Significance of variations in blood: breath partition coefficient of alcohol

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British Medical Journal, 1976, 2, 1479-1481

Summary
A helium-neon laser was used to measure the alcohol content of breath from six volunteers at regular intervals over up to four hours. The corresponding blood values were calculated with a breath/blood partition coefficient of 2100. When these values were compared with those obtained by direct measurement it was obvious that substantial variations occurred from one person to another in the derived values and that even in the same person the use of the partition coefficient of 2100 led to significant differences between the direct and derived values for blood, and these differences changed with time. Thus the assertion that a constant partition coefficient of 2100 exists between alcohol in blood and that in breath is not supported by the evidence. Accordingly the use of such a partition coefficient to derive blood alcohol values for law enforcement is not justified.

Introduction
The possibility that accurate blood alcohol values can be derived from measuring alcohol in breath has important implications in law, particularly in the United Kingdom in relation to the proposed revision of the relevant sections of the Road Traffic Act 1972.1 But before breath analysis can be accepted as a substantive test in the courts two vital questions need to be answered. Firstly, are techniques available that will allow the alcohol content of breath to be accurately determined? Secondly, can an accurate determination of the alcohol content of blood be obtained from breath analysis by using of a universally applicable conversion factor? We describe here experiments carried out in an attempt to answer these questions.

Method
Breath was analysed with a helium-neon infrared analyser designed and built by Powell7 and modified specifically for measuring alcohol vapour in breath by Alobaidi.4 The apparatus has been described in detail elsewhere.4 Calibration ethanol-air mixtures were generated by a slow injector system7 over the range of 5 to 28 000 parts per million (ppm) by volume (0-022-116-3 μmol/l (1-0-5356 μgl/l)) at 20°C and 760 mm Hg. Initially, the slow injector output was verified with the aid of a manometric mixing technique by volume fraction. The gas was chromatographed with oxygen as an internal standard.5 These known ethanol-in-air concentrations were used to calibrate the analyser before and after analysing each batch of breath samples. Six volunteers, five men and one woman aged 20 to 58 years and weighing 57 to 76 kg were studied. On arrival in the laboratory they had fasted and abstained from alcohol for at least 12 hours and had taken no soft drinks for at least four hours. Breath and venous blood samples were obtained as previously described.8 Five volunteers chose to drink whisky 70° proof 100 ml diluted with 100 ml of water; the sixth preferred gin 70° proof diluted with 100 ml of tonic water. Up to three minutes was allowed for drinking, and in some cases this was followed by two minutes’ mouthwashing. The length of each experiment varied but the average was three hours. During the first two hours after drinking batches of three breath samples were taken in rapid succession at five- to 10-minute intervals and then at 15-minute intervals. The mean value of the three results in each batch was calculated and recorded. Blood samples were withdrawn immediately after the third breath sample in each batch and stored in plastic pots (0-3 ml) or glass phials (1 ml). Only one type of container was used for each volunteer. The samples were stored in a domestic refrigerator until analysed by the method of Curry et al.7 All analyses were done in duplicate and many in triplicate.

The measured blood alcohol concentrations were compared with the calculated values derived from the measured breath concentrations. For this purpose the partition coefficient of 2100:1, recommended by the British Medical Association,8 was used. The actual partition coefficients were also calculated for each volunteer from paired breath and blood alcohol concentrations at regular intervals.

Results
CALIBRATION STUDIES
The results in table I indicate that a high degree of reproducibility was achieved at all three speeds over the range 205 to 1226 ppm. On the basis of calibration with such alcohol vapour mixtures the laser infrared analyser response was linear within ±5% over the range 0-12 000 ppm of ethanol vapour, with the gas mixtures having a coefficient of 2100:1 (10 to 49.8 μmol/l (0-226 μgl/l) at 20°C and 760 mm Hg). Over the range of interest of 0-500 ppm (0 to 2-08 μmol/l (0-96 μgl/l) at 20°C and 760 mm Hg) ethanol vapour

References
2 General Practitioner Research Group, Practitioner, 1971, 206, 412.
9 Miusan, G, et al, Clinical Science and Molecular Medicine, 1975, 48, 85s.
TABLE I—Chromatographic calibration results from three slow injector speeds

<table>
<thead>
<tr>
<th>Liquid sample introduction speed (μl/min)</th>
<th>Gas flow rate (1/min)</th>
<th>Average peak height ratio vapour: oxygen</th>
<th>Standard deviation</th>
<th>No of samples</th>
<th>Concentration (ppm v/v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-22</td>
<td>0-1</td>
<td>10-371</td>
<td>0-305</td>
<td>20</td>
<td>1226</td>
</tr>
<tr>
<td>0-0090</td>
<td>0-1</td>
<td>3-875</td>
<td>0-125</td>
<td>19</td>
<td>449</td>
</tr>
<tr>
<td>0-00372</td>
<td>0-5</td>
<td>3-427</td>
<td>0-0848</td>
<td>11</td>
<td>402</td>
</tr>
</tbody>
</table>

NB A maximum coefficient of variation of ±22%, at the 449 ppm v/v level was produced.

concentrations could be measured with a precision of ±3%, when calibration checks were performed immediately before and after each batch of analyses.

