

## Sudden death in relation to inhaling lighter fluid in adolescents

Turgay Bork<sup>1\*</sup>, Osman Celbis<sup>1</sup>, Semih Petekkaya<sup>2</sup>, Bedirhan Sezer Oner<sup>3</sup>, Emine Samdanci<sup>4</sup>

**Abstract:** *Background.* Sudden death as a consequence of lighter fluid abuse, though rare, happens during the adolescence period. The purpose of this study is to discuss the findings related to the deaths of young adults who died due to inhalation of lighter fluid.

*Material and Methods.* 4 cases who died due to lighter fluid inhalation are included in the study. The autopsy as well as toxicological and pathological procedures of the cases are conducted in Malatya Council of Forensic Sciences. The age, sex, height, weight, clinical findings before death, place of death, autopsy and histopathology findings are assessed in comparison to the toxicological results.

*Findings.* All the cases in the study are male. The ages are  $15.75 \pm 1.25$ , heights are  $167.75 \pm 12.68$  cm and weights are  $58.50 \pm 8.69$  kg. In blood analyses, n-butane and isobutane are found in all of them while 3 of them has propane. Besides, 2 of the cases had Tetrahydrocannabinol in their blood and urine. Three of the deaths happened in the hospital while 1 of them was in the crime scene. In the autopsy of the cases, macroscopically, intensive point bleedings are detected while alveolar fresh bleeding centers are found in the histopathology.

*Conclusion.* Autopsy and histopathologic findings are non-specific and the decision shall be given by assessing toxicological findings, crime scene examination and witness statements. In suspicious adolescent death, the detection of propane, isobutane and n-butane in toxicological examination is the only finding that makes us think of the presence of lighter fluid inhalation.

**Key Words:** forensic toxicology, butane, propane, isobutane, sudden death.

### INTRODUCTION

Volatile substances are commonly abused by young people since they are easily found, cheap and have a delighting effect [1]. Lighter fluid is a colorless and odorless gas and is a volatile substance used for igniting purposes. Generally it is inhaled into the body by squeezing it inside a nylon bag, soaking a cloth with it or inhaling directly. Its content include 54% n-butane, 20% isobutane and 26% propane [3]. Having a low molecular weight, lipophilic structure and aliphatic hydrocarbon structure, the n-butane leads to a sedative effect on central nervous system [7, 8]. Volatile substances such as n-butane are

thought to be the responsible for the death as a result of lighter fluid inhalation [4]. The exchange of n-butane gas with oxygen in the lungs causes asphyxia effects in the body. These effects may lead to unconscious dangerous behaviors, vagal inhibition, respiratory depression as well as sudden sniffing death syndrome [5]. In autopsies for death cases due to sniffing volatile substances including lighter fluid, macroscopic and microscobic patagnomic finding has not been described [6]. The purpose of this study is to discuss the findings related to the deaths of young adults who died due to inhalation of lighter fluid, and propose measures to prevent the abuse of volatile substances.

1) Inonu University, Medical School, Forensic Medicine Department, Malatya, Turkey

\* Corresponding author: Tel.: +904223410660-1776, E-mail: tbork7@hotmail.com

2) Abant Izzet Baysal University, Medical School, Forensic Medicine Department, Bolu, Turkey

3) Amasya University Medical School Forensic Medicine Department

4) Inonu University, Medical School, Pathology Department, Malatya, Turkey

## MATERIAL AND METHOD

Four cases who died due to lighter fluid inhalation are included in the study and their autopsies are made by Council of Forensic Sciences Malatya Group Administration. Before the autopsy, the medical history of the cases are obtained from the families of the cases and from the law enforcement officers investigating the incidences. Crime scene investigation minutes are examined. In the autopsy operation, the liver, kidney, stomach content, inner eye fluid, bile, blood samples as well as the whole right lung which was tied from the bronchial level are extracted for toxicological examination. Brain, cerebellum, brainstem, lungs, liver, kidneys, pancreas and heart samples are taken for histopathologic examination.

