Deaths Due to Methanol Poisoning: Forensic Autopsy Series

Metanol Zehirlenmesine Bağlı Ölümler: Adli Otopsi Serisi

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Abstract

Methyl alcohol is a substance often associated with toxic effects and fatalities due to its use in the production of counterfeit alcohol. The primary mechanism of poisoning occurs when it is metabolized in the body by the enzyme alcohol dehydrogenase, resulting in the formation of formic acid. This formic acid can lead to metabolic acidosis, loss of vision, and neurological damage because of its strong toxic effects. Symptoms of poisoning may include vomiting, headache, cyanosis, and "blizzard vision." In such cases, the typical cause of death is acidosis, and the formation of formic acid can be mitigated by using ethyl alcohol as treatment. In forensic autopsies, the cause of death resulting from methanol poisoning, the method of ingestion, and the quantity consumed are determined through toxicological analysis. This study presents four cases of death due to methanol poisoning from the Artvin Forensic Medicine Branch Directorate and emphasizes the need to raise awareness, develop effective public health policies, and implement comprehensive measures to protect public health.

Keywords: Methanol, poisoning, autopsy

Öz

Metil alkol, genellikle sahte içki üretiminde kullanımıyla, toksik etkiler ve ölümlerle ilişkilendirilen bir maddedir. Vücutta alkol dehidrogenaz enzimiyle metabolize edilerek formik asite dönüşmesi, zehirlenmenin temel mekanizmasını oluşturur. Formik asit, güçlü bir toksik etkisi nedeniyle metabolik asidoza, görme kaybına ve nörolojik hasarlara yol açabilir. Zehirlenme belirtileri kusma, baş ağrısı, siyanoz ve "kar fırtınası görme hissi" gibi etkilerle kendini gösterebilir. Bu tür vakaların ölüm sebebi genellikle asidoz olup, tedavide etil alkol kullanılarak formik asit oluşumu engellenebilir. Adli otopsilerde, metanol zehirlenmesine bağlı ölüm vakalarının nedeni, alım şekli ve miktarı toksikolojik analizle belirlenir. Çalışmada, Artvin Adli Tıp Şube Müdürlüğü'nde metanol zehirlenmesi nedeniyle ölen 4 olgu sunulmuş, bu konuda toplum sağlığını korumak için farkındalığın artırılması, etkili kamu sağlığı politikalarının geliştirilmesi ve kapsamlı önlemler alınmasının gerekliliği vurgulanmıştır.

Anahtar kelimeler: Metanol, zehirlenme, otopsi

Introduction

Alcohol is an organic compound formed by the combination of hydrogen, carbon, and oxygen atoms in a specific arrangement. The most widely known type of alcohol in daily life is ethanol, which is used for both medical purposes and in the beverage industry. Alcohol dependence is a serious health problem characterized by an individual's inability to control alcohol consumption, negatively impacting their quality of life (1). This addiction can lead to physical and psychological disorders, affecting both the individual and those around them. Additionally, alcohol dependence may also manifest as a tendency toward methanol, which can sometimes develop into methanol dependence (2).

Methyl alcohol (CH3OH) is a solvent used for de-icing and paint removal, and intoxication occurs as a result of unintentional or intentional consumption. Methyl alcohol, associated with deaths in Turkey due to the production of counterfeit liquor, can reach toxic levels through skin absorption or inhalation. Symptoms of poisoning may appear some time after ingestion and are caused by the metabolism of formic acid. In the liver, methyl alcohol is converted to formaldehyde by the enzyme alcohol dehydrogenase, which is then converted to formic acid. Formic acid is six times more toxic than methyl alcohol and triggers metabolic acidosis. Symptoms of poisoning include nausea, vomiting, headache, and cyanosis. Formic acid can cause vision problems by damaging retinal cells, leading to a phenomenon known as "snow-storm vision." Neurological symptoms and permanent blindness may develop, along with signs of parkinsonism. The most significant cause of death in methyl alcohol poisoning is acidosis, a condition triggered by formic acid. The intake of ethyl alcohol during treatment inhibits the metabolism of methyl alcohol and reduces the formation of formic acid (1).

