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CASE REPORT

An unusual case of homicide by chronic methanol poisoning

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Abstract An unusual case of homicide by chronic methanol poisoning is presented. A 37-year-old man with a month-long illness of intermittent nausea, vomiting, and shortness of breath presented in the emergency department with severe gastrointestinal pain, diaphoresis, tachycardia, metabolic acidosis, and tachypnea with labored breathing. Stat toxicology testing disclosed a serum methanol level of 750 mg/l. Despite appropriate medical treatment the patient developed multi-organ failure and died. The investigation revealed that bottles of a sport drink ingested regularly by the victim and prepared by a family member were the source of the methanol. The family member was convicted of murder. The use of methanol as an agent for murder is extremely rare.

Keywords Methanol · Murder · Poisoning · Stat toxicology testing

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Introduction

Methanol (methyl alcohol, wood alcohol) is produced from the destructive distillation of wood. It is widely used as a solvent in paints and paint removers, varnishes, duplicating fluids, windshield wiper solutions, gas-line de-icers, and ethanol denaturants. Suicidal or accidental ingestion of methanol is common [1]. Occasional epidemics of methanol poisoning have occurred due to the consumption of illicit alcoholic beverages contaminated with methanol. However, the use of methanol as an agent of murder is extremely rare. Avela et al. [2] reported a homicide in which a woman suffering severe traumatic injury had methanol fuel additive poured over her body. Percutaneous absorption was sufficient to cause toxic concentrations of methanol that contributed to her death. Similarly, Saxena et al. [3] also reported a case of attempted murder that involved multiple traumatic injuries and methanol poisoning. However, methanol has rarely been used as an agent of homicidal poisoning.

We present an unusual case of homicide by chronic methanol poisoning.

Case history

Prior to his poisoning, the victim was a physically active 37-year-old man in good health who exercised regularly and played sports. Approximately 1 month prior to his death, he complained of intermittent gastric distress, nausea, and episodes of shortness of breath. When his symptoms first developed, his physician considered heart disease; however, the victim underwent a stress echocardiogram that yielded normal findings. After a family gathering, the victim awoke the next morning feeling

unwell. Despite burning in his throat, nausea, and shortness of breath, he went to work, but his symptoms worsened during the day and he returned home. His gastric distress worsened, vomiting ten times, and his breathing became labored. At this point paramedics were called and he was transported to hospital.

On admission, the victim complained of severe gastrointestinal pain and tenderness, was diaphoretic, tachycardic, mentally confused, and tachypneic with labored breathing. Initial chemistries revealed severe metabolic acidosis (Table 1). His calculated ion gap was 28 and the osmolality gap was 28. A stat serum toxicology screen was ordered with particular reference to agents associated with metabolic acidosis and elevated osmolality gap, such as ethylene glycol and methanol. The results showed a serum methanol concentration of 750 mg/l and serum salicylate concentration of 2.8 mg/dl. Acetaminophen, tricyclic antidepressants, ethylene glycol, and other alcohols were not detected.

Despite hemoperfusion and ethanol antidote administration, the patient developed multi-organ failure and died 2 days after admission. As the victim had no known occupational or recreational exposure to methanol, the police were called and asked to investigate the death.

Toxicology testing

Serum volatiles procedure

Methanol was determined in serum by a modified whole blood headspace gas chromatography method [4]. Briefly, 100-µl aliqots of patient serum and control specimens containing 400 and 800 mg/l methanol (UTAK Labs, Valencia, CA, USA) were pipetted into separate clean headspace vials. Then 0.9 ml of *t*-butanol (internal standard) was added to each vial. Each vial was then capped and sealed by crimping. The samples were then placed in a headspace autosampler (Genesis 705 headspace autoSampler, Varian, Walnut Creek, CA, USA) fitted with a Hydroguard MXT® 2 m × 0.53 mm ID sample loop and phenylmethyl silicone deactivated 0.53 mm ID transfer line guard column (Restek, Bellefonte, PA, USA) connected to a Star 3400CX gas chromatograph with flame ionization detection (Varian). Methanol and other volatiles were separated in a Rtx®-BAC2 30 m × 0.53 mm ID × 2.0 µm blood alcohol column (Restek). Temperature settings were: oven, isothermal at 40°C; detector, 235°C. Gas flow rates were: helium carrier gas, 9.5 ml/min; detector gases, helium makeup gas 20 ml/min, hydrogen 30 ml/min, and air 300 ml/min.

