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The Effect of Lung Disease on the Accuracy of the Breath Alcohol Test

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The authors discuss the effect of lung disease on the accuracy of breath alcohol testing. A number of scientific studies have been undertaken in this area. In the authors' opinion, these studies support the proposition that the use of breathalyzer testing on subjects with various types of lung disease to determine blood alcohol concentration is valid.

Les auteurs discutent de l'effet des maladies pulmonaires sur la précision des tests permettant d'établir la concentration d'alcool présent dans l'haleine. Un certain nombre d'études scientifiques ont été entreprises dans ce domaine. Selon les auteurs, ces études appuient l'argument selon lequel l'utilisation de tests d'haleine, sur des personnes souffrant de divers types de maladies pulmonaires, est valide afin de déterminer la concentration d'alcool dans le sang.

1. INTRODUCTION

Breath alcohol tests have been used for medicolegal purposes since 1927.[1] The breathalyzer, a particular type of breath alcohol testing instrument, has been used in Ontario since 1956.[2] Many

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1 E. Bogen, (1927) 89 J. Am. Med. Assoc. 1508.

2 D.M. Lucas & R.C. Charlebois, (1978) 11 Can. Soc. Forens. Sci. J. 75.

laboratory and field studies on the accuracy of breath alcohol tests have been conducted on subjects with normal lung functions or whose lung function was unknown.[3] Until relatively recently, however, laboratory tests have not been conducted specifically on subjects with lung disease. The purpose of this article is to review these recent studies on the effect of lung disease on the accuracy of the breath alcohol test. While this article will not deal with the issue of the ability of persons suffering from lung disease to provide suitable samples into breath alcohol testing instruments, it should be noted that subjects with lung disease in these studies could provide suitable breath samples for analysis.

2. ACCURACY OF BREATH ALCOHOL TESTS

The accuracy of a breath alcohol test may be determined by the simultaneous collection of breath and blood samples and analysis of the respective alcohol concentrations. By comparing the blood and breath alcohol concentrations, an apparent blood:breath alcohol ratio ("BBR") may be calculated. This apparent BBR depends not only on the accuracy of the breath alcohol test, but also on the accuracy of the blood alcohol test, the blood alcohol concentration ("BAC") and several factors of biological variability.[4] Although the apparent BBR is not the ideal method for assessing the accuracy of breath alcohol tests, it is commonly used, and with reservations will be employed in this article.

The breathalyzer and other breath alcohol testing instruments used in Canada are based on a BBR of 2100:1, that is, 2,100 ml of breath contains the same amount of alcohol as 1 ml of blood. Breath alcohol tests based on this ratio tend to have lower results than the actual BAC as the apparent BBR in the general population is actually closer to 2300:1.[5] Breath alcohol tests on persons with a BBR greater than 2100:1 will be *lower* than the actual BAC. Persons with a BBR of less than 2100:1 will have breath alcohol tests that are *higher* than the actual BAC.

One limitation in breath alcohol tests is that cooperation of the subject is required. The subject must provide a deep lung sample in order to obtain an accurate result. Subjects who provide only a puff into the instrument or a shallow sample will obtain low breath alcohol test results. For example, a study by Jones has shown that on average if a subject provides only 13.5 per cent of the volume of breath sample that a subject can provide, the breath alcohol results will be lower by 20 per cent.[6] This is because the BBR is based on the exchange of alcohol between the breath and blood in the alveolar region of the lung and not in the upper parts of the respiratory tract.