The samples are sent to the chemistry laboratory to be examined for the presence of propane, isobutane, n-butane, drugs, hypnotics, stimulants, alcohol and other substances (medicines and toxic substances). The analysis of propane, isobutane and n-butane in blood and tissue samples are conducted by headspace gas chromatography (HS/GC) device. In toxicological examination, one milliliter or 1.0 gram sample and 2.0 mL water are mixed in 10 mL cylindrical bottle. The cylindrical bottle is closed with a teflon tap tightly and left in water bath at 55°C for 30 minutes. After balancing with room temperature, 1.0 mL sample gas is injected into chromatography device. The content of the gas is determined by Shimadzu GC device with ionisat detector. The gases are distinguished over capillary colon (GS-Q, 30m 0:53mm i.d.). After the injection, temperature of the colon is increased to 1500°C from 1250°C with an average change of 50° C/min. The injection port is 1500°C while the detector temperature is 2000°C. The speed of helium carrier is 5.8 mL/min. In the histopathologic examination, the tissues found to be at 10% formality are painted with hematoxylin and eosin after routine tissue tracking and assessed under light microscope.

The age, sex, height, weight, clinical findings before death, place of death, autopsy and histopathology findings are assessed in comparison to the toxicological findings. The obtained data is analyzed in SPSS 17.0 (Statistical Package for Social Science) software. The specified mean values are given in arithmetic mean  $\pm$  standard deviation.

## FINDINGS

The youngest of the cases is 14 years old while the oldest is 17, and the age average is  $15.75 \pm 1.25$ .

Age, height, weight, BMI, place of death of the cases are given in Table 1.

It is found that the Case 1 felt unwell while playing football with his friends, was taken to the hospital by his friends and family but died despite all the medical effort.

He had lighter fluid abuse and bally adhesive sniffing in his medical record.

It is found that the Case 2 felt unwell while at home, was taken to the hospital by his family but died despite all the medical effort.

Case 3 is found dead in the roof of their house. Lighter fluid tube and bally adhesive package are found near the corpse. In his medical record, his brothers said that they saw him abuse lighter fluid many times.

It is found that Case 4 felt unwell while inhaling lighter fluid in a empty field with his friends, emergent help team came and intervened in the scene and the patient died in the hospital while by treated.

In the autopsy, blood, stomach content, brain, lung and liver samples of 4 cases are examined for the presence of n-butane, isobutane and propane and given in Table 2.

In Case 1, aside from lighter fluid components, hashish metabolite Tetrahydrocannabinol of 43 ng/mL in blood and 106 ng/mL in urine is found.

In Case 3, aside from lighter fluid components, hashish metabolite Tetrahydrocannabinol of 26 ng/mL in blood and 47 ng/mL in urine is found.

No alcohol is found in any of the cases.

Histopathologic findings of the cases are given in Table 3.

In Case 2, bridging is found in the coronary vein in the heart. In histopathologic examinations of other cases, non-specific changes are found.

Macroscopic autopsy findings of the cases are given in Table 4.

## DISCUSSION

Lighter fluid inhalation is an important public health problem causing sudden adolescent deaths in all the world. In a study on volatile substances including lighter fluid inhalation in Turkey, the abuse of volatile substance at least one time in life time is found to be 8.8% [12]. In a study on 12-17 year-old adolescents in Australia, the abuse of volatile substance at least one time in life time is found to be 27.3% [13].

Death due to lighter fluid inhalation are more common among adolescents and young adults [9, 10]. In our study, the age interval of the cases are between 14-17 while the average age is  $15.75 \pm 1.25$ . These are the common age intervals for beginning the abuse of substance, we think that since lighter fluid is cheap, easy-to-find and legally attainable, its abuse among adolescents is increasing.

