JOURNAL OF FORENSIC SCIENCES

J Forensic Sci, May 2012, Vol. 57, No. 3
doi: 10.1111/j.1556-4029.2011.02003.x
Available online at: onlinelibrary.wiley.com

CASE REPORT

TOXICOLOGY; PATHOLOGY/BIOLOGY

Riccardo Rossi,[1] *M.D.; Fabio Suadoni,*[2] *M.D.; Ludovica Pieroni,*[2] *M.D.; Fabio De-Giorgio,*[1] *M.D., Ph.D.; and Massimo Lancia,*[2] *M.D.*

Two Cases of Acute Propane/Butane Poisoning in Prison

ABSTRACT: Hydrocarbon inhalation is seldom chosen as a means to commit suicide. This practice is exclusively a prerogative of the prison population; it is, however, only exceptionally found in this environment. The two cases of lethal inhalation of propane/butane gas observed by us over a very short time occurred in this context. Toxicologic analyses were performed by means of gas chromatography (head space) and revealed a propane/butane mixture in all specimens (heart blood, bile, and urine) except vitreous humor. Although fatal arrhythmia posthydrocarbon gas abuse is well known, the concentrations of the two hydrocarbons were sufficient to induce death by asphyxiation and were distributed (fairly) homogeneously in all biological fluids and organs examined, a parameter permitting one to assume that death occurred within a relatively short period of time. The absence of finding in vitreous humor and the trace amount in urine suggests that both men died very quickly.

KEYWORDS: forensic science, propane, butane, suicide, prison, hydrocarbons

Recent studies (1–4) carried out mainly in the United States show that the practice of inhaling such substances as petrol, hydrocarbons (propane, butane, etc.), glue, shoe polish, industrial solvents, and products with similar characteristics has increased greatly in the last few years. This is particularly the case among adolescents, in whom the proportion of inhalers varies from 9 to 20%.

American researchers have revealed some correlation between the abuse of these substances and a higher tendency of these adolescents to behave antisocially (5) and/or attempt suicide (6) relative to their peers who do not take such substances.

In the case of adults, the use is frequently found in a prison environment, where drug addicts who are unable to obtain their habitually abused substances resort to this alternative practice (7–10).

Numerous cases of sudden deaths caused by intentional propane and/or butane inhalation (11–13) have been described in the (existing) literature. Regular users in trying to prolong the effects of these substances increase the number and length of inhalations, which is frequently responsible for the cardiac arrests known as "sudden death caused by inhalation syndrome."

Case No. 1

The 25-year-old prisoner was found unconscious by the toilet of his own cell, laying face down on the floor with his arms bent around a bucket and his head wrapped in a plastic bag inside it. When the detainee reached the nurse, he was unconscious and had no carotid pulse, no spontaneous respiratory activity, and fixed mydriasis that did not react to light. During cardiorespiratory maneuvers, a gas odor came from the patient's mouth. Upon inspection, a small camping stove with a gas cylinder often used by prisoners to cook in their cells was found inside the bucket.

Case No. 2

The 50-year-old prisoner was found inside his cell, lying on the bed, completely covered with a sheet and with his head enclosed in a large cellophane bag tied around his neck. Two little burners together with their respective cylinders marked "butane/propane mixture" and an envelope sealed with nylon were found on his abdomen. The detainee was moved outside his cell, and attempts made to resuscitate him were in vain. The envelope contained three letters in which the prisoner listed the reasons for this action and described the methods used to carry out his detailed plan.

In both cases, autopsy revealed polivisceral congestion, fluid brownish blood, and pulmonary and cerebral edema; these findings were confirmed by histological examinations and indicated death by asphyxiation.

Materials and Method

To carry out qualitative and quantitative research on propane, butane, and other toxic gases, a 1-mL sample of each biological fluid (blood, urine, bile, vitreous humor, and gastric contents) and a gram of each organ and tissue (encephalon, lungs, kidneys, and liver) were taken.

These samples were placed separately in hermetically sealed vials with a Teflon lid and metal ring and were incubated in a water bath at 60°C for *c.* 30 min. A milliliter of a propane/butane mixture contained in a 230-g cylinder obtained from Camping Gaz Italy S.r.l.

[1]Institute of Legal Medicine, Catholic University of the Sacred Heart, Largo F. Vito, 1, 00168 Rome, Italy.
[2]Institute of Legal and Sports Medicine, University of Perugia, 06123 Perugia, Italy.

Received 3 Nov. 2010; and in revised form 11 Jan. 2011; accepted 9 Feb. 2011.

(Brescia, Italy) was simultaneously removed by a syringe (model 1002 LTN) supplied by Hamilton Company (Bonaduz, GR, Switzerland), by inserting the needle thereof in a protection valve and obtaining a standard solution of propane and butane with a known concentration (80/20). The gas was then placed inside a 10-mL glass vial used for head space.

