Legal Medicine 19 (2016) 83–87

Contents lists available at ScienceDirect

Legal Medicine

journal homepage: www.elsevier.com/locate/legalmed

Case report

Postmortem diffusion of *n*-butane and *i*-butane used for anticontagious plugging spray

Katsuhiro Okuda [a,*], Chikatoshi Maseda [a], Masaru Asari [a], Shotaro Isozaki [a], Hiroshi Kiya [b], Daisuke Yajima [a,c], Hiroshi Shiono [a], Keiko Shimizu [a]

[a] Department of Legal Medicine, Asahikawa Medical University, 2-1-1-1 Midorigaoka-Higashi, Asahikawa 078-8510, Japan
[b] Investigation Division, Hokkaido Asahikawa Area Police Headquarters, 10 Chome 6 Jodori, Asahikawa 070-8521, Japan
[c] Department of Legal Medicine, Graduate School of Medicine, Chiba University, 1-8-1 Inohana, Chuo-ku, Chiba 260-8670, Japan

ARTICLE INFO

Article history:
Received 5 June 2015
Received in revised form 20 August 2015
Accepted 21 August 2015
Available online 21 August 2015

Keywords:
Butane
Blood concentration
Postmortem distribution
Postmortem treatment
Autopsy

ABSTRACT

Blood and tissue samples from a forensic autopsy of a man in his late 60s, who developed dementia and died of multiple head traumas due to a fall from a moving vehicle, contained certain amounts of *n*-butane and *i*-butane. The concentration of *n*-butane was in the range of 0.48–70.5 μL/g, which would be considered as toxic or lethal levels. We had to distinguish whether the cause of his unexplained behavior was due to his pre-existing condition (dementia), or from a confused state induced by butane abuse. No traces of butane use were found at the scene. Police investigation revealed that a propellant used in an anticontagious plugging spray had been administered to him during a postmortem treatment in the emergency hospital. In order to prove the postmortem butane diffusion had resulted from the spray administration and to estimate the diffused concentration, experimental simulation was conducted by using rats. As a result of postmortem treatment with the spray, *n*-butane at concentrations of 0.54–15.5 μL/mL or g were found in the rat blood and tissues. In this case, we provided further evidence that the postmortem butane diffusion, caused by using the anticontagious plugging spray containing butane gas as a propellant administered to a cadaver during a postmortem procedure prior to forensic autopsy, should be distinguished from cases of actual butane poisoning.

1. Introduction

Butanes refers to the two isomers of butane, *n*-butane and *i*-butane, which are highly flammable, colorless gases having an unpleasant smell, and which are easily liquefied. These petroleum gases are commonly utilized as lighter fluid, canned fuel, aerosol propellant and so forth. In recent years, unintended butane poisoning has become a major concern due to its general diversity of uses and its easy accessibility. In addition, some people, mainly in the young generation, inhale these vaporized butanes from a plastic bag to get 'high' as an alternative to paint-thinner or the other organic solvents which are controlled by laws, such as the Poisonous and Deleterious Substances Control Act, in Japan. Inhalation of butanes causes fatal arrhythmia, respiratory depression, asphyxia, and vagal collapse possibly followed by sudden death. There are several reports of sudden death from intentional butane inhalation, and the phenomenon is called as Sudden Sniffing Death Syndrome (SSDS) [1–9]. Even if it does not result in death, users are likely to suffer from damage to neural systems and other harmful conditions in which compete recover is less likely [10–12].

The purpose of this study is to verify the conclusion of an autopsy where lethal concentrations of butanes was detected in the blood and other body tissues, in spite of no traces of butane use before a fatal traffic accident. According to the police investigation, the body was suspected to have been contaminated with butanes from an anticontagious plugging spray used in postmortem treatment at the emergency hospital prior to forensic autopsy. Classically, the method of plugging cottons has been used to prevent body fluids leaking from the mouth, ears, nose and anus. However, it is becoming common to use superabsorbent polymers as substitute for cotton in postmortem treatments in many hospitals. There are two kinds of plugs with superabsorbent polymers in Japan: one is the applicator-type and the other is the spray-type. In the applicator-type plugging kit, the polymer slurry is prefilled in two different plastic syringes which are used for the pharynges and anus, respectively. In the spray-type plugging kit, the polymer is filled in a spray-can fitted with a plastic nozzle-tube to facilitate propellant delivery at and into various locations. The spray-type

* Corresponding author.
E-mail address: k-okuda@asahikawa-med.ac.jp (K. Okuda).

http://dx.doi.org/10.1016/j.legalmed.2015.08.003
1344-6223/

plugging kit was used in this case, and we investigated if the detected butanes were contaminants derived from spray propellant. In order to confirm postmortem diffusion from butanes administered to the cadaver after death, we performed an *in vivo* experiment using rats by simulating the conditions of the postmortem treatment in the hospital before autopsy, and compared the tissue distribution and concentration of butanes between the autopsy case and the experimental simulation.

2. Case history

A Japanese man in his late 60s, 164 cm in height and 46.5 kg in weight, suddenly jumped from the backseat of a running vehicle moving at a speed of 60 km/hr, driven by his brother. He died on arrival by ambulance at a hospital. The deceased was known to have developed severe dementia two years earlier.