Under these conditions the retention times of low molecular weight volatile compounds were: methanol, 1.32 min; ethanol, 1.71 min; acetone, 1.83 min; 2-propanol, 2.00 min; and *t*-butanol (internal standard), 2.21 min. Methanol was quantified with serum calibrators of 0, 390, 790, and 1580 mg/l methanol. The limit of detection (LOD) and limit of quantitation (LOQ) of methanol were 100 mg/l and the upper limit of linearity was 3500 mg/l.

Table 1 Admission serum chemistries of victim

Serum analyte	Value	Reference range
Glucose (mg/l)	181[a]	136–145
pCO_2 (mmol/l)	7[a]	21–32
Blood urea nitrogen (mg/dl)	18	7–18
Na^+ (mEq/l)	142	136–145
K^+ (mEq/l)	5.1	3.6–5.2
Cl^- (mEq/l)	107	98–108
HCO_3^- (mEq/l)	2.3[a]	22–26
Arterial pH	7.07[a]	7.35–7.45
Creatinine (mg/l)	1.8[a]	0.8–1.3
T prothrombin (g/dl)	9.7[a]	6.4–8.2
Ca^{2+} (mg/dl)	9.8	8.8–10.5
Albumin (g/dl)	5.3[a]	3.4–5.0
Alanine aminotransferase (U/l)	88[a]	30–65

[a] Abnormal

Serum ethylene glycol procedure

Serum was tested for ethylene glycol by gas chromatography as previously described [5].

Serum immunoassay testing

Fluorescence polarization immunoassays were used to test serum for acetaminophen [6], tricyclic antidepressants [7], and salicylates [8].

Investigation

Investigation revealed that the victim had no occupational or recreational exposure to methanol. Whiskey bottles obtained from the victim's home tested negative for methanol. However, it was soon learned that to augment his regular exercising, the victim had a history of using creatine as a nutritional supplement. The victim's wife prepared his regular supplement by mixing a large tablespoonful of powdered creatine into 20-fluid-ounce bottles of a popular sports drink. The victim had ingested a bottle of this prepared drink the evening before his hospitalization. Police recovered a bottle of prepared creatine–sports drink mixture from the victim's home refrigerator, two bottles from a refrigerator at the victim's workplace, and a

fourth bottle (one third full) on his desk at work. These items were found to contain 3.3, 3.6, 3.6, and 4.7% of pure methanol. These data are consistent with a 1/10 dilution of a windshield wiper solution (32.8% methanol) with the sports drink. The recent medical history of the victim and toxicology findings were consistent with a chronic exposure to methanol. At the conclusion of the investigation, the Medical Examiner determined the cause of death to be methanol poisoning and the manner of death was ruled homicide. The decedent's wife was arrested and charged with murder. This was the wife's second marriage. Apparent ongoing domestic discord over money and problems associated with her son from the prior marriage were considered possible motives for the poisoning. In anticipation of the trial, several bottles of the sports drink were purchased by the laboratory and analyzed both with and without added creatine. No methanol was detected in the sports drink nor was creatine converted to methanol. At the behest of the defense council, an independent laboratory duplicated these tests and observed the same results.

Discussion

The serum salicylate concentration of 2.8 mg/dl is consistent with the therapeutic administration of one to three 300-mg tablets of aspirin 6–10 h prior to death [9]. While salicylate poisoning may produce metabolic acidosis after an initial respiratory alkalosis, even mild acidosis is associated with serum concentrations of several hundred milligrams per deciliter [10]. Given the methanol findings, it was felt that salicylate contributed little to the severe metabolic acidosis in this case.

Methanol is biotransformed by alcohol dehydrogenase to formaldehyde, which is then rapidly metabolized by aldehyde dehydrogenase and, to a lesser extent, various catalases and peroxidases to formic acid. The pathophysiology of methanol poisoning is associated with the accumulation of this formic acid metabolite. Formic acid inhibits cytochrome oxidase and causes a decrease in the intercellular NAD/NADH ratio with resultant accumulation of lactic acid. The resultant metabolic acidosis leads to central nervous system (CNS) ethanol-like intoxication with ataxia, impaired balance, mental confusion, and respiratory depression. Additional symptoms may include Parkinson-like syndrome or spasticity, tremor and hypokinesis, tachycardia, and shock progressing to multi-organ failure. In instances of massive ingestion, renal tubular degeneration may develop. The accumulation of formic acid causes edema in the optic nerve with symptoms of blurred vision, constricted field of vision, "snowfield vision," and photophobia progressing to blindness [8]. Treatment of methanol poisoning involves correction of acidosis with administration of sodium bicarbonate, infusion of ethanol to block metabolism of methanol to formic acid, and rapid removal from the body by hemodialysis [11].

