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Note

Ethanol levels in postmortem body fluids

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Although blood is the sample of choice for postmortem toxicological analysis, there are many occasions where blood is not available or where enough blood for all the drug testing desired is not available. In some cases the body is too badly decomposed to obtain a blood sample and in others the injuries are so severe that only a small amount of blood is obtained. In these cases (1–3% of the cases in our laboratory), the ethanol analysis must be performed on another body fluid such as urine, bile, vitreous humor, or cerebrospinal fluid. The physician, then, needs to know how the ethanol level found in the fluid analyzed compares to the level the blood contained at the time of death, since cause of death is generally determined based on the blood levels of drugs detected.

Some work has been done in the determination of the correlation between alcohol levels in the blood and other body fluids[1–7]. Urine/blood alcohol ratios have been reported to average between 1.2 to 1.4 (refs. 4–9); vitreous humor/blood ratios have been reported to be 1.1 (refs. 3 and 4); cerebrospinal fluid/blood ratios have been reported to average 1.18 (refs. 1–7); and bile/blood ratios have been reported to average 1.0 to 1.2 (refs. 4 and 6).

Experience has shown variation in these figures, especially in postmortem cases. It was found that urine/blood ratios will be lowered if the specific gravity of the urine is high[2]. It was found that if the bladder urine represents a long period of secretion during which the blood alcohol level changed greatly, that the urine level will not be an accurate reflection of the blood level at the end of the period[10]. Finally, it was found that alcohol is evenly distributed throughout the body fluids in accordance with the law of diffusion provided that the diffusion equilibrium has been attained. However, in postmortem cases equilibrium may not have been reached at the time of death and therefore other body fluid levels may not accurately reflect the blood alcohol levels in accordance with the commonly accepted ratios. If the death occurs rapidly after the victim began drinking, bile/blood ratios will be substancially elevated[7] and cerebrospinal/blood ratios will be lowered[7,8].

This study was done to determine the extent of variation that can be expected in biological fluid/blood alcohol ratios in postmortem cases. The pathologist will gain some indication as to the reliability of calculations of blood alcohol levels from the levels in other biological fluids: urine, bile, cerebrospinal fluid, and vitreous humor.

EXPERIMENTAL

Samples

The body fluids analyzed in this study were from persons who died in Los Angeles County between October 1, 1981 and January 31, 1982. In all cases where the blood was found positive for ethanol, all other body fluids taken at autopsy were also analyzed.

Reagents

The following reagents were used: (1) 10% sodium tungstate, and (2) acid–internal standard solution: 2/3 *N* sulfuric acid containing 2 ml/l of *tert.*-butanol.

Chromatography

The samples were analyzed on a Hewlett-Packard gas chromatograph (Model 5750) containing a 6-ft metal column packed with Porapak Q, operated at 191°C.

Analysis procedure

To a 12-ml centrifuge tube was added 1 ml of the sodium tungstate solution, 1 ml of the body fluid to be analyzed, and 1 ml of the acid–internal standard solution. The tube was tightly capped and the mixture shaken for 10 sec. The tube was then centrifuged at 5149 *g* for 10 min. An aliquot of the supernatant liquid is then injected into the gas chromatograph.

Interpretation of results

Ethanol levels were measured to three decimal places with the third decimal place being dropped. Levels below 0.02% are normally considered negative, but for the purposes of this study were rounded down to the nearest 0.005%. Ratios between the fluid levels for each case studied were rounded to one decimal place.

RESULTS AND DISCUSSION

Approximately 500 Los Angeles County Coroner's cases between October 1, 1981 and January 31, 1982, were found to have positive blood alcohol concentrations ($\geqslant$0.02%). In all these cases the alcohol concentration was determined in other body fluids (bile, urine, vitreous humor, and cerebrospinal fluid) taken at autopsy. The results were tabulated and correlated in an attempt to determine whether good enough correlation generally existed among the body fluid alcohol concentrations for a victim so that the alcohol concentration in one body fluid could be used to predict accurately the concentration of alcohol in the blood. This correlation would be extremely useful in cases where blood cannot be obtained at autopsy since the blood alcohol concentration is important in determinations of cause of death.

