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Casuistic

Analysis of inflammable substances to determine whether death has occurred before or after burning*

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Summary. In two murder cases involving burning, both victims had been set on fire in the open air after being drenched with kerosene. In the first case, carbon monoxide hemoglobin (COHb) saturation was found to be 2.1% in the left heart blood and 0.8% in the right heart blood, a ratio of 2.6 for left to right heart blood. Paraffin hydrocarbons were also detected in the left heart blood. It was determined that the victim had been set on fire before death and that burning had been the cause of death. In the second case, the COHb saturation was 0.21% in the left heart blood and 0.24% in the right heart blood, giving a left-to-right ratio of 0.9. Paraffin hydrocarbons were detected in the hair sample, but not in the left heart blood. It was determined that the victim had been set on fire after death, and the cause of death was suspected to be asphyxia due to compression of the neck.

Key words: Burning, before or after death – Carbon monoxide hemoglobin, gas chromatography – Inflammable substances, gas chromatography-mass spectrometry

Zusammenfassung: Bei zwei Mordfällen wurden die Opfer im Freien verbrannt, nachdem sie mit Benzin übergossen worden waren. Im ersten Fall wurde eine CO-Hämoglobin-Konzentration von 2,1% im Blut des linken und von 0,8% im Blut des rechten Herzens nachgewiesen, woraus sich ein Verhältnis von 2,6 errechnet. Paraffinartige Kohlenwasserstoffe wurden im Blut aus dem linken Herzen nachgewiesen. Es wurde daraus geschlossen, daß das Opfer vor Eintritt des Todes Feuer ausgesetzt war und daß Verbrennung als Todesursache anzusehen ist. Im zweiten Fall lag die CO-Hämoglobin-Konzentration im linken Herzblut bei 0,21% und im rechten Herzblut

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bei 0,24%, woraus sich ein Verhältnis von 0,9 (links zu rechts) errechnete. Paraffinartige Kohlenwasserstoffe wurden in Haarproben, jedoch nicht im linken Herzblut bestimmt. In diesem Fall wurde das Opfer offensichtlich nach Eintritt des Todes infolge von Ersticken verbrannt.

Schlüsselwörter: Verbrennen vor oder nach Todeseintritt – CO-Hämoglobin, Gaschromatographie

Introduction

In cases of death with extensive burns on the skin, it is extremely important to determine whether burning has occurred before or after death. Usually, the presence of erythema and/or vesiculation is used to determine whether death has occurred before or after burning, but these signs can both be produced after death [1–3]. Therefore, the presence of soot must be looked for in the airway and carbon monoxide hemoglobin (COHb) saturation in blood samples must be examined. However, when the victims have been drenched with inflammable substances and set on fire before death and in the open air, soot in the trachea and bronchi is often not detectable by the naked eye, and COHb saturation in the blood is also sometimes at a level normal for tobacco smokers [1, 4]. If the victim inhales small amounts of CO and inflammable substances before respiration stops the COHb saturation in the left heart blood may be higher than in the right heart blood and inflammable substances may be detected in the left heart blood [5]. In the study reported in this paper, COHb saturations in the left and right heart blood samples were analyzed by gas chromatography and the presence of inflammable substances was examined by gas chromatography-mass spectrometry to confirm whether the burning had occurred before or after death.

Case histories and autopsy findings

Case 1. A 79-year-old man was found dead in his garden on 9 January 1988. There were streams of blood from open wounds on his face and much of his clothing was burned away.

The victim's son, a 46-year-old schizophrenic, was arrested. The son reported that he had quarreled with his father. Losing control, he had struck him on the head and other parts of the body with a stick and a shovel and his father had fallen down unconscious. He had then drenched him with kerosene and set him on fire. The remaining kerosene was not found. The victim was a smoker.

The autopsy was performed about 7 h after the victim was found. The body was 153 cm in length and weighed 37 kg. When the clothes were removed, a clear vesiculation with surrounding erythema was seen on the lower part of the left leg. Erythema, vesiculations, necroses of the skin and subcutis, and charring were also found on most of the surface of the body except for the face and head. There were two small incision wounds on the face and several subcutaneous hemorrhages on the face and head without underlying fracture. A small subarachnoid hemorrhage was found on the surface of the brain, but there were no injuries to the brain. Some subcutaneous hemorrhages with fractures of several ribs and several subcutaneous hemorrhages on the extremities without underlying fracture were observed. No soot was detectable by the naked eye in the trachea and bronchi. There were no heart anomalies with left-to-right shunt, fatal diseases or injuries other than those caused by burning.

Case 2. At around 17.30 on 10 January 1988, a 14-year-old girl, a junior high school pupil, was found buried on a beach below the high tide line. The body was covered with a white sheet,

which was partially burned away. There was evidence of burning on the upper left side of the body.

