts as evidence of impairment and constitute the main prosecution evidence necessary for a DUI conviction. Table 1 summarizes the major developments in legislation on alcohol and traffic safety in Sweden.

Table 1. Highlights of Alcohol-Traffic Legislation in Sweden

<table>
<thead>
<tr>
<th>Year</th>
<th>Highlights</th>
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<tbody>
<tr>
<td>1916</td>
<td>Demands made for restraint from use of alcohol as a condition for obtaining a driver's licence.</td>
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<tr>
<td>1923</td>
<td>Provisions in the law for punishment of drunk drivers based on results of a clinical examination of the suspect.</td>
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<td>1925</td>
<td>Criminal liability for alcohol impairment at the wheel was written into the law.</td>
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<td>1930</td>
<td>Field trials began with Widmark's method of blood-alcohol analysis.</td>
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<td>1934</td>
<td>Mandatory blood testing was approved in criminal investigation including the offence of driving under the influence.</td>
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<tr>
<td>1941</td>
<td>Punishable limits of alcohol concentration were written into the law; a two tier offence 0.8 mg/g and 1.5 mg/g.</td>
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<td>1957</td>
<td>Lower limit of 0.8 mg/g reduced to 0.5 mg/g.</td>
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<tr>
<td>1958</td>
<td>First use of road-side breath-alcohol screening test; the Alcotest tube and bag device.</td>
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1975 Introduction of random roadside sobriety checks with breath-alcohol instruments.

1981 The mandatory clinical examination of drunk drivers was abolished.

1989 Approval of breath-alcohol concentration as evidence of impairment; 0.25 mg/L and 0.75 mg/L.

**Scientific research on alcohol in Sweden**

Forensic alcohol research in Sweden has long traditions of excellence.

Table 2 lists in chronological order some of the contributions made by Swedish researchers in the field of alcohol, drugs, and traffic safety.

Table 2. Highlights of alcohol-traffic research in Sweden

1913 Widmark's first publication on the analysis of alcohol in urine for use as a diagnostic test of intoxication.

1922 Widmark's micro-method of blood alcohol analysis was published in an international journal.

1929 Widmark and collaborators published research on alcohol analysis in post-mortem specimens.

1930 Widmark published his studies of the relationship between blood-alcohol concentration and signs and symptoms of impairment.

1930 Liljestrand and Linde published a classic study on the physiological principles of breath alcohol analysis and the blood/air partition coefficient.

1932 Widmark's classic monograph was published concerning absorption, distribution, and metabolism of alcohol in the body.

1949 Bjerver and Goldberg demonstrated the untoward effects of small doses of alcohol on actual driving performance.

1951 Bonnichsen and Theorell developed the enzymatic (ADH) method of blood alcohol analysis.

1956 ADH method introduced for forensic analysis of blood samples in Sweden and other countries.

1962 Bonnichsen and coworkers published a paper on alcohol analysis by gas chromatography.

1965 Bonnichsen and coworkers published extensively on methods of analyzing drugs in body fluids with gas chromatography and mass spectrometry. Among early Swedish pioneers in the field of alcohol research, the following individuals deserve a special appreciation; Magnus Huss (1807-1890), Erik M.P. Widmark (1889-1945), Gran Liljestrand (1886-1968), Erik Wolff (1891-

Erik M. P. Widmark - biographical note

Erik M. P. Widmark lives from 1889-1945. The 100 year anniversary of his birth was commemorated this year with a symposium on the subject of alcohol and traffic safety. This was arranged at the University of Lund where Widmark was appointed Professor and chairman of the Department of medical and Physiological Chemistry at the age of 31. (Anderson, 1986). Widmark held this position until his untimely death in 1945 at the age of 56. A bronze bust of Widmark was placed at the entrance to the newly erected building for Chemical Sciences.