As indicated earlier, until recently there have been only limited studies of the effect of lung disease on the BBR. From a theoretical viewpoint, it was believed that if a person suffering from lung disease could not provide a proper, forceful sample, the breath alcohol test result would be low. This was considered to be similar to a healthy subject providing a poor quality sample into the instrument. However, in science sometimes the theory does not fit the observations and actual studies of the effect of lung disease on the BBR are preferable

3. LUNG DISEASE

Healthy male subjects of average height, with no lung disease, should be able to exhale fully about 5 l of breath after a full inspiration. This volume is called the forced vital capacity ("FVC"). Healthy male subjects should also be able to exhale approximately 4 l of breath within 1 second, after a full inspiration. This measure of lung function is called forced expiratory volume in 1 second ("FEV_1"). The ratio between FEV_1 and FVC may be calculated and a percentage derived. Normally the FEV_1/FVC ratio should be about 80 per cent (i.e., 4.0 l/5.0 l x 100). A normal pattern of FEV_1 and FVC can be seen in Figure 1 at the end of the article. The vertical

3 T.B. Begg, I.D. Hill & L.C. Nickolls, (1964) i Br. Med. J. 9; A.A. Landauer, (1972) 5 Australian N.Z. J. Criminol. 250; P.G.W. Cobb & M.D.G. Dabbs, (London: Her Majesty's Stationery Office, 1985); P.M. Harding, R.H. Laessig & P.H. Field, (1990) 35 J. Forens. Sci. 1022.

4 J.G. Wigmore & D.M. Lucas, "The Scientific Validity of the Decision in *R. v. Phillips*" (1990) 2 J.M.V.L. 43.

5 A.W. Jones, (1976) 11 Mod. Probl. Pharmacopsych. 68.

6 A.W. Jones, (1982) 114 Acta Physiol. Scand. 407.

axis indicates the number of litres of breath exhaled and the horizontal axis indicates the time in seconds.

In most subjects with lung disease, the FVC, FEV_1 or the ratio is affected. There are two main types of ventilatory defects in lung disease: obstructive and restrictive.

(a) Obstructive

Obstructive lung disease is the most common and includes such diseases as asthma, or chronic airflow limitations due to bronchitis or emphysema. Obstructive diseases involve the obstruction of airways through several known pathogenetic mechanisms. The effect is similar to a normal person trying to blow through a narrow diameter tube such as a straw. The FVC decreases to below normal values as the amount of breath that can be forced through a narrow diameter airway in a given time becomes smaller, and the FEV_1 will be decreased. This is shown in Figure 2. In this hypothetical individual with an obstructive lung disease, the total volume of breath that can be exhaled (FVC) is reduced to 3.1 l and the rate at which breath is exhaled is much slower, so that the amount exhaled after 1 second (FEV_1) is only 1.3 l. The ratio of FEV_1 to FVC was also different from that found in normal, healthy subjects and was only 42 per cent rather than 80 per cent.

(b) Restrictive

Restrictive lung diseases are less common than obstructive lung diseases and include such diseases as pulmonary fibrosis. Restrictive lung diseases are a result of a restriction of the ability to inhale the full predicted capacity. This is analagous in a healthy person to having a belt tied tightly around the chest, so that the person cannot inhale completely. The diameter of the airways is also diminished, but only in proportion to the general diminution of lung size, so that the FEV_1/FVC ratio is generally not affected, or can be abnormally high. Therefore, in restrictive disease, the total volume that may be exhaled is decreased to below normal values but the percentage of breath that can be exhaled after 1 second may be close to

normal values, even though in absolute terms the FEV_1 is often also reduced.

Results for a hypothetical individual with a restrictive lung disease are shown in Figure 3. The FVC is only 3.1 l, but the FEV_1 is close to normal values: in this particular case, 2.8 l. This results in an FEV_1/FVC ratio that is greater than normal.

4. BREATH ALCOHOL TESTS AND LUNG DISEASE

The first study on the effect of lung disease on the accuracy of breath alcohol tests was conducted in 1972 by Haas and Morris.[7] In this work, 24 male patients hospitalized mainly for obstructive diseases consumed the equivalent of 7 to 8 ounces of liquor (40%v/v alcohol) within 1 hour. Blood and breath samples were collected simultaneously at least 40 minutes after drinking ceased and on two additional occasions 30 to 60 minutes later. The BAC was determined by gas chromatography ("GC") and the breath alcohol concentration ("BrAC") was determined by a Breathalyzer Model 900. Breath results were on average 11 to 15 per cent lower than the actual BAC. The authors state:

> Up to now, there has been no published information concerning breath-alcohol analysis in individuals who have documented chronic bronchopulmonary disease. Comparative studies on the presence of breath alcohol in individuals with normal function and in those with obstructive pulmonary disease have not been carried out. Reports of correlation between blood-alcohol levels determined by direct blood analysis and breath analysis do not refer to the pulmonary function status of their subjects. . . . In general, our findings agree with reports by others who found that breath values tend to lie somewhat below true blood values. The possibility of a result prejudicial to an accused individual being presented to the court is virtually negligible if duplicate or triplicate breath samples are analyzed.[8]

The second study was conducted 11 years later in Canada by Russell and Jones.[9] Ten male patients with obstructive lung disease and a comparison group of eight normal male subjects consumed the equivalent of 5 ounces of liquor (40%v/v alcohol) within 15 minutes.

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7 H. Haas & J.F. Morris, (1972) 25 Arch. Environ. Health 114.
8 Ibid.
9 J.C. Russell & R.L. Jones, (1983) 16 Clin. Biochem. 182.

Samples of breath and plasma were collected 40 minutes after drinking ceased and repeated every 20 minutes for 120 minutes. Plasma alcohol concentration was determined by GC, and BrAC was determined by a Breathalyzer Model 900A and GC. One potential problem with this article is that plasma alcohol concentrations were determined rather than whole blood alcohol concentrations. Converting the plasma alcohol concentration into a whole blood alcohol concentration introduces an additional variable as the plasma/whole blood alcohol concentration ranges from 1.09 to 1.17:1.[10]

Although the authors cautioned against the use of breath alcohol tests in subjects with obstructive lung disease, the data indicate that there was no significant difference in the apparent BBRs of healthy subjects and those with obstructive lung disease.

The third study was conducted in Germany by Theil, Erkens and Klobe in 1984.[11] Twenty patients with obstructive and restrictive lung diseases such as bronchial asthma or silicosis were tested. These patients were compared with a group of ten healthy subjects. Each subject consumed the equivalent of 5 ounces of liquor (40%v/v alcohol) within approximately 30 minutes. Blood and breath alcohol concentrations were determined 15, 30, 60, and 90 minutes after drinking ceased. BrAC was determined by an Alcotest 7010 or Alcotest 7310, two breath alcohol testing instruments used in Germany. It is not indicated how the BAC was determined.

The authors found no difference in the apparent BBRs between the subjects with or without lung disease and concluded that

> [t]he relationship between the blood and breath alcohol concentrations in the measured expired air showed no regular deviations from what was found in the case of healthy subjects. This indicates either that such a difference does not exist or that the difference is lost in the tolerance range of the measurement methods.[12]

This study is interesting in that it is the only one that determined the accuracy of breath alcohol tests on subjects with restrictive disease. All the other studies were conducted on subjects with obstructive lung disease.

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10 C.L. Winek & M. Carfagna, (1987) 11 J. Anal. Toxicol. 267.

11 M. Thiel, M. Erkens & K. Kolbe, (1984) 21 Blutalkohol (in German) 457.

12 Ibid.

The fourth study was conducted in Canada by Wilson, Sitar, Molloy, and McCarthy in 1987.[13] Ten subjects with a history of chronic obstructive lung disease and ten subjects without lung disease consumed the equivalent of 6 ounces of liquor (40%v/v alcohol) over 1 hour. The subjects with obstructive lung disease had an FEV_1 ranging from 0.40 to 1.8 l compared with a range of 1.2 to 4.6 l in healthy subjects. The FEV_1/FVC ratio ranged from 19 to 48 per cent in subjects with lung disease and 53 to 84 per cent in normal subjects. The age of the subjects was between 52 and 80 years.

