DOI: 10.37990/medr.1343983 Med Records 2023;5(Suppl 1):138-43

MEDICAL RECORDS-International Medical Journal

Research Article

# A Case Series of Butane Intoxication Fatalities in the Southeastern Anatolia Region of Türkiye

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**Abstract**

**Aim:** Volatile solvent abuse (VSA), is the third most common form of substance abuse after alcohol and cigarettes. The aim of this study was to determine the incidence of fatalities due to butane gas.

**Material and Methods:** From 8,075 autopsies conducted in our center in Şanlıurfa, Türkiye in a 10-year period, 10 deaths were determined to be due to butane gas intoxication.

**Results:** All the fatalities were males (mean age: 17.6 years). Friends reported chronic use of lighter gas by the fatalities prior to the incident. In contrast, close relatives stated that it was the first instance of VSA. The preferred inhalation methods were bagging (i.e., inhaling gas from a plastic bag, n=4) and direct inhalation (i.e., spraying the gas directly in the mouth, n=6). The scene of incident findings revealed more than one lighter gas cartridge at the scene in nine cases and many lighters at the scene in one case. The autopsy examinations revealed minimal grazing on the body in three cases and no traumatic findings in seven cases. Butane was detected in blood samples in all 10 cases and in lung tissue samples in eight cases. In all 10 cases, there were areas of intra-alveolar swelling, edema, and bleeding in the lungs.

**Conclusion:** The actual incidence of VSA-related deaths is likely much higher than the number of reported cases, as our center is located near the Syrian border and has one of the highest populations of children and young people in Türkiye.

**Keywords:** Forensic science, volatile solvent abuse (VSA), butane, chronic abuse, sudden death, autopsy

## INTRODUCTION

Volatile solvent abuse (VSA) is defined as the intentional inhalation of a volatile substance to reach a state of euphoria (1). After alcohol and cigarettes, VSA is the third most common form of substance abuse. The most frequently used VSA substances in Türkiye are toluene (paint thinner), chloride hydrocarbons (commonly found in solvents and pesticides), and lighter gas fluid (2,3). The incidence of VSA among adolescents and young adults in the U.S. has been estimated to vary between 10 and 15%, with a higher incidence among states with large rural populations (4).

Butane (n-butane, butyl hydrate; equivalent to the isomer isobutane) is a gas used in industrial products, personal care products, and cosmetic products. Thus, butane is commonly found in lighter fluid, fuel bottles, paint, hairspray, air fresheners, and deodorants. Butane is obtained by liquefaction and distillation of petroleum and classified as an aliphatic hydrocarbon (1). Typically, the composition of commercial butane gas is butane (60%), isobutane (30%), propane (9%), and ethane (1%) (5-7). Butane is the most widely used substance among children and adolescents with a VSA habit and has the highest death rate (5-7). Its widespread use is primarily due to its low cost, ease of availability, and lack of legislation governing its sale. (2-6). Deaths resulting from butane intoxication are typically due to i) butane causing direct toxicity and cardiac arrhythmia, such as ventricular tachycardia and fibrillation (8,9); ii) indirect toxicity caused by hypoxemia, anoxia, and vagal inhibition due to oxygen in the airway being used up (10); or iii) trauma associated with high-risk behaviors due to confusion while intoxicated (11). A combination of these factors may also be implicated in butane intoxication-related deaths (8-11).

Butane evaporates rapidly from biological samples after death, making it difficult to detect and analyze the gas postmortem. Most forensic publications recommend immediate taking of samples in suspected cases of butane intoxication and sample storage in appropriate closed glass jars, followed by analysis in as short a time as possible after collection (4-8). Despite the rapid clearance

CITATION

Dundar AS, Altin I. A Case Series of Butane Intoxication Fatalities in the Southeastern Anatolia Region of Türkiye. Med Records. 2023;5(Suppl 1):138-43. DOI:1037990/medr.1343983

**Received:** 15.08.2023 **Accepted:** 13.09.2023 **Published:** 11.10.2023
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of inhaled butane, it tends to remain in brain and fat tissues because of high liposolubility (12,13). Sironi et al. investigated the distribution of butane and propane in two cases of fatal butane intoxication and showed that a high concentration in fat (adipose) tissue was consistent with the time interval from gas inhalation to death (12,14).

