CASE REPORT

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Postmortem Blood and Vitreous Humor Ethanol Concentrations in a Victim of a Fatal Motor Vehicle Crash*

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ABSTRACT: A 20-year-old male was found on the passenger side of a small car after a collision with a semi-trailer truck. Postmortem blood, collected from the chest cavity, and vitreous humor samples were collected following harvesting of the heart and bones. Gas chromatographic analysis revealed a blood ethanol concentration of 0.32 g/dL and a vitreous humor ethanol concentration of 0.09 g/dL. The stomach was intact and full of fluid and food, but its contents were not collected. Possible explanations for the large difference between the two results include diffusion of ethanol from the stomach into the chest cavity, contamination of the blood sample prior to collection, and ingestion of a large quantity of ethanol shortly before death. This case demonstrates the importance of proper quality assurance procedures in collecting postmortem specimens and of collecting a vitreous humor sample for ethanol analysis in postmortem toxicology cases.

KEYWORDS: forensic science, ethanol; postmortem; forensic toxicology

A postmortem blood ethanol concentration (BEC) can be affected by several factors, including: quality and location of the sample collection; trauma to the body; length of time between death and autopsy; presence of microorganisms in the body; diffusion of alcoholic beverages present in the stomach into the pericardial fluid; and diffusion of ethanol in aspirated vomitus into cardiac blood (1–5). These factors can cause site-dependent postmortem changes in BEC, making estimations of the BEC at the time of death more difficult. Caplan and Levine (3) reported negative vitreous humor ethanol concentrations (VHEC) in 41 cases that had associated BECs greater than 0.01 g/dL. One case had a BEC of 0.12 g/dL. Caplan and Levine (3) also reported 205 cases in which BECs were at least 0.10 g/dL or more indicated that the average VHEC to BEC ratio was 1.17. Pounder and Kuroda (4) reviewed 349 cases in which VHECs and BECs were measured. They developed a regression equation describing the relationship between observed postmortem VHECs and BECs in the post-absorptive phase: BEC = 3.03 + 0.852 VHEC (95% prediction interval: $\pm$0.019 [$715727 + (VHEC–189.7)^2]^{1/2}$.

Pounder and Kuroda (4) also noted four cases in which death occurred during the absorptive phase, which had VHEC to BEC ratios of 0.94, 0.86, 0.31, and 0.26, respectively. Plueckhahn and Ballard (5) instilled alcoholic beverages (varying from 250 mL of a 10% v/v solution to 500 mL of a 25% v/v solution) into the stomachs of 17 cadavers that had negative blood and pericardial fluid ethanol concentration. Autopsies were performed between six and 50 h later. The ethanol concentration in the pericardial fluid in all samples at autopsy was greater than 0.01 g/dL, including 6 samples where the pericardial fluid ethanol concentration was greater than 0.15 g/dL. In addition, the ethanol concentration in the left pleural fluid was greater than 0.02 g/dL in 11 of these samples.

Case History

A 20-year-old male (height = 172 cm, weight = approx. 72 kg) was found dead on the passenger side of a small car after a collision with a semi-trailer truck. Investigations concluded that the car was struck on its right passenger side by the truck, and the passenger was unrestrained. Police responded to the accident within 30 min. The body was immediately transferred to the coroner's office. The time elapsed between death and autopsy was 17 h and 43 min. The autopsy was performed following harvesting of the heart and bones by the Red Cross Tissue Bank. Only blood spilled into the chest cavity was available for collection.

The autopsy revealed a large basilar skull fracture, avulsion of the upper cervical cord/medulla, laceration and avulsion of the aortic arch, lacerations of the liver and spleen, superficial lacerations of the right kidney, and broken bones, including several broken left and right ribs. The lateral fractures on the right were associated with the piercing of the right pleura. A small amount of blood was present in the pericardium. The stomach was intact and it contained a large amount of liquid and poorly chewed food. The primary cause of death was ruled to be basilar skull fracture with avulsion of upper cervical cord/medulla, and laceration and avulsion of aortic arch with hemothorax.

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Materials and Method

Blood (6 mL) was collected in a 7-mL sterile evacuated blood collection tube containing sodium fluoride (preservative) and potassium oxalate (anticoagulant). Vitreous humor (2 mL) was collected in a 10-mL sterile evacuated blood collection tube containing no additives. The blood sample was sent by U.S. Mail to the Minnesota Forensic Science Laboratory from a county coroner's office with notes stating that this blood sample had been collected from the chest cavity and that blood could not be collected from anywhere else in the body. After the coroner received the results of the blood ethanol analysis the vitreous humor sample was sent by U.S. Mail to the Minnesota Forensic Science Laboratory.

The samples were analyzed in duplicate using headspace gas chromatography technique. A 0.5 mL aliquot of sample was diluted 1:5 with an aqueous internal standard mixture consisting of 30 mg/mL sodium fluoride and 5 mg/mL n-propanol in a 22 mL headspace vial. The vial was then capped with a rubber stopper and crimp-sealed with an aluminum seal. A Perkin-Elmer HS-40XL Automated Headspace Analyzer connected to a Perkin-Elmer Autosystem XL gas chromatograph with flame ionization detector and a Restek Rtx®-BAC-2 column, 30 m $\times$ 0.32 mm $\times$ 1.2 μm, was used to analyze the samples. The temperatures were as follows: sample, 40°C; transfer line, 70°C; injection port, 200°C; column oven, 40°C; detector, 300°C. The times were set as follows: pressurization: 0.5 min; injection: 0.04 min; withdrawal: 0.20 min. The carrier gas was helium with a flow rate of 1–2 mL/min.

Results

The BEC of the chest cavity blood sample was 0.32 g/dL. The Coroner indicated that he felt that this concentration was excessive without further explanation, and forwarded a vitreous humor sample—obtained at autopsy along with the blood sample—for VHEC analysis. The reported VHEC was 0.09 g/dL. The VHEC to BEC ratio was 0.28. After a further discussion with the Coroner the laboratory received copies of the Autopsy Report, the Coroner's Case Report, and the Minnesota State Patrol Traffic Accident Report.

Discussion

If the subject of this case were known to be in the post-absorptive phase, the expected BEC at the time of death, based on the regression equation of Pounder and Kuroda (4), would be 0.08 g/dL with a 95% confidence interval of 0.03 to 0.13 g/dL. The observed BEC of 0.32 g/dL greatly exceeds the predicted range of 0.03 to 0.13 g/dL. The VHEC to BEC ratio of 0.28 is similar to two of the absorptive phase cases noted by Pounder and Kuroda—0.31 and 0.26.

Among the possible explanations for the elevated BEC relative to the VHEC are: (a) the diffusion of ethanol from the intact stomach into the blood in the chest cavity during the interval between death and autopsy; (b) ingestion of a large quantity of ethanol shortly before death; and (c) contamination of the chest cavity blood during harvesting of the heart and bones.

Potential source of ethanol in the chest cavity area also includes microbial production of ethanol following a traumatic injury; however, this microbial contribution appears to be unlikely due to rapid emergency scene response and the short interval between death, harvesting of the heart, and autopsy.

This case demonstrates the importance of proper quality assurance procedures in sampling of postmortem specimens, and of collecting and analyzing simultaneously collected blood and vitreous humor sample in deaths, especially in traumatic deaths. It further notes the need to collect stomach contents or at least to save them for subsequent analysis should it be warranted by later investigation. The BEC by itself in this case would have suggested that the deceased was extremely intoxicated at the time of death. The VHEC, without additional specimens to analyze, while not eliminating that possibility, renders the question of BEC at the time of death a greater challenge to answer definitively.

References

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