Fatal group ethylene glycol intoxication associated with hypothermia

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Abstract: in this case report, we present a fatal incident of group ethylene glycol poisoning involving three individuals. The bodies were discovered near a river in an advanced stage of decomposition and transported to the Department of Forensic Medical Examination at the State specialized institution "Kharkiv Regional Bureau of Forensic." In the absence of external signs of violent death, such cases are investigated using all available forensic methods, including autopsy, toxicological screening, and histological examination. The autopsy did not determine a definitive cause of death, and the histological examination revealed no features typically associated with ethylene glycol intoxication. However, qualitative forensic toxicological analysis confirmed the presence of ethylene glycol in renal and hepatic tissues. Clustered fatalities of this nature are relatively rare but do occur in forensic medical practice and require meticulous investigation to determine the underlying cause and circumstances of the death.

Keywords: Forensic Medicine, Forensic Toxicology, Ethylene Glycol, Poisoning, Autopsy

Introduction

Ethylene glycol is a widely used chemical compound and an essential intermediate in various industrial processes. Due to its unique properties and broad industrial applications, numerous catalytic and non-catalytic chemical systems have been investigated for their synthesis. These systems often rely on reaction pathways derived from fossil fuels as well as biomass-based resources. [1].

Ethylene glycol (EG) is a technical fluid commonly used as an antifreeze agent. EG poisoning is usually marked as domestic or accidental for the purpose of intoxication, even though there are many genuine suicide attempts. The severity of a toxic effect will depend on the general condition of the organism, its individual features, ethylene glycol intake, and previous or simultaneous ethanol alcoholization.

In previous researches was mentioned [2, 3, 4] that ethylene glycol intoxication is occasionally encountered in forensic practice; however, such cases are relatively rare and typically do not involve multiple individuals.

Three bodies, members of the same family – were delivered to the Department of Forensic Medical Examination at the State specialized institution "Kharkiv Regional Bureau of Forensic", According to the investigator's decree, the bodies were discovered at the beginning of March near a river, lying close to one another. At the time of discovery, they were frozen and in an advanced stage of decomposition,

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showing signs of partial mummification. All three deaths are considered as a single case report since bodies were found at the same location and the incidents occurred at approximately the same time with an identical cause of death.

Aim

The main goal of this case report is to describe and analyse a fatal case of group ethylene glycol intoxication, emphasizing the clinical presentation, diagnostic challenges, laboratory findings, and forensic aspects, in order to highlight the importance of early recognition of ethylene glycol poisoning.

Materials and Methods

Autopsies were performed using the method of complete evisceration (according to Schor). After collecting venous blood and urine (where it was possible), the detection of alcohols (methyl, ethyl, isopropyl, n-propyl, isobutyl, n-butyl, and isoamyl alcohols) was conducted using an "LKhM-80" gas chromatograph according to standard methodology. The detection method for presence of ethylene glycol is used as qualitative and based on examining the aqueous portion of the distillate in a reaction with sodium sulfite and fuchsine sulfuric acid. Histological examination was performed by staining the specimens with hematoxylin and eosin and then examining them under an OLYMPUS CX-23 light microscope with magnification x4, x10, x20, x40, x100.

Case description

First Body – Male, 54 Years Old. Postmortem changes were observed, including green skin discoloration in both iliac regions, consistent with putrefactive changes. Deposits of soot were noted on the skin of both hands. Upon examination, the testicles were not palpable within the scrotum, having retracted to the level of the external inguinal canal. An autopsy revealed that all bodily fluids were in a frozen state.

The brain weighed 1290 grams. The brain tissue, on section, exhibited a well-preserved general pattern corresponding to its anatomical structures. The tissue appeared edematous, moist, and congested, with no visible focal lesions. The lungs were of average size, with emphysematous expansion along the periphery. The right lung mass was 600 grams, and the left lung was 570 grams. Palpation revealed that the lungs have a dough-like consistency. The lung tissue, both on the surface and the section, was red brown. On compression of the cut surface, a large quantity of reddish, foamy fluid mixed with frozen blood was released. The esophagus contained a black, viscous fluid mixed with ice. The stomach contained approximately 200 mL of dark brown liquid. Multiple petechial hemorrhages, ranging up to 0.3 cm in diameter, were observed at the apices of the gastric folds. These hemorrhages shifted upon gentle scraping with the back of a knife. The urinary bladder contained approximately 200 mL of urine.

