Distribution of Ether in Two Postmortem Cases

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Abstract

Diethyl ether (ether) is a volatile liquid that was used in the 1800s as an anesthetic agent; however, it is no longer used for this purpose, partly because of its odor and flammability. Two postmortem cases in which ether was detected are presented. The first case was an 18-year-old male found hanging from a basement ceiling brace in a semi-sitting position with a gas mask covering his face. A container of Prestone starting fluid and a bong were found on the floor close to the body. The second case was a 20-year-old male found unresponsive in his dormitory room with two black plastic trash bags secured over his head. Two saturated rags and a resealable bag containing a clear liquid were contained within these trash bags. An almost empty can of Tradco starting fluid was also found at the scene. Ether concentrations were determined by headspace gas chromatography-mass spectrometry in the selective ion monitoring mode. In case #1, the medical examiner ruled that the cause of death was asphyxia due to hanging; the manner of death was undetermined. In case #2, the medical examiner ruled that the cause of death was asphyxia and the manner of death was suicide.

Introduction

Diethyl ether (ether) is a volatile liquid that was used in the 1800s as an anesthetic. It had a number of advantages when used in this capacity (1). It was readily available in pure chemical form. It was also easy to administer and a small amount can produce anesthesia. It is not toxic to vital organs and does not affect respiration or circulation when used in therapeutic amounts (2). However, because ether has a high solubility in body fluids and tissue, it produced a slow induction of and a longer recovery time from anesthesia (1). This fact, along with its odor and high flammability, especially in combination with oxygen, caused the cessation of its use as an anesthetic. Today, it is found as a component of starting fluids for heavy machinery (1).

Blood ether concentrations are generally correlated with central nervous system depression. Blood concentrations between 100 and 500 mg/L produce analgesia, but not unconsciousness. Surgical anesthesia occurs at blood concentrations in the 500–1500 mg/L range (3). Over 90% of a dose of ether is eliminated from the body via the lungs as unchanged chemical, but a small amount of ether appears in the urine, sweat, and milk (4). There are also reports that ether is metabolized to acetaldehyde and carbon dioxide (5).

Although ether has been around for a long time, there are limited reports of quantitative results in the literature. The following are two cases investigated by the Office of the Chief Medical Examiner where ether was identified in the postmortem specimens.

Case Histories

Case #1

An 18-year-old male (6'0", 234 lbs) was found hanging from a basement ceiling brace in a semi-sitting position with a gas mask covering his face. A container of Prestone starting fluid (40–70% diethyl ether, Prestone Products Corp.) and a bong were found on the floor close to the body. There were no pornographic materials found at the scene, and the decedent was fully clothed. In addition, there was no evidence of physical trauma. His roommate last saw the decedent alive approximately 10½ h before he was found. Prior history indicated that the decedent used marijuana, but he did not have enough money to purchase the drug recently. At autopsy, a ½-in. thick rope was found around the decedent's neck. A 15½-in. circumferential ligature abrasion was on the anterior neck, extending upwards behind the ear lobes. Examination of the body revealed bilateral distinct petechiae on the conjunctiva and pulmonary congestion with slight to moderate amounts of bloody fluid. Other autopsy findings were unremarkable.

Case #2

A 20-year-old male (5'7", 138 lbs) was found unresponsive in his dormitory room. There were two black plastic trash bags secured over his head with a rubber band. Two saturated rags and
a clear resealable bag containing a clear liquid were contained within these trash bags. An almost empty can of Tradco starting fluid was also found at the scene. The decedent's roommate last saw him alive approximately 8 h prior to finding him unresponsive. The decedent kept a journal that documented his lack of optimism for the future and his desire to kill himself. In addition, the decedent's journal mentioned alcohol, amphetamine, and cocaine use. At autopsy, a strong chemical odor was noted. Examination of the body indicated dense pulmonary congestion with slight to moderate amounts of bloody fluid. There were no other remarkable autopsy findings.

Experimental

Materials

Ether (specific gravity 0.7079 g/mL) and 2-butanone (MEK) were purchased from Sigma Aldrich (St. Louis, MO).

Method

To 500 μL blank blood or urine calibrator, control, or fluid or 500 mg tissue (as a homogenate) in a 22-mL headspace vial was added 2.5 mL of internal standard solution (2 mg/dL MEK in deionized water). Calibrators were prepared at concentrations of 10, 25, 50, 100, 250, 500, and 1000 mg/L by adding ether to blank blood or urine. Blood and urine control concentrations were 100 and 1000 mg/L. The headspace vials were immediately capped and sealed. All calibrator, control, and sample preparations was performed in a 4°C refrigerator to preserve ether concentrations.

Instrumentation

Each vial was sampled with an Agilent 7694 headspace sampler. The oven, sample loop, and transfer line temperatures were set at 70, 80, and 95°C, respectively. The vial equilibrated for 15 min in the oven. The 1-mL sample loop was filled for 0.15 min and then equilibrated for 0.10 min. One milliliter of headspace was injected into the gas chromatograph (GC).