The death due to lighter fluid inhalation are generally caused by dangerous behaviours, vagal inhibition, respiratory failure and cardiac arrhythmia due to sudden sniffing death syndrome. Since there are no macroscopic and microscopic findings for diagnostic purposes in the autopsy, the cause of death is rarely found in the autopsy

Table 1. Details of the cases

Case No	Sex	Age (year)	Height (cm)	Weight (kg)	Body Mass Index (BMI) kg/m <sup>2</sup>	Clinical findings	The place of death
1	M	16	169	54	18.9	Sudden disturbance	Hospital
2	M	14	161	60	23.1	Sudden disturbance	Hospital
3	M	16	156	50	20.5	Sudden death	Crime scene
4	M	17	185	70	20.5	Sudden disturbance	Hospital

Table 2. Determined lighter gas types in toxicological analysis

Toxicological Samples	n-butane Case				isobutane Case				propane Case				
	1	2	3	4	1	2	3	4	1	2	3	4	
Blood	+	+	+	+	+	+	+	+	+	+	-	+	+
Stomach contents	-	-	-	+	-	-	-	-	-	-	-	-	+
Brain	+	-	-	-	-	-	-	-	-	-	-	-	-
Lungs	+	+	-	+	+	-	-	+	+	-	-	-	+

Table 3. Findings of histopathology

Case	Brain	Cerebellum	Brainstem	Lungs	Liver	Kidney	Pancreas	Heart	Coronary arteries
1	congestion	congestion	congestion	Edema Intraalveolar fresh bleeding	congestion	congestion	congestion	congestion	Regular structure
2	congestion	congestion	Point fresh bleeding	Foreign body aspiration compatible with food content Intraalveolar fresh bleeding Edema	congestion	congestion	congestion	congestion	Bridging at LAD (1 cm)
3	congestion	congestion	congestion	Intraalveolar fresh bleeding Edema	congestion	congestion	congestion	Focal interstitial fibrosis	Minimal intimal thickening
4	congestion	congestion	congestion	Intraalveolar fresh bleeding Edema	congestion	congestion	congestion	congestion	Regular structure

Table 4. Findings of autopsy

Case	Autopsy Findings
1	On an area of 3x10 in the inner surface of the right arm, a tattoo including the letters "A" and "F" is found. The weights of the organs are: brain 1587 gram, heart 312 gram, right lung 762 gram, left lung 529 gram, liver 1549 gram, pancreas 96 gram, spleen 414 gram. Petechial bleedings are found in the surface of heart and lungs.
2	Healed incision scars are found in the outer surface of the left arm. The weights of the organs are: brain 1122 gram, heart 293 gram, right lung 332 gram, left lung 315 gram, liver 1673 gram, pancreas 134 gram, right kidney 131 gram, left kidney 125 gram. Petechial bleedings are found in the surface of lungs.
3	The weights of the organs are: brain 1501 gram, heart 226 gram, right lung 529 gram, left lung 265 gram, liver 1596 gram, pancreas 107 gram, right kidney 143 gram, left kidney 152 gram. Edema in brain, petechial bleeding in the surface of the lungs, bloody mucosal liquid in the bronch and bronchiols are found.
4	The case had a "Good day to Die" tattoo in the front side of the left arm and circular tattoo including 2 panter figures in the left hand. The weights of the organs are: brain 1434 gram, heart 320 gram, right lung 846 gram, left lung 1058 gram, pancreas 178 gram, right kidney 143 gram, left kidney 147 gram. Congestion in the brain, subepicardial petechial bleeding and congestion, edema and petechial bleeding in the lungs are found.

[7, 8, 11]. The content of the lighter fluid material found in the crime scene and the correlation of the inhaled substances detected in the toxicological examination of the samples are very important for the diagnosis [17]. Lighter fluid tubes are found near the corpses of Case 3 and 4, and gas components (n-butane, isobutane, propane) are also found in their blood and tissue samples. In Case 1 and 2, no lighter fluid tube is found in the crime scene.