VOLUNTEER STUDIES

A large signal, attributable to mouth alcohol, was recorded immediately after drinking, but this dropped steeply over the next 10 minutes. Thereafter the breath alcohol concentration rose steadily until a peak was reached between 18 and 85 minutes after drinking. The peak concentrations varied significantly between the volunteers over the range 0-0347 to 0-0890 mmol/l breath (0-16-0-41 mg/100 ml). Although these variations in peak times and peak concentrations were substantial they followed almost exactly the pattern of the corresponding blood alcohol concentrations, except in one volunteer (subject 1), who produced a series of breath alcohol values that did not correspond with the coincident blood values (table II). For example, 69 minutes after he had stopped drinking his maximum breath concentration was 1136 ppm by volume, equivalent to 106 mmol/l blood (488 mg/100 ml), when his measured blood alcohol concentration was only 8 844 mmol/l (40-75 mg/100 ml). There was no obvious explanation for this deviation from the normal pattern.

The quantitative data for breath and blood collected from each experiment are set out in tables II and III together with the derived partition coefficients. From these data it is clear that not only did the blood-breath partition coefficients vary from one person to another but also that they varied with time in the same person. Tables II and III also list the calculated blood alcohol concentrations obtained when the recommended partition coefficient of 2100:1 was used to convert the measured breath alcohol values.

Discussion

Over the range of immediate interest (65 to 1200 ppm) ethanol vapour concentrations can be measured with a precision of ±3% when calibration checks are carried out before and after analysing each batch. This corresponds with the degree of accuracy shown for the conventional Luft-type non-dispersive infrared gas analyser,* but extends it over a greater range.

TABLE II—Breath and blood alcohol concentrations and corresponding partition coefficients obtained from volunteer (subject 1) who did not follow usual pattern. Values above short dividing lines were obtained before alcohol peaks were reached

<table>
<thead>
<tr>
<th>Measured blood alcohol (mmol/l)</th>
<th>Breath alcohol (mmol/l)</th>
<th>Partition coefficient</th>
<th>Calculated blood alcohol (mmol/l) (breath value × 2100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-245</td>
<td>0-006 94</td>
<td>1043</td>
<td>14-58</td>
</tr>
<tr>
<td>8-473</td>
<td>0-005 36</td>
<td>1581</td>
<td>12-26</td>
</tr>
<tr>
<td>10-745</td>
<td>0-006 62</td>
<td>1624</td>
<td>13-90</td>
</tr>
<tr>
<td>9-826</td>
<td>0-007 57</td>
<td>1297</td>
<td>13-50</td>
</tr>
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<td>9-457</td>
<td>0-009 31</td>
<td>1016</td>
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</tr>
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<td>8-413</td>
<td>0-010 15</td>
<td>742</td>
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</tr>
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<td>8-843</td>
<td>0-050 51</td>
<td>175</td>
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<td>0-007 05</td>
<td>1219</td>
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<td>0-008 27</td>
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<tr>
<td>5-994</td>
<td>0-003 78</td>
<td>1561</td>
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</tr>
<tr>
<td>6-508</td>
<td>0-003 45</td>
<td>1886</td>
<td>7-25</td>
</tr>
</tbody>
</table>

Conversion: SI to traditional units—Alcohol: 1 mmol/l = 4-6 mg/100 ml.

*This exceptionally high breath alcohol value, obtained after re-ignition, was disregarded in all calculations.

Thus there is ample evidence from these experiments and from those of other workers using different types of equipment that the amount of ethanol present in a gas mixture can be measured with a substantial degree of accuracy.* It is reasonable therefore to conclude that techniques are available which will allow the alcohol concentration in breath to be accurately determined.

When breath alcohol measurements were used to calculate the amount of alcohol present in whole blood the derived values often differed substantially from those obtained by direct measurement. The validity of the conversion factor of 2100 must therefore be in doubt. This factor has already been questioned by Payne et al, who published data showing that the blood:breath partition coefficient was probably too low, that it gave wrong
Coagulation and fibrinolysis in intact hydatidiform molar pregnancy

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British Medical Journal, 1976, 2, 1481-1484

Summary
Tests of coagulation, fibrinolysis, and platelet function were performed in 17 patients with intact molar pregnancies. Women with intact molar pregnancies had higher fibrinogen, factor VIII, and fibrinogen degradation products, concentrations and lower prothrombin, factor X, plasminogen, and plasminogen activator concentrations than controls with normal pregnancies. They also had reduced platelet counts and thromboelastographic values, which indicated hypo-coagulability. These results suggest that intravascular coagulation occurs in intact hydatidiform molar pregnancies.

Introduction
Normal pregnancy is accompanied by changes in the coagulation as well as the fibrinolytic system. These changes occur in parallel with the period of gestation, being minimal in the first trimester and changing progressively thereafter. Certain abnormal pregnancy states, such as eclampsia, pre-eclampsia, intrauterine death, amniotic fluid embolism, abruptio placenta, and septic abortion, are also accompanied by coagulation and fibrinolytic abnormalities.

Coagulation disorders have been suspected in hydatidiform molar pregnancies when there has been a previous serious

References
4 Eniknap, T A A; and Hill, D W, Journal of Physics E, 1975, 8, 30.