Finally, a gas chromatographic technique (head space) analysis was carried out using an automatic sampling system connected to a Fractovap 2300 model Carlo Erba gas chromatograph (Milan, Italy), equipped with a column filled with 5% Carbopak (Amsterdam, Netherlands) on 2 m of 20 M Carbowax in the following operating conditions: column temperature 70°C isotherm; injector temperature 150°C; detector temperature 150°C; and carrier gas 11.5 mL/min nitrogen.

Results and Discussion

An analysis carried out on the samples showed the following concentrations (parts per million) of a propane/butane mixture:

Case No. 1: blood 3.9; urine traces; bile 2.88; undetectable vitreous humor; gastric content 0.68; encephalon 0.88; lungs 1.05; kidneys 0.45; and liver 1.36.

Case No. 2: blood 1.17; urine traces; bile 0.76; undetectable vitreous humor; gastric content 1.08; encephalon 1; lungs 0.45; kidneys 0.87; and liver 0.93.

In both cases, the gas chromatographic scan was unable to resolve the peaks between butane and propane.

The inhalation of organic solvents constitutes a rather widespread phenomenon among adolescents. In fact, a recent study showed that these were the main substances of abuse used by young Americans, second only to marijuana.

For the youngest adolescents, using this group of substances is simplified by the absence of a strict ratio of individual/substance addiction, the frequency with which it is found in adult drug addicts, and a desire to widen their toxicomanic experiences.

Furthermore, the inhalants are readily available, have low costs, and, above all, are not subject to any legal restrictions, which allow youngsters to obtain them easily and free of the fear of punishment usually connected to the possession of common substances of abuse.

The inhalation of organic solvents is not, however, exclusively the toxicomanic behavior of adolescents, as their use among adults is also increasing, although the patterns of the two age groups differ considerably.

The latest studies of Wu and Ringwalt (6) have shown how adults tend to approach these substances at a mature age for the first time and how, relative to adolescents, they experiment with a much more limited variety, using them sporadically, and the use is less correlated with antisocial behavior (7).

In countries where prison cells are equipped with combustible gas cylinders (e.g., Italy and other European countries, Australia, New Zealand), the abuse of volatile substances is particularly widespread among adults. Indeed, drug addicts are unable to obtain their habitually abused substances and thanks to the availability of the gas and to the relative toxicity of propane and butane, which constitute the most common components (9), they resort to this alternative practice.

Propane and butane are aliphatic hydrocarbons derived from the process of refining petrol. They are nonhalogenated, odorless, and colorless, acting mainly as "asphyxiating gases." Their action is carried out at the central nervous system and myocardium levels. They are absorbed by inhalation and are bio-distributed with similar patterns to various tissues and with an elective tropism for the encephalon, spleen, liver, and kidneys. Finally, they are eliminated unmodified in exhaled air after their systematic absorption.

Their psychotropic effect depends on the quantity of substance inhaled, its concentration, and the length of the inhalation (14).

Owing to their desire to increase its effects, those who abuse propane/butane often develop a tendency to prolong the inhalation and to increase the concentration of the substance, consuming it directly from the supplying source or by using a plastic bag in which the gas is inhaled and consequently increasing the exponential risk of death by acute asphyxiation.

Our first case falls into this context.

The investigation carried out revealed that the detainee usually inhaled the contents of the camping stove gas cylinders with which he cooked.

In this specific instance, he had placed the stove inside a bucket, and to strengthen the psychotropic effects of the substance, he had inhaled the mixture directly from the bucket with his head wrapped in a plastic bag.

The prolonged inhalation of the gas together with the exclusion of oxygen resulted in death by asphyxiation.

The second case is a suicide and not an accidental death. In the last 10 years, the number of suicides in the general prison population has risen constantly (1,15–17).

An analysis of data regarding suicides in a prison environment (15,18–22) indicates that the method of choice is hanging, while the inhalation of volatile gases is extremely rare, consistent with our findings.

In both cases, the hypothesis of death by asphyxiation was confirmed by pathological and toxicological reports, which indicated the presence of a propane/butane mixture qualitatively analogous to the contents of the cylinders in all biological samples examined (23).

Although fatal arrhythmia posthydrocarbon gas abuse is well known, the concentrations of the two hydrocarbons were sufficient to induce death by asphyxiation and were distributed (fairly) homogeneously in all biological fluids and organs examined, a parameter permitting one to assume that death occurred within a relatively short period of time.

The absence of finding in vitreous humor and the trace amount in urine suggests that both men died very quickly.

The homogeneity of the concentration indicates that the gas was disseminated, this occurs rapidly by diffusion and also indicates the absence of an accumulation or an elimination of the gas, both of which occur over a longer period.