Blood samples were collected hourly using an indwelling catheter and simultaneous breath samples were also collected. The BAC was determined by GC, and the BrAC by a Breathalyzer Model 900A. The mean apparent BBR was 3760:1 (range 3216 to 4853) for subjects with obstructive lung disease and 3051:1 (range 2325 to 3995) for normal subjects. In no instance was the BBR less than 2100:1, which indicates that the BrACs in these subjects were all lower than the actual BAC.

The apparent BBRs of these older subjects were compared with the apparent BBRs of younger healthy males aged 24 to 38 years. The authors concluded that the apparent BBR increases with age and that obstructive lung disease causes an increase in the apparent BBR.

The fifth study was conducted at the Home Office Central Research and Support Establishment in Britain by Gomm, Osselton, Broster, Johnson and Upton in 1990.[14] Eight asthmatic subjects and three normal subjects consumed five glasses containing 4.5 ounces of wine (9%v/v alcohol), each over 1 hour. Thirty minutes later, simultaneous breath and blood samples were collected. The BrAC was determined by an Intoximeter 3000 and the BAC was determined by GC.

The apparent BBR ranged from 2082:1 to 2773:1 in subjects with asthma and 2543:1 to 2618:1 in healthy subjects. The lowest apparent BBR of 2082:1 would mean a breathalyzer test would be about 0.8 per cent higher than the actual BAC. For example, a BAC of 100 mg/100 ml would read as a BrAC of 100.8 mg/100 ml.

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13 Wilson et al., (1987) 11 Alcoholism: Clin. Exp. Res. 440.

14 Gomm et al., (1991) 31 Med. Sci. Law 226.

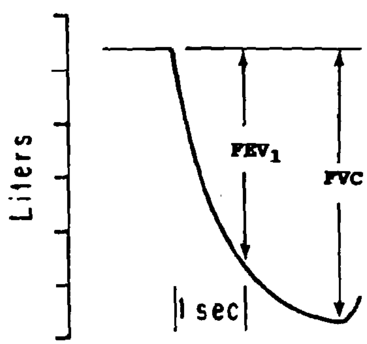
This study also determined the effect of using a bronchodilator inhaler (containing salbutamol) just prior to breath alcohol testing on the apparent BBR. The author's conclusions are as follows:

> In asthmatics who were known to be capable of using the evidential breath alcohol testing devices, improvements in pulmonary function following the use of salbutamol had no effect on either breath or blood alcohol concentrations after consumption of alcohol. It is likely that in some asthmatic subjects who are normally unable to use breath alcohol testing devices, the use of a bronchodilator inhaler will cause an improvement in respiratory capacity such that the requirements of evidential breath alcohol testing devices could be satisfied without prejudice to their breath alcohol measurements.[15]

5. CONCLUSIONS

A review of five studies on the effect of various restrictive and obstructive lung diseases on the accuracy of the breath alcohol test has shown that in four of the studies there was no effect. One study indicates that subjects with lung disease will tend to have breath alcohol results lower than those of normal subjects. Therefore, in subjects with various types of lung disease, the use of breath alcohol testing to determine BAC in forensic cases is valid.

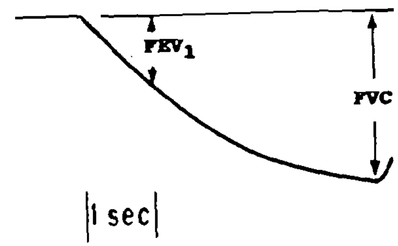
Figure 1
Normal Forced Expiration



FEV_1 = 4.0 L
FVC = 5.0 L
FEV_1/FVC = 80%

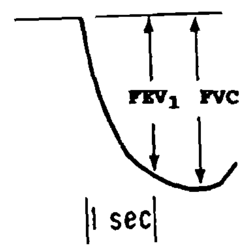
15 Ibid.

Figure 2
Obstructive Forced Expiration



FEV_1 = 1.3 L
FVC = 3.1 L
FEV_1/FVC = 42%

Figure 3
Restrictive Forced Expiration



FEV_1 = 2.8 L
FVC = 3.1 L
FEV_1/FVC = 90%