In this study, scene of incident findings, autopsy findings, and histopathological and biochemical analyses of samples taken postmortem were examined in deaths resulting from butane gas intoxication. The aim of this study was to determine the incidence of fatalities due to butane gas.

## MATERIAL AND METHOD

This study was approved by the Training and Scientific Research Committee of the Council of Forensic Medicine Directorate (Date: 26/09/2022, Decision number: 21589509/2022/854). In total, 8,075 forensic autopsy cases were examined. The examinations of all the cases took place at the Forensic Medicine Institute, Şanlıurfa, Türkiye between 1 January 2012 and 31 December 2021. Of the cases examined, 10 cases were identified as deaths resulting from butane intoxication.

We conducted a retrospective examination of the hospital files of the cases, including autopsy reports and photographs, histopathology reports, incident reports prepared by the police or armed forces, witness statements, and expert opinion reports. The cases were examined in respect of sociodemographic data, findings in the area of the incident, information related to substance addiction, autopsy findings, histopathology and toxicology analysis results of bodily fluid and internal organ samples taken during the autopsy, and cause of death.

### Headspace Gas Chromatography/Mass Spectroscopy (HS-GC/MS) Analysis of Butane

N-butane gas was detected in this study using a CLARUS 500 Gas Chromatograph (Perkin Elmer) and a Headspace sampler Turbo Matrix 16 device (Perkin Elmer). In the analyses, a C10 column and nitrogen as the carrier gas were used. A flame ionization detector was operated under the following conditions: temperature of 250°C, A-Cap of 120°C, injection section temperature of 60°C, column temperature of 40°C, and carrier gas of 20 psi. From the blood samples taken from the cases, 200 µl was taken using an automatic pipette and placed in a 20 ml gas chromatography/headspace vial. The vial was immediately closed with a silicone cover and metal ring using the crimping method. The butane gas content of a commercial lighter gas cartridge purchased in a local market was used as a reference in the analysis. Using the HS/GC method, the presence of n-butane in femoral blood taken during the autopsy was analyzed.

## RESULTS

The study population comprised 10 (0.12%) cases that resulted in death after been admitted to the emergency department with cardiac arrest, where the cause of death was determined to be butane intoxication in an autopsy. All the cases were males, and the mean age was 17.6 years, ranging from 14–23 years. The incidents occurred most often in the summer months. None of the deceaseds had any known chronic disease. In all the cases, arrest occurred either at the scene of the incident or on the way to the hospital. The location of the incident was most often the home of the deceased (n=8). Before the autopsy, information about the incident was obtained from close relatives or friends of the deceased. In anamneses taken from friends of the deceased, chronic use of lighter gas before the incident was described. In contrast, in anamneses taken from close relatives, they reported that to their knowledge, this was the first instance of VSA. According to the findings at the scenes of the incidents and witness statements, the inhalation method was via a plastic bag filled with gas in four cases and spraying the gas directly into the mouth in six cases. The scene of incident findings revealed more than one lighter gas cartridge in nine cases and many lighters in one case.

In the autopsies, no acute traumatic lesions were seen in seven cases. One case had been sitting on a school's garden wall, approximately 1 meter in height, inhaling lighter gas, when he suddenly felt bad and fell to the ground. In this case, grazing was found on the knees and face. One case had inhaled the lighter gas at home and then gone out into the street and collapsed on the pavement in front of his house. In this case, minimal grazing was found. Another case had been released from prison because of the COVID-19 pandemic. In this case, the individual was presumed to have fallen down four or five steps when leaving his house after inhaling lighter gas, and there was minimal grazing on the face and extremities. In another case, the individual had been arguing with friends inside a vehicle when he suddenly became ill. However, no traumatic findings were found in the autopsy.