A forensic autopsy was performed two days after the time of death reported in the emergency hospital. The autopsy revealed multiple head injuries, such as abrasions and bruises of head skin, subcutaneous bleeding, hemorrhages on bilateral temporal muscles, calvarial bone fracture and transverse basilar fracture, subarachnoid hemorrhage, and cerebral contusion. There were slight abrasions and bruises on the face and four limbs. In addition, traces of superabsorbent polymer were found extending from the pharynges to the esophagus/trachea, and through the external acoustic meatus, as well as at the basal brain (Fig. 1). There was no evidence of lethal disease.

3. Materials and methods

3.1. Chemicals and animals

Standard gasses, such as 9.08% *n*-butane, 5.97% *i*-butane, and 99.5% propane, were purchased from GL Sciences (Tokyo, Japan). Other chemicals used were of the highest quality commercially available.

Male Wistar/ST rats (8 weeks of age) were purchased from Japan SLC, Inc. (Shizuoka, Japan). All animal studies were approved by the Animal Laboratory for Medical Research, Center for Advanced Research and Education, Asahikawa Medical University, and the animals were handled according to the institutional guidelines and regulations.

3.2. Sample preparation

A fluid sample (0.5 mL) and 0.5 g of thin sliced frozen tissue respectively from a cadaver and rats were placed in separate 20-mL GC vials before adding 0.5 mL of 0.05% acetonitrile to each vial as an internal standard. The vials were tightly sealed and subjected to GC analysis. Standard curves were plotted for the authentic gasses, 9.08% *n*-butane and 5.97% *i*-butane in duplicate. The gasses were injected by an electric microsyringe into a tight-sealed vial to which control blood and internal standard samples were previously added. The injection volumes were set as 0, 40, 60, 80, 100 μL to make the final contents 0, 7.26, 10.90, 14.53, 18.16 μL/mL for *n*-butane, 0, 4.78, 7.16, 9.55, 11.94 μL/mL for *i*-butane, respectively.

3.3. GC/FID and GC/MS conditions for butanes determination

Analyses of butanes were also performed by headspace GC under the following conditions: *GC System*, column: SUPEL-Q PLOT 30 m × 0.32 mm i.d., SPELCO; carrier: He, 1 mL/min; oven: 60 °C to 150 °C at 10 °C/min then hold 1 min; injection: volatiles interface, 150 °C, split 5: 1; detector temperature: 250 °C; *headspace sampler*, loop size: 1 mL; oven temperature: 55 °C, loop temperature: 70 °C; transfer line temperature: 80 °C; vial pressure: 10.2; equilibration time: 15 min.

Identification of butanes was performed using GC/MS (Shimadzu GC/MS-QP2010 Ultra) under the following conditions: *GC System*, column: DB-5MS 30 m × 0.25 mm i.d., J&W; carrier: He, 0.47 mL/min; oven: 40 °C (6 min); injection: volatiles interface, 150 °C, split 15: 1; detector temperature: 200 °C.

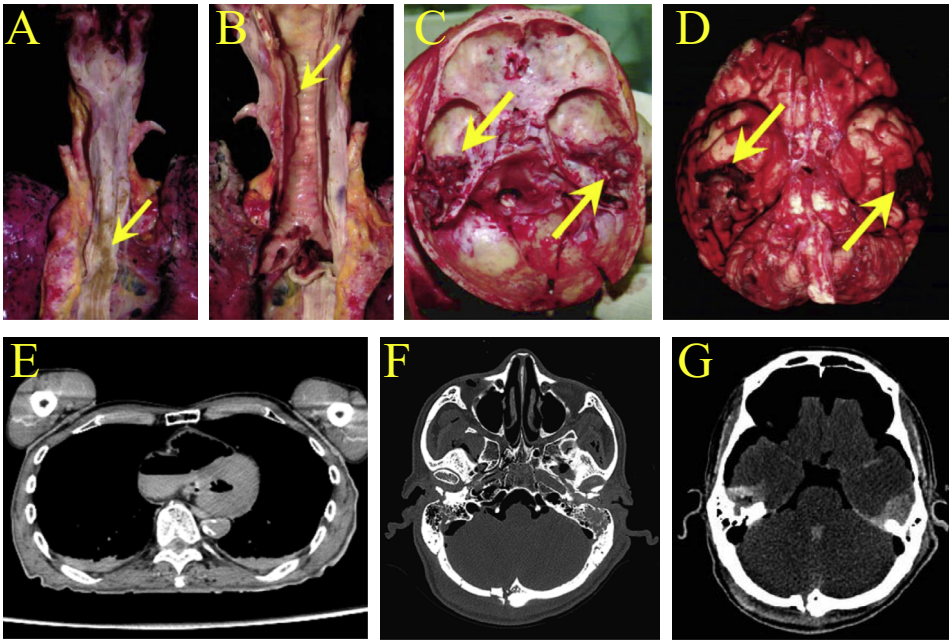

Fig. 1. Autopsy photos and computed tomography (CT) images of the autopsy case. Superabsorbent polymer retained in the esophagus (A), trachea (B), base of skull (C) and bottom of the temporal lobes (D). CT images in the chest level (E; WW250, WL40) and basal skull level (F; WW1300, WL330), and bottom of the temporal lobe level (G; WW140, WL90).