Widmark's experiments on the fate of alcohol in the body represent his most important contribution to science (Widmark 1932). He developed and tested a method to evaluate the BAC time course in quantitative terms and introduced two important kinetic parameters which he called "r" and "R". The "r" factor depicts the rate of disappearance of alcohol from blood (mg/g/h) and "R" depicts the volume of distribution of alcohol or the ratio of the concentration of alcohol in the whole body (g/kg) to the concentration in blood (mg/g). These alcohol parameters are still widely used by forensic scientists to estimate quantities of alcohol consumed from the measured blood-alcohol concentration. The theory and practice of back extrapolation of BAC from the time of sampling blood to the time of drinking has its roots in Widmark's work.

A prerequisite for this work on alcohol kinetics was the availability of an accurate and precise method for analyzing alcohol in small volumes of blood. Widmark's micromethod was published in 1922 (Widmark, 1922). In brief, ethanol was separated from 100 milligrams of whole blood by diffusion in specially blown glassware; Widmark flasks. The ethanol was then oxidized in a reaction with excess potassium dichromate-sulfuric acid mixture. The amount of oxidizing agent used up was determined by addition of potassium iodide to liberate from iodine and then back titration with sodium thiosulfate with starch indicator. The Widmark micromethod made it possible to bring into force an effective standard protocol to record signs and symptoms of impairment. This protocol became widely used by physicians during the clinical examination of drunk drivers.

Roger K. Bonnichsen - biographical note

Roger K. Bonnichsen died in 1986. A review of his life and work with main emphasis on his achievements in forensic and biochemical alcohol research was recently published (Andrasson and Jones, 1989). Although born and trained as a physician in Copenhagen, Denmark, Roger Bonnichsen spent his entire scientific career in Stockholm, Sweden. Bonnichsen joined a research group under the leadership of Professor Hugo Theorell. Theorell's department at the Karolinska Institute was recognized as a center of excellence for research particularly studies of the biochemistry of enzymes. Roger Bonnichsen became internationally known through a paper published in 1949 (Bonnichsen and Wassn, 1949). This article described the purification of alcohol dehydrogenase (ADH), an enzyme located in the cytosol fraction of liver extracts. With ADH in a relatively pure form, this opened the possibility to make detailed studies of its kinetic properties and substrate specificity. An early paper together with his teacher, Hugo Theorell, Described a useful social-medical application of
ADH; they developed a new highly sensitive and specific method of blood-alcohol analysis. This technique became known as the alcohol dehydrogenase (ADH) method and the original procedure as well as many modifications of it are still widely used today. Much basic research on ADH followed including intricate experiments on its equilibria, specificity for substrates and reaction mechanism. One of these early publication has become a citation classic, accumulating more than 300 citations until 1980 (Andrasson and Jones 1989).

In 1956, Roger Bonnichsen was appointed Professor and Chairman of the newly formed Toxicology Department of the National Laboratory of Forensic Chemistry in Stockholm. His research efforts now turned towards the development of methods for analysis of drugs and poisons in body tissue. Together with colleagues, he used has chromatography and gas chromatography-mass spectrometry to solve hitherto difficult problems in forensic toxicology. With GC-MS and mass fragmentography, he showed it was possible to identify and quantitate drugs and their metabolites in blood and body fluids in nanogram (10^-9g) amounts. Bonnichsen was associated with one of the first papers to described the use of gas-liquid chromatography for analysis of alcohol and other volatiles in urine. Another paper suggested that blood-alcohol could be analyzed by gas chromatography and mass spectrometry as a routine method. Like Widmark, Bonnichsen was also interested in the metabolism of alcohol in the body, specifically, how this process was altered after chronic consumption. This led to studies of the elimination of alcohol from blood of alcoholics when they underwent detoxification.

After his official retirement in 1979, Roger Bonnichsen was kept fully active as a consultant to the National Swedish Police Board. He became the driving force behind legislation concerning the use of evidential breath-alcohol analysis in Sweden. Roger Bonnichsen was the undisputed expert in matters concerned with forensic alcohol analysis for more than 30 years.

References