Although methyl alcohol is produced by various methods in industrial processes, theoretically it has the potential to be produced even at home using simple reactions. The ease of access to the necessary equipment and chemicals has paved the way for an increase in such unauthorised and uncontrolled production. Individuals who die as a result of methyl alcohol poisoning are subjected to autopsy in accordance with Article 89 of the Code of Criminal Procedure (CPC). In such cases, toxicological tests are performed during the autopsy to determine the cause of poisoning, method of ingestion, and quantity consumed. Conducting forensic processes such as crime scene investigation, autopsy, and toxicological analyses is crucial for the effective progress of the forensic investigation and the provision of justice. Additionally, since methyl alcohol intoxications are often linked to crimes such as the production of counterfeit liquor, the proper handling of these cases in the field of forensic medicine is critical for public health and safety (4).

Methanol is often used in the production of counterfeit liquor because it is a low-cost and easily accessible substance. As a result, the consumption of counterfeit liquor and the associated risk of methanol poisoning pose a serious threat to public health. This issue can even lead to addiction due to the easy access to methanol. When methanol is ingested and reaches high concentrations in the bloodstream, it can cause fatal consequences by leading to serious organ damage from toxic metabolites formed in the body. In cases of methanol intoxication, delayed or inadequate medical treatment can result in death, as well as vision loss and neurological disorders (5).

The aim of this study was to investigate instances where methanol poisoning was determined to be the cause of death in autopsies performed at the Artvin Forensic Medicine Branch Directorate of the Forensic Medicine Institution and to develop recommendations for the investigation and prevention of such deaths.

Methods

Autopsies performed in Artvin Forensic Medicine Branch Directorate between 2016 and 2024 were analysed retrospectively. It was determined that 4 of the 261 autopsies were due to methanol poisoning. The cases were evaluated based on age, gender, nationality, autopsy findings, crime scene investigation information, and methyl alcohol levels. Information about the cases included in the study was obtained from our archive

records and the National Judicial Network Project (UYAP) system. The study was discussed at the Education and Scientific Research Commission meeting on 03.12.2024 at the Presidency of the Forensic Medicine Institute and was accepted by decision number 2024/1405. In this study, ethical approval was obtained from the Artvin Çoruh University Scientific Research and Publication Ethics Committee with decision number E-18457941-050.99-157216, dated 21.11.2024. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Cases

Case 1

In December 2016, a 29-year-old male Georgian citizen, reported to have died under suspicious circumstances in the Hopa district of Artvin, was examined. It was found that there were old scar tissues on his right arm, likely from a sharp instrument injury. He was then referred to the Artvin Forensic Medicine Branch Directorate for an autopsy to determine the exact cause of death.

In the autopsy, macroscopic examination revealed mild discolouration and epidermal peeling on the right foot, enlarged superficial vessels, flattened gyri, erased sulci in the brain, edema in the brain and internal organs, and 20-30% narrowing atheroma in the coronary arteries. The toxicological examination of the samples taken indicated 150 mg/dL of methanol in the blood and 209 mg/dL of methanol in the intraocular fluid.

Figure 1. Crime scene investigation images of case 2

Case 2

In March 2022, a 36-year-old male citizen of Georgia was reported to have been found dead at home by a colleague in the Borçka district of Artvin. Following the death examination, he was referred to the Artvin Forensic Medicine Branch Directorate for an autopsy. The examination of the forensic documents revealed that the crime scene investigation report stated the individual was lying on the floor. A 1-liter cologne bottle with the lid open was found near his head, containing only 100 mL of cologne. Additionally, there was an empty 400 mL cologne bottle in the pantry-style section of the room, along with four empty cologne bottles, two empty vodka bottles, one empty beer bottle, and one empty wine bottle in the kitchen.

Autopsy revealed brain oedema, erosive gastritis with haemorrhage, pulmonary oedema on macroscopic examination, 30-40% narrowing atheroma in the coronary artery, chronic cholecystitis and hepatic steatosis on histopathological examination. The toxicological examination of the samples indicated 730 mg/dL of methanol in the blood and 812 mg/dL of methanol in the intraocular fluid.

Case 3

In May 2023, a 63-year-old male citizen of Georgia, who was working as a seasonal laborer in the Arhavi district of Artvin, presented as an outpatient at the district state hospital with complaints of chest pain. He

was referred to another district state hospital for further examination and died on the same day while receiving treatment.

