Rom J Leg Med [28] 403-405 [2020]
DOI: 10.4323/rjlm.2020.403

IDENTIFICATION OF A FLAMMABLE SUBSTANCE IN A FIRE-RELATED DEATH

Hiroshi Kinoshita[1,*], Naoko Tanaka[1], Mostofa Jamal[1], Ken Nagata[1], Mitsuru Kumihashi[1], Kunihiko Tsutsui[2], Shoji Kimura[1]

Kagawa University, Faculty of Medicine, [1]Department of Forensic Medicine, [2]Health Sciences, School of Nursing, Kagawa, Japan

Abstract: The identification of flammable substances provides useful information in fire-related deaths. Hydrocarbons can be detected in blood, intratracheal gas and other body samples, including stomach contents, due to the unintentional swallowing and/or ingesting of vapour or liquid. The present results demonstrate the usefulness of sampling and analysing stomach contents.

Keywords: kerosene, GC-MS, hydrocarbons, stomach contents.

INTRODUCTION

The identification of flammable substances is important in fire-related deaths [1-3]. The present study describes the investigation of a death caused by burning, the detection of kerosene in blood, intratracheal gas, and stomach contents, and the usefulness of sampling and analysing stomach contents.

CASE HISTORY

The severely burned body of a male in his forties (height, 164 cm; weight, 50.5 kg) was found on a riverbed in Japan with a plastic container containing kerosene close by.

Autopsy findings indicated no evidence of external injury other than broad third- to fourth-degree skin burns with carbonization [4]. The heart weighed 309 g and contained 150 mL of dark-red blood without coagulation. The left and right lungs weighed 449 g and 539 g, respectively, and were congested. A small amount of soot was present in the trachea and bronchus. Marked congestion was observed in each organ. Approximately 20 mL of brownish fluid with an oily smell was in the stomach. A drug screening test using an IVex-screen® panel (Biodesign Inc., Tokyo, Japan), ethanol determination by routine headspace-gas chromatography (HS-GC), and routine toxicological examination using liquid chromatography tandem mass spectrometry were performed [5]. Carboxyhemoglobin saturation was measured using an AVOX 4000 oximeter (International Technidyne Corporation, Piscataway Township, NJ) [6]. Post-mortem samples were collected for toxicological examination, including femoral blood, stomach contents and intratracheal gas samples. Intratracheal gas was collected by direct puncture of the tracheal wall using a syringe with a needle, then the trachea was exposed by a frontal neck incision at autopsy. The collected intratracheal gas was immediately injected in a 20 mL glass vial sealed with a silicon-rubber septum and aluminium cap.

Equipment and sample preparation for volatile hydrocarbon analysis

Volatile hydrocarbons were analysed in accordance with previous reports [7] using a gas chromatography mass spectrometer (GC-MS) model QP-2010 Plus (Shimadzu, Kyoto, Japan) fitted with a DB-5MS column (30 m × 0.25 mm I.D., 0.25 µm film thickness; Agilent Technologies, Santa Clara, CA). Helium was used as the carrier gas (1.78 mL/min) and the operating conditions were as described previously [7]. Each separated compound was identified based on retention time and confirmation ion [7].

*Correspondence to: Hiroshi Kinoshita, Kagawa University, Department of Forensic Medicine, Faculty of Medicine, 1750-1 Ikenobe, Miki, Kita, Kagawa 761-0793, Japan, E-mail: kinochin@med.kagawa-u.ac.jp

Headspace-solid phase microextraction (HS-SPME) was conducted according to a previous report [7,8]. In brief, 0.5 mL of left heart blood or stomach contents mixed with 0.5 mL of distilled water was placed in a 20 mL glass vial and sealed with a silicone-rubber septum and aluminium cap. The SPME fibre assembly (polydimethylsiloxane, 100 μm thick; Sigma-Aldrich Japan, Tokyo, Japan) was inserted into the HS of the glass vial through the septum. The vial was heated at 60ºC for 15 min in a heating block and the fibre was exposed to the HS of the intratracheal gas sample at room temperature for 15 min.