The results of this study are shown in the tables: Table I illustrates the body fluid alcohol concentration ratios, the range of one standard deviation for the ratios, and the correlation coefficient for the ethanol concentrations of each pair of body fluids studied. Table II illustrates the fluid ratio and the range of one standard deviation for urine and blood at five urine alcohol concentration ranges.

The body fluid alcohol ratios determined in this study (Table I) are similar to

TABLE I

BODY FLUID ALCOHOL CONCENTRATION RATIOS

Biological fluids	*Cases*	*Average ratio*	*Standard deviation*	*Range of one standard deviation*	*Correlation coefficient*
Urine/blood	109	1.5	±0.7	0.8–2.2	0.90
Bile/blood	100	1.1	±0.3	0.8–1.4	0.94
Vitreous humor/blood	15	1.3	±0.6	0.7–1.9	0.88
Cerebrospinal fluid/blood	5	0.9	±0.4	0.5–1.3	0.55
Urine/bile	69	1.6	±0.8	0.8–2.4	0.90
Urine/vitreous humor	4	1.3	±0.2	1.1–1.5	0.99

TABLE II

URINE/BLOOD RATIOS

Urine alcohol range level (%)		*Cases*	*Average ratio*	*One standard deviation*	*Ratio range of one standard deviation*
Low	0 to 0.09	28	1.41	±1.21	0.20 to 2.62
Medium–low	0.10 to 0.23	32	1.73	±0.62	1.11 to 2.35
Medium	0.24 to 0.33	24	1.39	±0.37	1.02 to 1.76
Medium–high	0.34 to 0.47	18	1.38	±0.28	1.11 to 1.67
High	≥0.48	7	1.13	±0.17	0.96 ± 1.30

those reported in the literature[1–9]. As might be expected, there are strong correlations between the various body fluid levels. As indicated by the standard deviations, though, there was substantial variations of the concentration ratios among the victims. The variations were, of course, the greatest at low alcohol concentrations where a change of ±0.01% can very significantly alter the fluid ratios. This finding is verified in Table II which shows that for urine/blood ratios the standard deviation for low concentrations of urine alcohol was ±1.2 compared to ±0.7 overall (Table I) and ±0.2 for high urine alcohol concentrations.

Several factors contributed to the wide variations found: First, alcohol accumulates and concentrates in the urine after the person stops drinking, especially overnight. Thus in some cases, the urine alcohol level was much higher than expected from the other body fluids due to a long period of alcohol concentrating just prior to death. Second, in some cases death occurred before the alcohol distribution within the body fluids of the drinker had reached equilibrium. The various fluids respond at different rates to the introduction of alcohol into the body. For example, the cerebrospinal fluid/blood ratio has been found to be less than 1 if the blood concentration is increasing and greater than 1 if the blood concentration is decreasing since the cerebrospinal fluid alcohol level responds slowly to blood concentration changes[8]. Also, if death occurs rapidly after a victim began drinking, the bile level will exceed the levels found in other fluids and the urine level which normally is higher than all the other fluid levels may be lower than most of the other fluid levels[7].

Although the strong correlation coefficients suggest that one fluid alcohol level might be used with a high degree of reliability to calculate another fluid level, the standard deviations indicate that the accuracy will be somewhat lower than might be desired. The results shown in Table I indicate that the bile level is much more reliable than urine levels for the determination of blood levels since the bile standard deviation is much lower. This finding is not unexpected since the bile does not concentrate the alcohol as the urine does and the bile will more quickly reflect alcohol entering the blood stream.

The urine/blood ratios have been divided into 5 ranges based on the urine alcohol level (Table II). Use of these results allows more accurate determination of blood levels from urine levels. As can be seen from Table II as well as from a plot of blood and urine alcohol levels, the blood–alcohol relationship is not strictly linear, but is a curve. The higher the blood alcohol level, the lower the urine/blood ratio.

Thus the alcohol levels in various other biological fluids can be used with a fair degree of accuracy to determine a blood alcohol level range which can in turn be used by the pathologist while making cause of death determination.

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