In the autopsy, macroscopic examination revealed mild discolouration and epidermal peeling autopsy, macroscopic examination revealed brain oedema, erosive gastritis, oedema in both lungs, multiple cystic lesions in the left lung, scar tissue secondary to a previous infarction in the myocardium, 30-40% narrowing atheroma in the coronary arteries, and cortical cyst in the left kidney. The toxicological examination of the samples taken found 319 mg/dL of methanol in the blood and 368 mg/dL of methanol in the intraocular fluid.

Case 4

In May 2022, a 53-year-old man working as a teacher in the Hopa district of Artvin, who had a long-standing history of alcohol addiction and had been hospitalized for this reason, was reported to have become distressed after drinking alcohol at home. He fell to the ground and called 112. He was first taken to the district state hospital and then transferred to the provincial center, where he died approximately 23 hours later.

In the autopsy; macroscopic examination revealed laceration with tissue bridges on the skin in the occipital region, oedema in the brain and lung, histopathological examination revealed 70-80% narrowing atheroma in the coronary arteries and pearlescent discolouration in the myocardium. The toxicological examination of the samples taken found 224 mg/dL of methanol in the blood and 249 mg/dL of methanol in the intraocular fluid.

Table 1. Information about the patients who died due to methanol poisoning

Case	Gender	Age	Nationality	Methanol level (mg/dL)		Autopsy Finding
				Blood	Intraocular fluid	
1	Male	29	Georgia	150	209	Brain oedema, sulcus obliteration, pulmonary oedema, *mildly narrowing (20-30%) atheromas in the LAD, decay of the right foot, congestion and oedema in the internal organs
2	Male	36	Georgia	730	812	Brain oedema, erosive gastritis, pulmonary oedema, 30-40% narrowing atheroma in coronary arteries, chronic cholecystitis
3	Male	63	Georgia	319	368	Brain oedema, erosive gastritis, oedema in the lungs, multiple cystic lesions in the left lung, scar tissue secondary to previous infarction in the myocardium, 30-40% narrowing atheroma in the coronary arteries, cortical cyst in the left kidney
4	Male	53	Türkiye	224	249	Skin laceration in occipital region, brain oedema, pulmonary oedema, 70-80% narrowing atheroma in coronary arteries, pearlescent discolouration in myocardium

*LAD: Left anterior descending coronary artery

In the examination of the E-Pulse records of the cases obtained through the National Judicial Network Project (UYAP); Since Cases 1, 2, and 3 were foreign nationals, it was understood that they did not have E-Nabız records, and no information could be obtained about their medical histories. In the medical history of Case 4, it was determined that he had diagnoses of "Acute Renal Failure" and "Acute Myocardial Infarction." He

had regular outpatient psychiatry appointments between February 2015 and April 2022, a history of alcohol use for many years, and had applied to the hospital several times with alcohol withdrawal symptoms, visual hallucinations, and tremors in his extremities. He also experienced syncope and was treated at AMATEM (Alcohol and Drug Addicts Treatment and Research Centre). Demographic data, autopsy findings, and results from toxicological and histopathological examinations are presented in Table 1.

Discussion

All cases in the study involved male patients. This may be attributed to the fact that the consumption of alcoholic beverages, particularly methanol, is more prevalent among men compared to women in our country (6). The mean age of the cases was 45.25 years, suggesting that methanol is a significant factor in deaths, particularly among middle-aged individuals. Socio-cultural pressures, biological factors, psychological tendencies, and unfavorable socio-economic conditions are the main reasons for higher alcohol consumption among males and middle-aged people (7).

Fatal blood concentrations in methanol intoxication have been reported in the literature to range from 15 mg/dL to 500 mg/dL (12). According to the Guideline for the Evaluation of Injury Offenses as Defined in the Turkish Criminal Code in terms of Forensic Medicine, intoxication is considered life-threatening if the blood concentration is 30 mg/dL or higher, or if eye dysfunction is detected, provided it is supported by clinical findings. Baduroğlu et al. reported that the consumption of as little as 10 mL of methyl alcohol may lead to permanent blindness (5,8). In our study, methanol levels in the blood were found to range between 150 and 730 mg/dL. When compared to the literature, the methanol levels observed in our cases were more than sufficient to cause death.

In Öztürk et al. study, although ethanol was found to be negative at autopsy performed eight days after hospitalisation, the cause of death could be determined because 209 mg/dL methanol was found in the witness sample (8,9). It was found that all of the cases in our study died within 24 hours after methyl alcohol consumption and methanol levels were high. Although we did not examine witness samples in our study, we would like to emphasise that analysing and preserving these samples is important in terms of clarification of forensic cases.