An Agilent 6890 GC equipped with an Agilent 5973N mass selective detector (MS) was used for ether analysis. An RTX-1 capillary column (60 m × 0.32-mm i.d., 3.00-μm film thickness) provided analytical separation. A 2-mm frosted glass injector insert was used without glass wool. The injector was operated in the split mode (20:1) with a split flow of 30 mL/min at a temperature of 200°C. The oven ran isothermally at 100°C for 12 min. Helium was the carrier gas with a constant flow of 1.5 mL/min. The transfer line and source temperatures were 280 and 230°C, respectively. The instrument was tuned using a low mass tune in order to measure 69, 121, and 139 amu. A solvent delay was set for 1 min. The MS acquisition was run in SIM mode measuring 31, 45, and 59 mass ions for ether and 43 and 72 mass ions for the internal standard. The area ratios of 31 mass ion to 43 mass ion were used for quantitation.

Results

The heart blood specimen from each case was tested for volatile substances, therapeutic and abused drugs. This included volatile testing for methanol, ethanol, acetone, and isopropanol by headspace GC; acid/neutral drug testing by GC-nitrogen-phosphorus detection (NPD); alkaline drug testing by GC-NPD; morphine by radioimmunoassay; and acetaminophen, ethchlorvynol, and salicylate by color test. Drugs were not detected in the two cases. Cannabinoid testing was not performed in either case. The heart blood ethanol concentration in case #1 was 300 mg/L; the subclavian blood ethanol concentration was 200 mg/L; and the vitreous humor ethanol concentration was 300 mg/L. No ethanol was detected in the heart blood from case #2 at a limit of quantitation of 100 mg/L. In both cases a peak close to acetone was observed on the heart blood volatile chromatogram. This peak was subsequently identified by full scan electron ionization GC-MS as diethyl ether.

A seven-point calibration curve (10-1000 mg/L) for ether in spiked blood was used for the heart blood, peripheral blood, kidney, and liver specimens with an R² value of 0.994. A seven-point calibration curve (10-1000 mg/L) for ether in spiked urine was used for the urine and bile specimens and had an R² value of 0.996. Limits of quantitation and detection for ether were 10 mg/L. The GC-MS chromatogram for case #2 is shown in Figure 1.

The concentrations of ether in the biological specimens for cases #1 and #2 are listed in Table I.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Ether (mg/L) Case #1</th>
<th>Ether (mg/L) Case #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart blood</td>
<td>26</td>
<td>319</td>
</tr>
<tr>
<td>Peripheral blood</td>
<td>24</td>
<td>304</td>
</tr>
<tr>
<td>Liver</td>
<td>24</td>
<td>442</td>
</tr>
<tr>
<td>Kidney</td>
<td>38</td>
<td>490</td>
</tr>
<tr>
<td>Bile</td>
<td>29</td>
<td>204</td>
</tr>
<tr>
<td>Urine</td>
<td>not available</td>
<td>123</td>
</tr>
</tbody>
</table>

Figure 1. GC-MS chromatogram for peripheral blood from case #2.
In case #1, the medical examiner ruled that the cause of death was asphyxia due to hanging; the manner of death was undetermined, as the investigation failed to clarify whether it was accidental or suicidal. In case #2, the medical examiner ruled that the cause of death was asphyxia and the manner of death was suicide.

Discussion

Volatile substances are a common source of death or non-fatal toxic reactions. They are quite common in children between the ages of 12 and 17 because they are easily obtainable (6). A common method for testing of volatile compounds is GC-flame-ionization detection (7,8), but headspace GC-MS is becoming more popular (9,10). Ether was originally used as an anesthetic agent in the 1800s, but its odor and high flammability cause it to be rarely used today. Exposure of ether at therapeutic concentrations cause nose and throat irritation, but exposure to higher concentrations can produce CNS depression with nausea, irregular respiration, and lowering of body temperature and pulse rate (1).

There have been several reports in the scientific literature related to the identification and quantitation of ether in fatalities. Campbell (11) reported five anesthetic-related deaths in which ether was detected. In five cases, both blood and liver ether concentrations were provided. The blood concentrations ranged from 190 to 3750 mg/L; the liver concentrations ranged from 260 to 1280 mg/kg. Four of these cases had liver-to-blood concentration ratios between 0.34 and 1.2. The fifth case had a ratio of 0.09. Ward and Meyerhein (12) published a report of three homicide cases where ether was used to incapacitate the victim. Ether was measured in the blood in two of these cases; the blood concentrations were 90 and 1700 mg/L.

In case #1 of the presented cases, the heart blood ether concentration was 26 mg/L, a concentration where loss of consciousness is not expected (3). However, in this case, the ether was an incidental finding in a hanging death. In case #2, the heart blood concentration, approached a concentration associated with anesthesia, but the death was attributed to a lack of oxygen caused by having a secured trash bag over the victim’s head. In two other published cases with a similar mechanism of death, the blood ether concentrations were 200 and 320 mg/L, respectively, and the liver concentrations were 460 and 100 mg/kg, respectively (13).

The distribution of ether in our reported cases is similar to the distribution in previously reported cases. The liver to heart blood concentration ratios in the presented cases are 1.4. Previously reported liver-to-blood ratios ranged from 0.09 to 2.3.

Acknowledgment

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References