However, lighter fluid abuse history of these two patients are found. Lighter fluid components are found in the blood and tissue samples of these cases, too. Crime scene examination findings as well as medical histories of these cases have been very useful for understanding the causes of death. In sudden adolescent deaths, substance abuse, especially the increasingly used lighter fluid inhalation lately, shall be considered for definitive diagnosis. Crime

scene examination reports and cases' medical histories are very important for detecting the cause of death in similar cases.

In the literature, it is reported that the components of lighter fluid are found in different amounts in blood and tissues [19]. In their study, Ozdemir *et al.* report that they found butane and/or isobutane and propane in blood samples of all their cases, and lighter fluid components were 55.6% in the lung samples, 61.1% in the kidney and liver samples [10]. In our study, we find n-butane and isobutane in blood samples of all the cases; propane in case 1, 3 and 4; n-butane in lung samples of case 1, 2 and 3; isobutane and propane in lung samples of case 1 and 4. We think that it is important to search for lighter fluid components in blood and lung samples in deaths due to lighter fluid. In such deaths, toxicological examination of blood, stomach content and tissue samples and their results may be the only evidence for determining the cause of death. For this reason, obtaining all toxicological samples including especially blood and lung samples and sending them immediately to the laboratory is necessary. Since volatile gases will be sought in this process, the person who will conduct the sampling shall be very careful.

The findings in the tissues after the histopathologic examination are non-specific and do not contribute much to understand the cause of death. No pathognomic finding is obtained for the internal organs in our study. Changes such as intraalveolar fresh bleeding in the lungs and edema are non-specific and can be present in many situations (such as agony period). We conclude that the detection of bridging in one case's left frontal coronary vein is an incidental finding and it increased cardiac side effects of lighter fluid.

Inhaling lighter fluid during a heavy physical activity increases risk of death [10]. Case 1 in our study felt unwell suddenly while playing football and died in the hospital due to ventricular fibrillation. Besides, we obtained information about the volatile substance abuse history of the case and found butane, isobutane and propane in the toxicological examination of the blood and lung samples. Heavy physical activity, sudden

fear and discharge of catecholamine during sexual intercourse after butane and isobutane inhalation may cause ventricular fibrillation [20]. Although arrhythmia mechanism is not explained completely in the literature, as a result of toluen abuse, the cardiac voltage dependent Na<sup>+</sup> channels are reported to be inhibited reversibly [14, 15]. We think that arrhythmia mechanism is similar to lighter fluid inhalation.

In studies on volatile substance abuse, it is reported that substance abuse is not limited to only one substance and is accompanied by other substances [16]. In our study, we have found n-butane, isobutane and propane in the bloods of case 1 and 3, additionally there was hashish metabolite Tetrahydrocannabinol in their urine and blood. Multiple and different volatile substance abuse by adolescents is in fact a step for using other sedative drugs. The struggle against these substances such as lighter fluid which are easy-to-find and legally sold can prevent other future drug addictions.

## CONCLUSION

Smoking rate between 13-15 age is reported to be 8.8% in Turkey [18]. Most of them carry lighter with them. For this reason, finding materials such as lighter, lighter fluid, tube of lighter fluid in crime scene brings death due to lighter fluid inhalation into the mind. The abuse of lighter fluid in the medical history of these cases shall be investigated. In the autopsy procedure, the toxicological samples duly obtained in terms of volatile substance shall be transferred rapidly to the laboratory and the toxicology laboratory shall be notified of the possible presence of volatile substances (butane, isobutane and propane). Besides, we believe that the addition of bad smelling gases into the lighter fluid will be very beneficial for preventing the abuse of lighter fluid among young adults.