In addition to blood samples, intraocular fluid, bile fluid, urine, liver, and kidney samples were taken for biochemical analysis in all 10 cases, as routinely done in autopsies in our center. Lung tissue samples were also taken in eight cases. In all 10 cases, butane (n-butane/isobutane) was detected in blood samples. In the blood samples, propane was detected in one case, ethanol in one case, and therapeutic drugs in three cases. Butane (n-butane/isobutane) was detected in all the lung sample tissues taken from the cases. As only a qualitative analysis was performed in our laboratory, the concentration of butane gas could not be determined. In three cases, throat and nasal smear samples were taken, but no volatile substance was detected. Details on all the findings are presented in Table 1.

In the histopathological examination, the brain, heart, lungs, liver, and kidneys were examined. In all the lung samples from all the cases, there were intra-alveolar areas of swelling, edema, and bleeding. In one case, edema and focal subarachnoid bleeding were detected in the brain, in addition to focal perivascular and interstitial fibrosis areas of a mild degree in the heart.

In one case where the anamnesis recorded no history of paternal chronic disease or substance addiction, macrovesicular steatosis was found in the liver and a minimal atrioventricular septal defect in the heart. Contraction band necrosis was found in the heart of one case and early-stage acute ischemic changes in the heart in another case. All the deaths were determined to be as a result of intoxication due to the inhalation of pure butane or derivatives.

DOI: 10.37990/medr.1343983

Med Records 2023;5(Suppl 1):138-43

**Table 1. Details on the 10 fatalities attributed to volatile substance abuse (VSA)**

| Case number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | M | M | M | M | M | M | M | M | M | M |
| **Age (years)** | 14 | 15 | 17 | 19 | 19 | 19 | 15 | 18 | 17 | 23 |
| **Season** | Fall | Winter | Summer | Summer | Summer | Fall | Spring | Fall | Summer | Spring |
| **Scene of incident** | Home (his own) | Home (a friend's) | School-yard | In a car | Home (a friend's) | Home (his own) | Home (his own) | Home (his own) | Home (his own) | Home (his own) |
| **First history taken before autopsy** | Friend | Friend | Friend | Friend | Uncle | Uncle | Cousin | Uncle | Brother | Father |
| **Chronic usage** | - Alcohol<br>- Drugs<br>- Lighter gas | - Alcohol<br>- Drugs<br>- Lighter gas | - Lighter gas | - Lighter gas | - None | - None | - None | - None | - None | - None |
| **Method** | Bag inhalation | Bag inhalation | Bag inhalation | Direct inhalation | Bag inhalation | Direct inhalation | Direct inhalation | Direct inhalation | Direct inhalation | Direct inhalation |
| **Source** | Lighter gas cartridge | Lighter gas cartridge | Lighter | Lighter gas cartridge | Lighter gas cartridge | Lighter gas cartridge | Lighter gas cartridge | Lighter gas cartridge | Lighter gas cartridge | Lighter gas cartridge |
| **Trauma signs** | None | None | Minimal abrasions on the knee and face | None | None | None | None | None | Minimal abrasions on face and extremities | Minimal abrasions on the face |
| **Chemical analysis** | Blood: Butane, ethanol (25 mg/dl), and chlorpheniramine | Blood: n-Butane | Blood: n-Butane<br>Lungs: n-Butane | Blood: n-Butane<br>Lungs: n-Butane | Blood: Butane<br>Lungs: Butane, isobutane, and propane | Blood: Butane<br>Lungs: Butane | Blood: Butane, pseudoephedrine/ ephedrine, and chlorpheniramine<br>Lungs: Butane | Blood: Butane and paracetamol<br>Lungs: Butane | Blood: Butane<br>Lungs: Butane and isobutane | Blood: Butane<br>Lungs: Butane and isobutane |

Sex (M=male, F=female)

## DISCUSSION

Worldwide, the use of sedative and narcotic drugs is a growing public health problem. Volatile substances have been added to the list of substances, such as heroin, cocaine, and synthetic synthetic drugs, that are already widely abused by the younger generation (i.e., children, adolescents, and young adults). According to a report by American Drug Use and Health Research Report on drug use in the U.S., in 2017, 9.3% of those aged ≤12 years, 8.6% of those aged 12–17 years, 9.5% of those aged 18–25 years, and 9.3% of those aged ≥26 years had used a volatile substance at least once (15).