Crime scene investigation in patients who die from methyl alcohol intoxication is critical for determining the cause of death, understanding the conditions of intoxication, and detecting possible criminal elements. This investigation provides evidence in the forensic process by analyzing the sources of methyl alcohol that caused the intoxication, as well as examining addiction status, consumption patterns, and the surrounding environment (10,12). Additionally, it may help implement necessary measures to prevent similar cases in the future. In case number 2, empty cologne bottles found both in the environment and in the cellar of the house suggest an effort to produce low-cost alcohol, which may have contributed to methanol addiction.

The autopsy diagnosis of methanol poisoning primarily relies on highly variable postmortem findings. While mild central nervous system symptoms, nonspecific gastrointestinal findings, and cerebral edema may be observed during autopsy, more severe signs such as degeneration of neurons in the parietal cortex, putaminal degeneration and necrosis, hemorrhage in the optic chiasm, renal tubular degeneration, patchy necrosis, and fatty changes in hepatocytes may be present in some cases. Therefore, a forensic diagnosis of methanol intoxication can be established more accurately by combining multiple diagnostic methods within toxicological and histopathological frameworks (13,14).

Psychological autopsy, which began to be applied in the United States in the 1950s, is a post-mortem psychological examination technique that utilizes secondary and tertiary sources to determine the cause and manner of death in cases of suicide and suspicious deaths (15). As of October 2024, thanks to the protocol signed between the Ministry of Justice and the Ministry of Health in Turkey, the UYAP Information System has been integrated with the E-Nabız system, allowing access to individuals' health data within the scope of forensic files. This integration enables the psychological autopsy technique to be used more widely by providing access to information such as chronic diseases, drug use history, presence and diagnosis of

psychiatric conditions, and suicide attempts in the medical history of the deceased. In our study, the first three cases involved foreign nationals, so there were no E-Nabız system records. However, in the psychological autopsy examination of case four, information indicated that the individual had received outpatient care at a psychiatric clinic and had been continuously using medication for approximately seven years. He was also alcohol-dependent and exhibited severe symptoms such as visual hallucinations, tremors in his extremities, and syncope, which supported the cause of death. To obtain data on the medical history of foreign nationals, we believe that E-Nabız records for foreigners temporarily staying in our country, as well as those with residence permits, along with new studies on this subject, will enhance the psychological autopsy technique, similar to what was done in case four.

The autopsy findings for case number 2 in our study confirmed that methyl alcohol intake reached the level of addiction. Indeed, studies have reported that excessive alcohol consumption can lead to erosive gastritis and cholecystitis (16,17).

Turkey has the lowest rates of alcohol consumption and continuous drinking in Europe. However, in recent years, methyl alcohol poisoning has reached nearly epidemic levels. As of October 9, 2020, the number of fatalities due to methyl alcohol poisoning in the provinces of Aydın, Istanbul, Izmir, Kırıkkale, Kırklareli, Mersin, Muğla, Tekirdağ, Trabzon, and Zonguldak has reached 63, with nearly 50 individuals still receiving treatment in hospitals. It has been reported that a total of 143 people were admitted to emergency services due to methanol poisoning especially in Istanbul and Ankara last year and 71 of them succumbed to the effects of poisoning, and methyl alcohol poisoning caused a mass disaster as it led to the death of more than 12 people (18-20). The prohibition of ethyl alcohol sales for domestic use over the internet due to legal regulations has increased the likelihood of individuals turning to more accessible and toxic methyl alcohol (21).

In conclusion, methanol poisoning is particularly associated with the production of counterfeit alcohol, which can lead to serious health problems and even addiction. Studies have shown that high concentrations of methanol in the blood can have fatal consequences and that the widespread use of counterfeit alcohol has led to an increase in poisoning cases. Crime scene investigations in methanol poisoning cases can help prevent similar incidents by identifying consumption patterns and sources of methanol.

In cases of methanol poisoning and suspicious death, the psychological autopsy technique can improve our understanding of the cause of death. This approach examines the psychological and social factors surrounding the death, such as stressful life circumstances or mental health problems that may have increased the individual's alcohol consumption. It also identifies risk factors for suicide attempts or substance abuse and helps to design more effective mental health support services for individuals in similar situations. Adopting a comprehensive approach to combating methanol poisoning will reduce the burden on the healthcare system and protect public health.

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