A cousin of the victim, a 22-year-old man, was arrested. According to his statement, at about 22.00 on 7 January, he had tried to persuade her to have sexual intercourse with him but had been rejected. He had then strangled her until she lost consciousness and attempted to rape her, but was unable to although he had inserted fingers into her vagina. As she recovered consciousness, he strangled her to death. He took off her clothes, wrapped her in a white sheet, and took her to the beach in his car. At approximately 02.30 on 8 January, he drenched the body with kerosene and set it on fire. At about 04.00, he buried the victim on the beach. The time that had elapsed between death and burning was estimated to be about 4 h. When the body was discovered, it must have been immersed five times in seawater at high tide according to tide tables. The remaining kerosene was not found. The victim was a non-smoker.

The autopsy was carried out about 3.5 days after death. The body was 160 cm in length and weighed 42.5 kg. Reddening was found around the necroses of the skin and subcutis and around the charring on the chest and abdomen. Excoriations suspected to be torn vesiculations were also found on the right breast. The skin of the neck was burned away and the tissues of the neck degenerated by heat. Fractures of the hyoid bone and the thyroid cartilage were not found. A small subcutaneous hemorrhage was observed on the right lower extremity. There were two small tears and a small abrasion on the surface of the hymen, all with hemorrhage. No soot was detectable by the naked eye in the trachea and bronchi. There were many petechial hemorrhages in the conjunctivae of the eyelids and the eyeballs, in the pleurae of the lungs and in the pericardium. The blood in the heart cavities and the major vessels was liquid and congestion was found in the liver and both kidneys. No heart anomalies with left-to-right shunt or fatal injuries or diseases were detected.

Laboratory findings

Alcohol analysis

Ethanol concentrations, analyzed by GC [6], were less than 0.1 mg/g in the blood and urine of case 1 and in the blood and stomach contents of case 2.

COHb analysis

Samples of the right and the left heart blood in both cases were analyzed by GC [7]. In case 1, COHb saturations in the left heart blood and in the right heart blood were 2.1% and 0.81% respectively. COHb saturations in the left heart blood and in the right heart blood were 0.21% and 0.24% respectively in case 2. In case 1, the ratio of COHb saturation in the left heart blood to that of the left heart blood was 2.6, while in case 2 the ratio was 0.9.

Analysis of inflammable substances

Blood samples from the left heart were analyzed in both cases and also a hair sample in case 2.

Of each blood sample, 2 g was poured into a test tube to which 2 ml of *n*-pentane was added. After mixing with a vortex mixer, the mixture was centrifuged at 3000 rpm for 5 min. The *n*-pentane layer was concentrated to about 0.3 ml under reduced pressure at less than 50°C after dehydration with anhydrous sodium sulfate. Then 2 µl of the concentrated solution was analyzed by electron impact (EI)-mass chromatography.

The hair sample (about 0.3 g) was placed in a test tube and 1 ml ethyl ether was added. After mixing well, the ethyl ether layer was dehydrated with anhy-

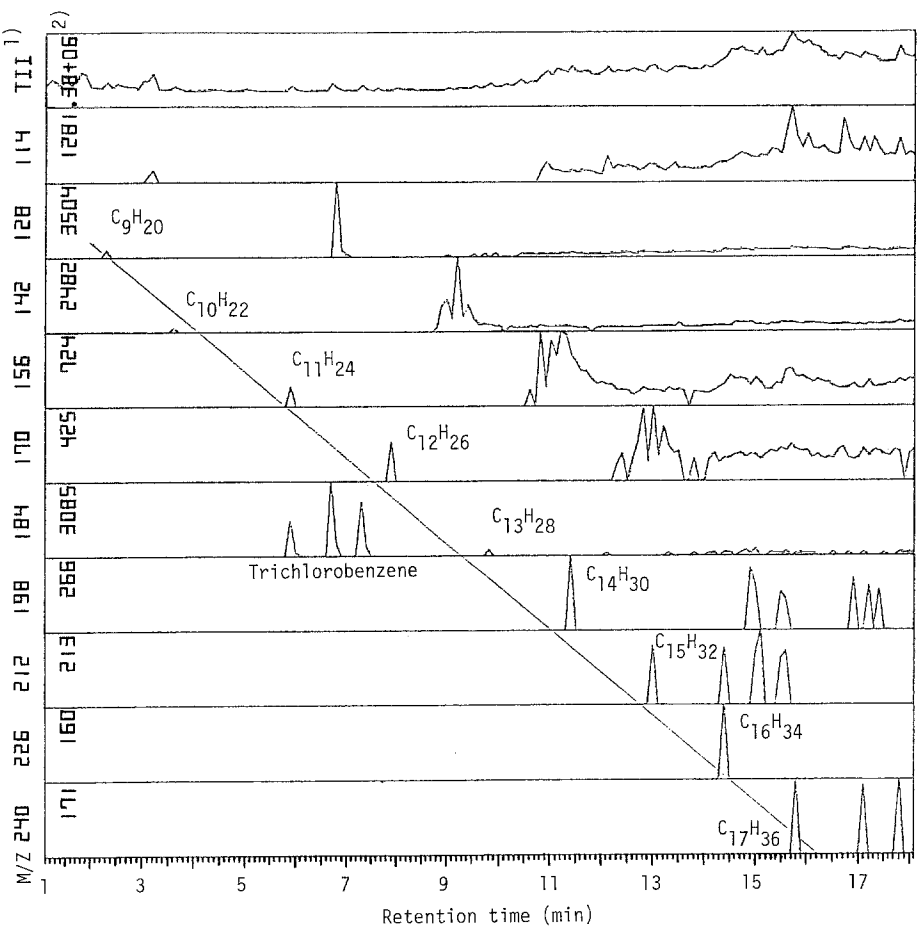

Fig. 1. EI-mass chromatogram obtained from the left heart blood in case 1. *1)* Chromatogram of total ion intensity; *2)* intensity of the largest peak in the chromatogram

drous sodium sulfate and concentrated to about 0.3 ml under reduced pressure at room temperature, and 2 µl of the concentrated solution were analyzed by EI-mass chromatography.

