Dilution of Blood Collected for Medicolegal Alcohol Analysis by Intravenous Fluids

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Abstract

Two case reports of the dilution by intravenous fluids of blood samples collected for medicolegal alcohol analysis are presented. The forensic significance of the findings is discussed.

Introduction

Blood samples collected for medicolegal alcohol analysis at the hospital from victims of motor vehicle accidents may be affected by different factors. These include the handling and storage of the samples, the type of collection tube used, the time of collection of the sample, and the type of sample (whole blood, serum, erythrocytes) analyzed. The two case histories reported here indicate another possible factor: dilution of the blood sample by intravenous (IV) fluids.

Case 1

A 42-year-old female driver was involved in a serious motor vehicle accident at approximately 7:00 p.m. She was treated at hospital and administered fluids intravenously. At 8:15 p.m. a blood sample, which was taken for medical purposes, was collected into a red-top Vacutainer tube. At 8:55 p.m. two additional blood samples were collected for legal purposes and placed into grey-top XF947 Vacutainer tubes. All samples were submitted to the Centre of Forensic Sciences (Toronto, Ontario, Canada) for alcohol analysis. The sample in the red-top Vacutainer tube consisted of clotted blood that was not separated into the serum and erythrocytes. This sample was homogenized before the alcohol analysis.

The first blood sample and one of the subsequent samples were analyzed for alcohol by headspace analysis using a Hewlett Packard (Mississauga, Ontario, Canada) 5890 series II gas chromatograph (GC) with a Tekmar (Cincinnati, OH) 7000 headspace sampler. T-Butanol was used as an internal standard, and the analysis was conducted according to the modified method of Machata (1). The mean of quadruplicate analyses was 0.134 g/100 mL for the first sample and 0.066 g/100 mL for the second sample, which was taken 40 min later. The second blood sample was observed to be very watery.

Case 2

A 24-year-old male driver of a snowmobile was involved in a serious accident when his snowmobile hit a parked car. The accident occurred at 5:45 p.m. The victim received serious head, chest, and leg injuries and was transported to a regional trauma center. A blood sample was collected at 6:37 p.m. for medical purposes in a grey-top Vacutainer tube. At 8:28 p.m. two blood samples were collected for legal purposes into two grey-top XF947 Vacutainer tubes. All blood samples were submitted to the Centre of Forensic Sciences for alcohol determination.

The first blood sample and one of the two subsequent blood samples were analyzed for alcohol by the headspace GC method described previously. The alcohol concentration of the first blood sample was 0.263 g/100 mL, and the alcohol concentration of the second was 0.111 g/100 mL. The second blood sample was again observed to be very watery.

Results and Discussion

In both cases, the agreement between the first and subsequent blood samples was poor, even allowing for the typical plus or minus 5% analytical variability and the time interval between the collection of the samples. The extreme range of the apparent rate of alcohol elimination can be calculated by adding 5% to the lowest blood alcohol concentration (BAC) and subtracting 5% from the highest BAC. This results in the smallest possible difference in BAC. The largest possible BAC is obtained by subtracting 5% from the lowest BAC and addings
5% to the highest BAC. The hourly rates can be calculated from these two extremes using the time difference between the blood samples.

By these calculations, the apparent rate of elimination of alcohol in the first case was between 0.087 and 0.117 g/100 mL/h, and it was between 0.072 and 0.092 g/100 mL/h in the second case. These rates of elimination are well outside the observed range in humans (0.009–0.036 g/100 mL/h) (2).

These apparent rates of elimination are not the result of possible pharmacokinetic alterations due to trauma (3,4). One possibility that could account for such large decreases in BAC would be redistribution changes resulting from a rapid consumption of a large amount of alcohol within a short time before the collection of the blood sample, which results in a diffusion drop or “Diffusionssturz” (5), and can occur in alcohol poisoning cases (6). This possibility is not consistent with the case histories in this report. The remaining possibility to be considered is the dilution of the blood samples.

The hemoglobin content was measured in the blood samples from both cases using an Hb Meter (American Optical, Buffalo, NY), and the results are shown in Table I. In the first case, the hemoglobin concentration of the first blood sample was 15.2 g/100 mL, and it was 9.3 g/100 mL in the second. In the second case, the hemoglobin concentration of the first blood sample was 16.0 g/100 mL, and it was 6.8 g/100 mL in the second. Normal hemoglobin concentrations are 14.0 g/100 mL (standard deviation, 2.0) for women and 16.0 g/100 mL (standard deviation, 2.0) for men (7). Thus, in both cases the subsequent blood sample had been diluted. If the BAC is adjusted for this dilution (Table I), the apparent rates of elimination are now within the observed range for humans. In the first case, the apparent rate of elimination is between 0.021 and 0.057 g/100 mL/h. In the second case, the rate of elimination is between 0 and 0.015 g/100 mL/h.

The dilution of blood samples collected for medicolegal alcohol determinations has been the subject of two case reports by Iffland (8). In both cases further investigation and detailed electrolyte analyses were conducted on the blood samples because they appeared watery. It was established in the first case that the blood sample was diluted by tap water by a physician who was a friend of the accused. In the second, it was determined that the blood was diluted during the administration of IV saline solution to the accused in the course of treatment of injuries.

No electrolyte analysis was conducted on the blood samples in the two cases reported here. The details regarding the type of fluid infused and the infusion rate are not known; however, the only common factor in both cases was the IV administration of fluids. Therefore, the most probable cause for the dilution of the blood samples in these cases was the administration of the fluids. In order for the IV fluids to have the substantial effect observed here, the blood samples would have to be collected proximally to the IV site in the arm. If the samples were collected distally or from the other arm, no significant dilution would be expected as the IV fluids would have been redistributed to other tissues of the body (4).

This dilution effect could explain some abnormal blood–serum alcohol ratios reported in blood obtained from patients in a hospital emergency department (9).

### Conclusion

The two reported cases show the possibility of the dilution of the blood sample by IV fluids, resulting in the lowering of the actual BAC. In order to minimize this phenomenon, blood samples should be collected distally from the IV infusion or from the other arm.

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### References


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<table>
<thead>
<tr>
<th>Time of collection of blood sample</th>
<th>BAC (g/100 mL)</th>
<th>Hb (g/100 mL)</th>
<th>BAC Corrected for Hb (g/100 mL)</th>
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<tbody>
<tr>
<td><strong>Case 1 (accident at 7:00 pm)</strong></td>
<td></td>
<td></td>
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<tr>
<td>8:15 p.m.</td>
<td>0.134</td>
<td>15.2</td>
<td>–</td>
</tr>
<tr>
<td>8:50 p.m.</td>
<td>0.066</td>
<td>9.3</td>
<td>0.108</td>
</tr>
<tr>
<td><strong>Case 2 (accident at 5:45 pm)</strong></td>
<td></td>
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<tr>
<td>6:37 p.m.</td>
<td>0.263</td>
<td>16.0</td>
<td>–</td>
</tr>
<tr>
<td>8:28 p.m.</td>
<td>0.111</td>
<td>6.8</td>
<td>0.261</td>
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