In a meta-analysis that examined the lifetime use of different substances by abandoned children living on the street in low socioeconomic environments, 47% reported at least one instance of use of substance inhalation (16). In another study of high-school students in Türkiye, 8.8% of students reported volatile substance use at least once (17). Although substance abuse is not gender specific, males account for 90% of deaths due to substance abuse (18). In the current study, all the cases were males, and the mean age was 17.6 years, which is consistent with the literature (1-5). Şanlıurfa, Türkiye has a continental climate, with the air temperature reaching up to 50°C in the summer. Most of the 10 deaths (n=4) in the present study occurred during the summer months.

Screening for volatile substances is not performed systematically during autopsies in many countries because of issues relating to cost. Thus, it is highly likely that the number of deaths attributed to VSA is under reported. Testing for butane is only performed when there is evidence suggesting butane intoxication. In addition, VSA-related deaths are frequently not witnessed, and the source of intoxication (e.g., aerosol deodorant) can be easily overlooked. When abuse of illegal toxic substances is suspected, such abuse can only be revealed through a structured, directed investigation (19).

In the current study, more accurate information was obtained about the incident when the informant was a friend of the deceased. When the informant was a close family member (e.g., parent, sibling, or cousin), the informant they tried to cover up the cause of the incident. The accuracy of the information provided by a child or friend of the deceased who had witnessed the incident was likely due to fear of punishment, whereas the family would try to hide the incident for various reasons, such as societal pressure. As shown by an examination of all the statements in the investigation file, family members denied any history of VSA by the deceased. However, closer investigation revealed that the family was aware of the VSA.

To avoid overlooking the use of lighter gas in the deaths of children and young people, sharing of information details amassed by the authorities conducting the investigation with the physician performing the autopsy makes an important contribution to the determination of the cause of death. Given the high prevalence of young people in Şanlıurfa, Türkiye, the incidence of VSA is likely much higher than that recorded in the present study.

Due to the volatility of butane, it can be difficult to amass toxicological evidence in cases of suspected VSA (20). Some analytes may be lost during collection and storage, and this can lead to incorrect quantitation and false negative results (21). In cases of suspected butane intoxication, fat and brain tissue samples, where butane remains for long periods, can be analyzed as alternatives to blood samples (12,14). Fat and brain tissue samples reflect chronic use of volatile substances. In addition, the butane concentration in such tissues is higher than that in lung tissue (22). There are very few cases in the literature in which butane levels in fat (adipose) tissue and lung tissue have been compared (1,10). Generally, butane levels found in fat tissue at autopsy are higher than those found in lung tissue, suggesting that most cases are chronic users (19). In the current series, butane was analyzed in blood samples from all cases and in lung samples from 80% of cases. However, fat and brain tissue samples were not taken in any of the cases. This could have been due to a lack of experience, as butane intoxication is uncommon, or it could have been due to insufficient information being obtained about the incident before the autopsy as family members tried to conceal the VSA.

Methods of substance abuse include blowing (inhaling using a piece of cloth soaked in a volatile substance), sniffing (inhaling directly from a tube), or bagging (inhaling from a plastic bag) (5). The highest gas concentration is generally obtained by inhaling via the sniffing method (6). Although it is not easy to determine the adjuvants in aerosols in toxicology analysis, what method can be used, as this has what advantage as compared to other methods of butane analysis In addition, the detection of substances added to butane to give the gas its distinctive smell can be helpful in determining the cause of death when butane cannot be detected in postmortem samples. Butane gas evaporates rapidly and may be totally eliminated from fluids and organs after death and before samples are taken, which makes the detection of butane intoxication difficult.

A previous report on a suspected case of butane intoxication reported that while nasal smears at autopsy were negative, swabs of the back of the throat were positive for decamethylcyclopentasiloxane, which showed that inhalation was probably through the mouth rather than the nose (19). This hypothesis was supported by a large amount of butane found in the stomach contents. The presence of toxic substances on the clothes and face in this case further suggested that a bag was used for inhalation (19). In the current study, the findings were limited to butane determined in blood and lung samples in a qualitative analysis. In three of the 10 cases in the current series, no volatile substance was detected in throat and nasal smear samples. However, as a result of information about the scene of the incident and witness

statements, butane intoxication most likely occurred via inhalation from a bag or directly from a spray into the mouth.