Second Body – Female, 73 Years Old. Mummification of the face and hands was noted. Putrefactive changes were observed, including a putrefactive venous network and putrefactive liquefaction of the eyes. Deposits of soot were present on the face, neck, and hands. Internal examination revealed a fibrous tissue replacement area measuring 2.0×1.5 cm on the posterior wall of the heart's left ventricle. The urinary bladder was empty.

Third Body – Male, 74 Years Old. Putrefactive changes were observed, including brown-green discoloration of the skin, a putrefactive venous network, and putrefactive liquefaction of the eyes. Internal examination revealed changes in the brain, lungs, and gastric mucosa similar to those observed in the first body.

For laboratory analysis, tissue samples from various organs were collected from all three bodies for forensic histological examination. Blood and urine samples (where available) were taken to determine the concentration of alcohol and carboxyhemoglobin. Additionally, a set of organs was collected for toxicological analysis to determine the concentration of unknown poisons, including the stomach with its contents, one meter of intestine with contents, cerebral cortex, liver with an intact gallbladder, and an intact kidney. A characteristic purple coloration indicative of ethylene glycol was observed in the tissue samples. Consequently, forensic toxicological analysis confirmed the presence of ethylene glycol in all three cases, except the first body where ethyl alcohol in the blood at a concentration of 0.88‰ and in the urine at 6.35‰ was found. Carboxyhemoglobin was not detected in the blood of any of the subjects by gas chromatography. The liver was not analyzed for starch due to the time of death, which occurred more than 24 hours before the forensic examination of the body.

Forensic histological examination revealed signs of postmortem autolysis in the second body. In the first and third bodies, there were signs of rapid death (acute circulatory failure in the internal organs, venous congestion of the internal organs, and edema of the brain and its membranes), along with hemorrhagic erosions of the gastric mucosa, saturated with erythrocytes, forming a brown granular mass. The leading cause of death was determined to be ethylene glycol poisoning.

Discussion

Therefore, in the absence of ethylene glycol, general hypothermia could be considered as a possible cause of death in this case.

Table 1. Comparison between findings in bodies

Findings	Body 1 (male)	Body 2 (female)	Body 3 (male)
Stage of putrification	green skin discoloration in both iliac regions	mummification of the face and hands; putrefactive venous network and putrefactive liquefaction of the eyes	brown-green discoloration of the skin, a putrefactive venous network, and putrefactive liquefaction of the eyes
Signs of sudden death	+	-	+
Puparev sign	+	not applicable	-
Vishnevsky spots	+	-	+
Other pathological conditions	-	fibrous tissue replacement area of the heart's left ventricle	-
Calcium oxalate deposits in organs	-	-	-
Presence of alcohol	blood – 0.88‰ urine – 6.35‰	-	-
Presence of carbon monooxide	-	-	-
Presence of ethylene glycol	+	+	+

Firstly, in the first body, palpation detected a significant retraction of the testicles toward the level of the external inguinal canal – a finding known as Puparev's sign – indicating antemortem exposure to low temperatures [5].

Secondly, in both the first and third bodies, multiple petechial hemorrhages were observed on the gastric mucosa. Histological examination identified these as hemorrhagic erosions, infiltrated with erythrocytes, and appearing as brown granular masses. Several studies [6,7] support hypothesis that these features resemble Vishnevsky's spots, typically associated with hypothermia.

Moreover, the presence of soot in the absence of carbon monoxide in the blood may suggest the existence of a nearby fire, possibly indicating that the individuals were near a source of warmth.

Histological signs of ethylene glycol poisoning involve multiple organs and systems [8]. In the central nervous system, edema, meningoencephalitis, and loss of Purkinje cells are typically observed [9]. The kidneys show proximal and distal tubular dilation, interstitial edema, tissue necrosis, and intratubular deposition of calcium oxalate crystals [10,11]. The adrenal glands may exhibit hemorrhages, while the lungs often present with edema and interstitial pneumonitis. Other affected organs include the myocardium, which appears pale and flaccid with signs of interstitial myocarditis and electrophysiological disturbances. Additionally, erythema of trachea, hepatic congestion, and calcium oxalate deposits in the retina may also be present [4,12]. However, in acute ethylene glycol intoxication cases, calcium oxalate crystals may not always be observed in the kidneys [4].