In both of the cases presented, the inhalation of the mixture of two gases in a confined space, here a plastic bag, certainly contributed to the increased concentration of gas inhaled, strengthening the asphyxiating effects and accelerating the onset of death.

References

1. Freedenthal S, Vaughn MG, Jenson JM, Howard MO. Inhalant use and suicidality among incarcerated youth. Drug Alcohol Depend 2007;90:81–8.
2. Beasley M, Frampton L, Fountain J. Inhalant abuse in New Zealand. N Z Med J 2006;119:U1952.
3. Spiller HA. Epidemiology of volatile substance abuse (VSA) cases reported to US poison centers. Am J Drug Alcohol Abuse 2004;30:155–65.
4. Howard MO, Balster RL, Cottler LB, Wu LT, Vaughn MG. Inhalant use among incarcerated adolescents in the United States: prevalence, characteristics, and correlates of use. Drug Alcohol Depend 2008;93:197–209.

5. Howard MO, Jenson JM. Inhalant use among antisocial youth: prevalence and correlates. Addict Behav 1999;24:59–74.
6. Wu LT, Ringwalt CL. Inhalant use and disorders among adults in the United States. Drug Alcohol Depend 2006;85:1–11.
7. Perron BE, Vaughn MG, Howard MO. Reasons for using inhalants: evidence for discrete classes in a sample of incarcerated adolescents. J Subst Abuse Treat 2008;34:450–5.
8. Pelissier B, Jones N. Differences in motivation, coping style, and self-efficacy among incarcerated male and female drug users. J Subst Abuse Treat 2006;30:113–20.
9. Bacci M, Chiarotti M, Giusti V. Su di un caso letale di inalazione voluttuaria di propano/butano in ambiente carcerario. Riv Ital Med Leg 1984;8:1127–31.
10. Boys A, Farrell M, Bebbington P, Brugha T, Coid J, Jenkins R, et al. Drug use and initiation in prison: results from a national prison survey in England and Wales. Addiction 2002;97:1551–60.
11. Fuke C, Miyazaki T, Arao T, Morinaga Y, Takaesu H, Takeda T, et al. A fatal case considered to be due to cardiac arrhythmia associated with butane inhalation. Leg Med 2002;4:134–8.
12. Doogue M, Barclay M. Death due to butane abuse—the clinical pharmacology of inhalants. N Z Med J 2005;118:U1732.
13. Pfeiffer H, Al Khaddam M, Brinkmann B, Köhler H, Beike J. Sudden death after isobutane sniffing: a report of two forensic cases. Int J Legal Med 2006;120:168–73.
14. Walker R, Flanagan RJ, Lennard MS, Mills GA, Walker V. Solid-phase microextraction: investigation of the metabolism of substances that may be abused by inhalation. J Chromatogr Sci 2006;44:387–93.
15. Shaw J, Turnbull P. Suicide in custody. Psychiatry 2006;5:286–8.
16. Fruehwald S, Frottier P, Matschnig T, Eher R. The relevance of suicidal behaviour in jail and prison suicides. Eur Psychiatry 2003;18:161–5.
17. Tatarelli R, Mancinelli I, Taggi F, Polidori G. Prison suicides in Italy in 1996-1997. Eur Psychiatry 1999;14:109–10.
18. Preti A, Cascio MT. Prison suicides and self-harming behaviours in Italy, 1990-2002. Med Sci Law 2006;46:127–34.
19. Grant JR, Southall PE, Fowler DR, Mealey J, Thomas EJ, Kinlock TW. Death in custody: a historical analysis. J Forensic Sci 2007;52:1177–81.
20. O'Driscoll C, Samuels A, Zacka M. Suicide in New South Wales Prisons, 1995-2005: towards a better understanding. Aust N Z J Psychiatry 2007;41:519–24.
21. Kariminia A, Butler TG, Corben SP, Levy MH, Grant L, Kaldor JM, et al. Extreme cause-specific mortality in a cohort of adult prisoners—1988 to 2002: a data-linkage study. Int J Epidemiol 2007;36:310–6.
22. Fruehwald S, Matschnig T, Koenig F, Bauer P, Frottier P. Suicide in custody: case-control study. Br J Psychiatry 2004;185:494–8.
23. Bouche MP, Lambert WE, Van Bocxlaer JF, Piette MH, De Leenheer AP. Quantitative determination of n-propane, iso-butane, and n-butane by headspace GC-MS in intoxications by inhalation of lighter fluid. J Anal Toxicol 2002;26:35–42.

Additional information and reprint requests:
Riccardo Rossi, M.D.
Institute of Legal Medicine
Catholic University
Largo F. Vito, 1
00168 Rome
Italy
E-mail: riccardo.rossi@rm.unicatt.it