In fatal cases of butane intoxication, warning symptoms, such as feeling faint, are uncommon, and most cases result in sudden death syndrome. The pathophysiological mechanism responsible for sudden death syndrome due to the abuse of a deadly substance is not clear (23). It has been reported that > 50% of sudden deaths are due to direct toxic effects, especially cardiac effects (23). N-butane can cause death by direct myocardial toxicity or ventricular arrhythmia secondary to global hypoxia due to butane/oxygen competition causing laryngospasms and direct damage to pulmonary tissue (19,23). Alunni et al. showed that butane inhalation directly affected pulmonary tissue (19). The majority of microscopic findings determined in cases of volatile gas inhalation are nonspecific, such as pulmonary and cerebral edema and subendocardial cardiomyocyte necrosis (6,19,24). Novosel et al. (24) observed hemorrhagic pulmonary edema, with macrophage activation following butane inhalation. Arrhythmia has been associated with coronary spasms in sudden sniffing death syndrome and consequently myocardial infarction and ventricular fibrillation in deceaseds with healthy coronary arteries (6,25). According to the literature, the direct effect of hypoxia on the brain and myocardium may lead to arrhythmia and necrosis via a catecholaminergic mechanism (26). Adrenergic activity due to physical effort or stress, together with aerosol inhalation, can increase the sensitivity of the heart to the autonomous effects of butane and render the individual more vulnerable to life-threatening tachyarrhythmias (26).

Several clinical patients reported in the literature have described the development of myocardial infarction, without any changes in coronary arteries (27). In all the cases in the current series, swollen intra-alveolar areas, edema, and bleeding in lung tissues were detected, consistent with the literature (1,2,6-9). Three cases became ill while performing tasks requiring sudden effort (descending steps, walking, and engaging in a violent argument). An atroventricular septal defect was detected in one case. These factors may have contributed to these deaths. In three cases, cardiac findings, including focal mild perivascular and interstitial fibrosis areas, contraction band necrosis, and early-stage acute ischemic changes in the heart, were detected, which were consistent with findings in the literature (25-27). Again, consistent with the literature, myocardial infarction, with early-stage ischemic changes, was detected in one case, despite healthy coronary arteries (6,25,27). These findings support the view that death could have occurred as a result of respiratory depression and asphyxia due to hypoxia and heart inhibition because of vagal nerve stimulation after spraying the gas into the mouth, leading to a vasospasm.

## CONCLUSION

In conclusion, the true incidence of deaths due to butane intoxication, which is an increasing public health problem, is unknown. The majority of reports in the literature related to deaths due to butane intoxication are case reports (2,3,7,12-14). Studies including multiple case series are limited, both in Türkiye and worldwide. Based on a search of the literature, the current study seems to one of the largest reported series. One of the most important reasons for this is the insufficent communication with the specialist performing the autopsy of guiding information related to the scene of the incident and consequently, butane intoxication can only be determined by chance. Moreover, in routine autopsy examinations performed in Türkiye, the toxicology examination does not include regions, such as brain and adipose tissue, where butane is absorbed and remains for a long period. In cases of sudden death, especially in the adolescent and young adult age group, butane intoxication should be kept in mind, and appropriate samples for biochemical analysis should be taken.

As our center is located in a city with one of the highest populations of children and young people in Türkiye, it can be estimated that the number of deaths resulting from butane intoxication is actually much greater than official records. The actual incidence of abuse of lighter gas, which is low cost and readily available, among the young population of Şanlıurfa is thought to be much greater than has been reported. There is a need for legislation and regulations governing the availability and sale of products containing butane. Furthermore, educational campaigns should be conducted to inform families, at-risk groups, and educators about the potential outcomes of lighter gas abuse for individuals and society. In addition, we suggest that professionals working with children and adolescents need to to take a more active role in VSA prevention.

***Financial disclosures:*** *The authors declared that this study has received no financial support.*

***Conflict of Interest:*** *The authors declare that they have no competing interest.*

***Ethical approval:*** *Permission was obtained from the Forensic Medicine Institute for the study (Decision no: 21589509/2022/854).*

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