**Conflict of interest.** The authors declare that they have no conflict of interest concerning this article.

## References

1. Volatile solvents abuse a global overview, World Health Organization, Substance Abuse Department 1999: 8-15.
2. Sugie H, Sasaki C, Hashimoto C, Takeshita H, Nagai T, Nakamura S, Furukawa M, Nishikawa T, Kurihara K, Three cases of sudden death due to butane or propane gas inhalation: analysis of tissues for gas components, *Forensic Sci Int.* 2004;143:211- 214.
3. Fuke C, Miyazaki T, Arao T, Morinaga Y, Takaesu H, Takeda T, Iwamasa T, A fatal case considered to be due to cardiac arrhythmia associated with butane inhalation. *Legal Medicine.* 2002;4:134-138.
4. Novosel I, Kovacic Z, Gusi S, Batelja L, Nesti M, Seiwerth S, Skavic J, Immunohistochemical detection of early myocardial damage in two sudden deaths due to intentional butane inhalation. Two case reports with review of literature. *Journal of Forensic and Legal Medicine.* 2011;18:125-131.
5. Butland BK, Field-Smith ME, Ramsey JD, Anderson HR, Twenty-five years of volatile substance abuse mortality: a national mortality surveillance programme, *Addiction.* 2013;108: 385-393.
6. Jackowski C, Römhild W, Aebi B, Bernhard W, Krause D, Dirnhofer R. Autoerotic accident by inhalation of propane-butane gas mixture. *Am J Forensic Med Pathol* 2005;26(4):355-359.
7. Shepherd RT. Mechanism of sudden death associated with volatile substance abuse. *Hum Toxicol* 1989;8:287-291.
8. Ögel K, Tamar D, Evren C, Çakmak D, The prevalence of volatile substance abuse: Evaluation of data in multi-center study, *Anadolu*

- Psikiyatr Derg. 2000;1: 220-224.
9. White VB, Bariola EE. Australian secondary school students' use of tobacco, alcohol, and over-the counter and illicit substances in 2011. December 2012.
  10. Rohrig, Timothy P. Sudden Death Due to Butane Inhalation. *The American Journal of Forensic Medicine and Pathology*. 1997;18(3):299-302.
  11. Ozdemir E, Es H, Demir M, Uzun İ. Forensic Medical Evaluation of Deaths Resulting From Inhalation of Cigarette Lighter Refill Fuel in Turkey. *Legal Medicine*. (<http://dx.doi.org/10.1016/j.legalmed.2016.10.008>).
  12. Nishi K, Ito N, Mizumoto J, Wada K, Yamada T, Mitsukuni Y, Kamimura S, Death associated with butane inhalation: report of a case. *Japanese J Leg Med*.1985; 39:214- 216.
  13. Sironi L, Amadasi A, Zoja R. Recreational inhalation of butane and propane in adolescents: Two forensic cases of accidental death. *Forensic Science International*. 2016; 266: 52-58.
  14. Tanaka N, Kinoshita H, Jamal M, Kumihashi M, Tsutsui K, Ameno K. An autopsy case of fuel gas abuse. *Rom J Leg Med*. 2012;20:195-196.
  15. Bass M. Sudden sniffing death. *J Am Med Assoc*. 1972;212:2075–2079.
  16. Cruz SL The latest evidence in the neuroscience of solvent misuse: an article written for service providers. *Subst Use Misuse* 46 2011 (Suppl 1); 62-67. doi:10.3109/10826084.2011.580215.
  17. Cruz SL, Orta-Salazar G, Gauthereau MY, Millan-Perez Peña L, Salinas-Stefanón EM. Inhibition of cardiac sodium currents by toluene exposure. *Br J Pharmacol*. 2003;140:653-660. doi:10.1038/sj.bjp.0705481.
  18. United Nations Office on Drugs and Crime. <http://www.unodc.org/unodc/en/press/releases/2014/June/global-drug-use-prevalence-stable-says-unodc-world-drug-report-2014.html>. (Erişim tarihi: 28.10.2015).
  19. Warren CW, Jones NR, Peruga A, Chauvin J, Baptiste JP, Costa de Silva V, el Awa F, Tsouros A, Rahman K, Fishburn B, Bettcher DW, Asma S; Centers for Disease Control and Prevention (CDC). Global youth tobacco surveillance, 2000-2007. Morbidity and mortality weekly report Surveillance summaries (Washington, DC: 2002). 2008;57(1):1-28.