In this case, we observed that histologically, no pathological changes were detected in the first body, apart from signs indicative of a sudden death. At the same time, cerebral and pulmonary edema were observed in this case, which may support the hypothesis of sudden death.

The second body was in a state of putrefactive decomposition. Although the organs were macroscopically preserved, microscopic examination showed marked postmortem autolysis, which precluded a reliable assessment of pathological or reactive tissue changes.

Recent study [13] indicates that measurement of glycolic acid levels may be useful in similar cases during postmortem investigations of EG poisoning, as determining EG concentration alone may not provide a sensitive indicator for detecting or assessing the severity of EG poisoning. Additionally, a method has been described for detecting elevated glucose levels in vitreous humor, which may correlate with EG poisoning [14].

The detection of ethylene glycol in the liver and kidneys by qualitative methods can be explained by the fact that the most significant amount accumulates in these organs, where it undergoes biological oxidation to form glycolates, glyoxalates, and oxalates, substances primarily responsible for initiating the toxic process [15].

Conclusions

This study highlights the diagnostic challenges of ethylene glycol poisoning, particularly in forensic contexts where toxicological testing is limited or unavailable. In the absence of direct detection of EG, alternative causes of death-must be carefully considered based on autopsy findings

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and histological features. Therefore, histological and biochemical markers-including glycolic acid levels and vitreous glucose-should be integrated into standard forensic protocols in Ukraine to improve postmortem detection of EG poisoning. Enhanced diagnostic awareness is essential for identifying this rare but potentially overlooked cause of fatal intoxication.

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Conflict of interests. Authors declare no conflict of interest.

Consent to publication. All authors reviewed the article and gave their consent to its publication.

Patient Consent. Informed consent for publication was not obtained from relatives due to the anonymization of information about the research subjects.

Ethics Approval Statement. Our clinical case was conducted in accordance with the principles of the Helsinki Declaration (2013) and was approved for publication by the Ethics and Bioethics Committee of Kharkiv National Medical University ("Expert opinion" dated June 25, 2025).

AI Statement. All the authors claim to not have used any tool based on artificial intelligence during the preparation of this manuscript.

Author Contributions (CRediT taxonomy). Conceptualization — Oleksii Shcherbak: Methodology — Oleksii Shcherbak, Daria Kuzmina, Pavlo Leontiev; Software — Daria Kuzmina; Validation — Oleksii Shcherbak, Daria Kuzmina, Pavlo Leontiev; Formal Analysis — Oleksii Shcherbak, Pavlo Leontiev; Investigation — Oleksii Shcherbak, Daria Kuzmina; Resources — Oleksii Shcherbak, Daria Kuzmina; Data Curation — Oleksii Shcherbak; Writing – Original Draft — Oleksii Shcherbak; Writing – Review & Editing — Daria Kuzmina; Visualization — Daria Kuzmina; Supervision — Pavlo Leontiev; Project Administration — Oleksii Shcherbak; Funding Acquisition — Not applicable

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Випадок смертельного групового отруєння етиленгліколем

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Анотація: у цьому клінічному випадку представлено летальний інцидент групового отруєння етиленгліколем, що стався з трьома особами. Тіла були знайдені поблизу річки в стадії значного аутолізу та доставлені до Відділу судово-медичної експертизи трупів Державної спеціалізованої установи «Харківське обласне бюро судово-медичної експертизи». За відсутності зовнішніх ознак насильницької смерті подібні випадки досліджуються з використанням усіх доступних судово-медичних методів, включаючи розтин, токсикологічний скринінг та гістологічне дослідження. Під час розтину не було встановлено остаточної причини смерті, а гістологічне дослідження не виявило змін, характерних для інтоксикації етиленгліколем. Проте якісний судово-токсикологічний аналіз підтвердив наявність етиленгліколю в тканинах нирок і печінки. Групові летальні випадки такого типу трапляються відносно рідко, проте зустрічаються у судово-медичній практиці й потребують ретельного розслідування для встановлення причини та обставин смерті.

Ключові слова: Судово-медична експертиза, судово-медична токсикологія, етиленгліколь, отруєння, розтин.