The victim in this case exhibited classic signs and symptoms of methanol poisoning. Gastrointestinal distress with nausea and vomiting are initial symptoms of methanol ingestion. Metabolic acidosis, tachycardia, disruptions in respiration, and mental depression then develop. The onset of symptoms may occur within 20 min of ingestion or be delayed for as long as 48 h. In this case, it appears the victim was suffering episodic intoxication with gastrointestinal distress, nausea, and shortness of breath for approximately 1 month. Apparently, he ingested significant amounts of methanol in the day or days preceding his hospital admission. Severe metabolic acidosis with a large osmolality gap and CNS symptoms alerted the emergency department physicians to a possible methanol poisoning. Serum HCO_3^- of less than 10 mEq/l is indicative of a poor prognosis. On admission, the victim had a serum HCO_3^- of only 2.3 mEq/l (Table 1). The estimated minimal lethal dose of methanol ranges from 30 to 75 ml for an adult. Therefore, ingestion over a day or two of one to several bottles of the creatine–sports drink mixture with 30 ml of methanol in each would account for the fatal poisoning in this case.

The differential diagnosis of severe metabolic acidosis with an elevated osmolality gap includes methanol or ethylene glycol poisoning, uncontrolled diabetes mellitus, alcoholic ketoacidosis, or chronic renal failure. Fortunately, stat gas chromatographic testing was available in this case for volatiles and ethylene glycol. This allowed the rapid diagnosis of methanol poisoning and timely initial inquiries by police. Considering that the victim was treated with several rounds of dialysis and died 2 days after admission, postmortem toxicology testing would have been of limited value. However, the clinical test results obtained with the well-documented chromatographic procedure for the identification and quantification of methanol provided readily acceptable evidence for the criminal proceedings. Methanol blood concentrations are considered toxic at 200 mg/l and potentially lethal without treatment at 400 mg/l. In the presented case, the victim's blood methanol concentration of 750 mg/l was almost twice the potential lethal value.

Conclusion

The recent medical history of the victim and toxicology findings were consistent with a chronic exposure to methanol with increasing incremental doses or an increased final dose resulting in a fatal accumulation of the toxic

metabolite formic acid. His continued physiological deterioration prior to and during his hospitalization, despite appropriate medical treatment, is consistent with the delayed severe toxicity of methanol. The victim's wife was convicted on the charge of first-degree murder.

References

1. Bronstein AC, Spyker DA, Cantilena LR, Green JL, Rumack BH, Griffin SL (29010) 2009 Annual report of the American Association of Poison Control Centers National Poison Data System (NPDS): 27th Annual. Clin Toxicol 48:979–1178
2. Avela J, Briglia E, Harleman G, Lehrer M (2005) Percutaneous absorption and distribution of methanol in a homicide. J Anal Toxicol 29:734–737
3. Saxena K, Lerud K, Cicero JJ (1987) Methanol intoxication in multiple trauma. Am J Emerg Med 5:60–63
4. O'Neal CL, Wolf C, Levine B, Kunsman G, Poklis A (1996) Gas chromatographic procedures for determination of ethanol in postmortem blood using t-butanol and methyl ethyl ketone as internal standards. Forensic Sci Int 83:31–38
5. Edinboro LE, Nanco CR, Soghoian DM, Poklis A (1993) Determination of ethylene glycol in serum utilizing direct injection on a wide bore capillary column. Ther Drug Monit 15:220–223
6. Edinboro LE, Jackson GF, Jortani SA, Poklis A (1991) Determination of serum acetaminophen in emergency toxicology: evaluation of new methods: Abbott TDx and second derivative ultraviolet spectrophotometry. Clinical Toxicol 29:241–255
7. Poklis A, Soghoian D, Crooks CR, Saady JJ (1990) Evaluation of the Abbott ADx total serum tricyclic immunoassay. Clin Toxicol 28:235–248
8. Karnes HT, Beightol LA (1985) Evaluation of fluorescence polarization immunoassay for quantitation of serum salicylates. Ther Drug Monit 7:351–354
9. Hollister GE, Kanter SL (1965) Studies of delayed-action medication. IV. Salicylates. Clin Pharmacol Ther 6:5–13
10. Temple AR (1981) Acute and chronic effects of aspirin toxicity and their treatment. Arch Intern Med 141:364–369
11. Barceloux DG, Bond GR, Krenzelok EP, Cooper H, Vale JA (2002) American Academy of Clinical Toxicology practice guidelines on the treatment of methanol poisoning. Clin Toxicol 40:415–446