The instrument used was a Shimadzu Auto GC/MS-6020 equipped with a 12 m × 0.53 mm (i.d.) wide-bore column (Shimadzu HiCap-CBP 1, membrane thickness 1.0 µm). The temperature of the column was maintained at about 36°C for 3 min, then 50°C for 2 min, after which it was set to rise by 8°C/min for 9–13 min. The temperatures of the injection port, the separator and the ion source were set at 250°C, 270°C and 300°C, respectively. The accelerating voltage and the electron energy for EI-mass spectrometry were set at 3.5 kV and 70 eV respectively. Helium was used as a carrier gas with a flow rate of 5 ml/min. For mass chromatography, the slide valve was opened 1 min after injection of the sample and the scanning interval was set at 10/min (6 s).

When the samples were screened by EI-mass chromatography for paraffin hydrocarbons from C_8 (M/Z 114) to C_{17} (M/Z 240), paraffin hydrocarbons were

detected in the left heart blood of case 1, as shown around the oblique line in the mass chromatogram in Fig. 1, and in the hair of case 2, but not in the left heart blood of case 2. The paraffin hydrocarbons detected were confirmed by EI-mass spectra. Trichlorobenzene was detected in both left heart blood samples but was found to originate from the *n*-pentane used for extraction.

Discussion

Carbon monoxide hemoglobin

COHb saturation in blood collected from a body with extensive burns should be determined by gas chromatography [1]. Many GC methods for COHb have been developed. Iffland et al. [8] have recently developed a sensitive method according to which the CO content is measured by GC and the iron content by atomic absorption spectrometry. In the present cases, COHb values were determined using the amount of CO analyzed by GC and the total hemoglobin measured by a cyanmethemoglobin method.

In case 1 the COHb saturations were found to be at a level normal for nonsmokers living in cities with minimal exposure to CO [4, 9]. The COHb saturation in the left heart blood, however, was 2.6 times that in the right heart blood. The absence of soot in the airway and the difference between COHb saturation in the left heart blood and that in the right heart blood indicate that the victim died immediately after inhaling a small amount of CO, although post-mortem movement of blood has been reported [10–12].

In case 2, COHb saturations in the left heart blood and in the right heart blood are almost equal and within the normal range [4]. These results suggest that the victim did not inhale CO immediately before death.

Inflammable substances

GC/MS is usually used for analysis of kerosene in biological materials, because kerosene is a mixture of many hydrocarbons and the concentrations of the components tend to be very low [5, 13–15]. In the present cases, paraffin hydrocarbons in the kerosene were screened by mass chromatography and confirmed by mass spectra.

In case 1, paraffin hydrocarbons were detected in the left heart blood although no soot was found in the airway, indicating that the victim had inhaled kerosene vapor immediately before death.

In case 2, paraffin hydrocarbons were detected in the hair but not in the left heart blood, which suggests that the victim was drenched with kerosene but did not inhale kerosene vapor.

Cause of death

In cases 1 and 2, blood alcohol concentrations of less than 0.1 mg/g indicate that the victims were not under the influence of alcohol at the time of death [2, 16, 17].

In case 1, the absence of soot in the airway, the difference between COHb saturation in the left heart blood and the right heart blood and the detection of

paraffin hydrocarbons in the left heart blood indicate that the victim died immediately after inhaling a small amount of CO. Erythema, vesiculations, necroses of the skin and subcutis, and deep burns and charring were observed on most of the surface of the body. There were no fatal diseases or injuries other those caused by burning. From the autopsy and toxicological findings it was determined that burning had been the cause of death.

In case 2, reddening and excoriations suspected of being due to vesiculations were found on the surface of the body. However, the absence of soot in the airway, the difference between COHb saturations in the left heart blood and the right heart blood, and the absence of paraffin hydrocarbons in the left heart blood suggested that the victim had died before burning. The reddening and the excoriations were not histologically examined, but it was concluded that they were produced after death by the effects of heat.

There were many petechial hemorrhages in the conjunctivae of the eyelids and the eyeballs, in the pleurae of the lungs and in the pericardium. The blood in the heart cavities and the major vessels was liquid, and congestions were found in the abdominal organs. The skin of the neck was burned away and the tissues of the neck degenerated by heat. Though there were no fractures of the hyoid bone or the thyroid cartilage, the autopsy findings suggest acute death by asphyxia due to compression of the neck.

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