RESULTS AND DISCUSSION

Figure 1 shows the total ion chromatograms for the intratracheal gas, left heart blood and stomach content samples from the deceased. Each peak in the intratracheal gas sample was identified as a saturated aliphatic hydrocarbon, including n-nonane (C9), n-decane (C10) and n-undecane (C11), and C10, C11, n-dodecane (C12) and n-tridecane (C13) were identified in the blood sample. These results indicate that the deceased had been exposed to kerosene or light oil prior to death [1-3]. Aliphatic hydrocarbons, such as C9, - C13, n-tetradecane (C14), n-pentadecane (C15), n-hexadecane (C16) and n-heptadecane (C17) were detected in the stomach contents. The height of each peak due to C15 to C17 decreased gradually, suggesting the presence of kerosene [9]. The presence of hydrocarbons in the stomach contents could be due to involuntary swallowing of kerosene [7], identified by the chromatographic pattern.

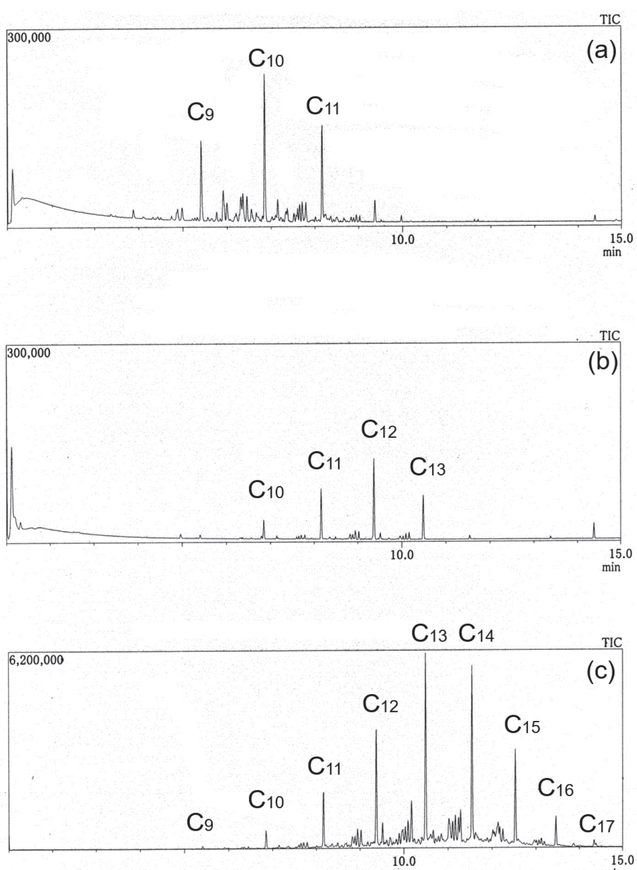

Figure 1. Total ion chromatograms of intratracheal gas (a), left heart blood (b) and stomach contents (c). N-nonane (C9), n-decane (C10) and n-undecane (C11) were detected in the intratracheal gas sample. C10, - C11, n-dodecane (C12) and n-tridecane (C13) were identified in the left heart blood sample. C9, - C13, n-tetradecane (C14), n-pentadecane (C15), n-hexadecane (C16) and n-heptadecane (C17) were detected in the stomach contents sample.

The IVex-screen® panel yielded negative results and no ethanol or other substances were detected. Carboxyhemoglobin saturation was 7.5% in the left heart blood sample, 6.7% in the right heart blood sample and 7.4% in the femoral venous blood sample. The autopsy, police investigation and toxicological examination findings all indicate that death was caused by burns caused by the use of kerosene.

Flammable substances such as gasoline, kerosene and light oil are discriminated chromatographically based on the pattern of saturated aliphatic hydrocarbons: gasoline contains n-pentane, n-hexane and n-heptane, whereas kerosene contains C9 to C13 aliphatic hydrocarbons [1, 3]. The intratracheal gas or intratracheal contents were screened by HS extraction [10,11]. Components of flammable substances are often detected in stomach contents [7,12-14] due to unintentional swallowing and/or ingestion of flammable vapours or liquids [7,15]. Kerosene and light oil can be distinguished by their chromatographic pattern [9].

The analysis of hydrocarbons helps identify flammable substances in instances of death by burning and the stomach contents of victims should be analysed when the involvement of a flammable substance is suspected.

Conflict of interest

The authors declare that they have no conflict of interest.

References

1. Morinaga M, Kashimura S, Hara K, Hieda Y, Kageura M. The utility of volatile hydrocarbon analysis in cases of carbon monoxide poisoning. Int J Legal Med. 1996; 109: 75-79.
2. Yonemitsu K, Sasao A, Oshima T, Mimasaka S, Ohtsu Y, Nishitani Y. Quantitative evaluation of volatile hydrocarbons in post-mortem

blood in forensic autopsy cases of fire-related deaths. Forensic Sci Int. 2012; 217: 71-75.
3. Waters B, Hara K, Ikematsu N, Takayama M, Kashiwagi M, Matsusue A, Kubo S-i. Volatile hydrocarbon analysis in blood by headspace solid-phase microextraction: the interpretation of VHC patterns in fire-related incidents. J Anal Toxicol. 2017; 41: 300-306.
4. Madea B. Injuries due to heat. In: Madea B. editor. Handbook of Forensic Medicine. West Sussex: John Wiley & sons, Ltd. 2014: 451-467.
5. Kinoshita H, Tanaka N, Takakura A, Kumihashi M, Jamal M, Ito A, Tsutsui K, Kimura S, Matsubara S, Ameno K. Flunitrazepam in stomach contents may be a good indicator of its massive ingestion. Rom J Leg Med. 2017; 25: 193-195.
6. Tanaka N, Ameno K, Jamal M, Ohkubo E, Kumihashi M, Kinoshita H. Application of oximeter AVOX 4000 for the determination of CO-Hb in the forensic practice. Res Pract Forens Med. 2010; 53: 39-43.
7. Tanaka N, Takakura A, Jamal M, Kumihashi M, Ito A, Tsutsui K, Kimura S, Ameno K, Kinoshita H. Detection of kerosene in stomach contents – useful indicator of vital reaction. Rom J Leg Med. 2016; 24: 128-130.
8. Takayasu T, Kondo T. Components of gasoline and kerosene. In: Suzuki O, Watanabe K. editors. Drug and poisons in humans. A handbook of practical analysis. Berlin Heidelberg: Springer-Verlag. 2005: 159-169.
9. Nakahara A, Kawagoe K, Nakamuta K. Analysis of mineral oils burnt in a fire by solvent extraction and thermal-desorption GC/MS. Bunseki Kagaku. 2005; 54: 837-847.
10. Takayasu T, Ohshima T, Kondo T, Sato Y. Intratracheal gas analysis for volatile substances by gas chromatography/mass spectrometry- application to forensic autopsies. J Forensic Sci 2001; 46: 98-104.
11. Adachi N, Kinoshita H, Nishiguchi M, Takahashi M, Ouchi H, Minami T, Matsui K, Yamamura T, Motomura H, Ohtsu N, Yoshida S, Ameno K, Hishida S. Analysis of tracheal contents using headspace gas chromatography-mass spectrometry to screen for accelerant use. Soud Lek. 2009; 54: 2-3.
12. Shiono H, Matsubara K, Akane A, Fukushima S, Takahashi S. Immolation after drinking kerosene. Am J Forensic Med Pathol. 1989; 10: 229-231.
13. Yoshida M, Watabiki T, Tokiyasu T, Akane A, Ishida N. Case of death by fire with kerosene -Analysis of contents of trachea and stomach-. Nihon Hoigaku Zasshi. 1994; 48: 96-104.
14. Yoshida M, Akane A, Okii Y, Yoshimura S, Kobayashi T, Tokiyasu T, Watabiki T. A case report of detection of ethylene, propylene and kerosene from the burned body. Res Pract Forens Med. 1997; 40: 177-182.
15. Ganong WF. Regulation of gastrointestinal function. In: Review of medical physiology, (22nd Ed.). New York, Chicago: The McGraw-Hill Companies Inc. 2003: 479-513.