Unusual greenish tissue discoloration in fatal aluminium phosphide poisoning: clinical and forensic perspectives

Nietypowe zielonkawe przebarwienie tkanek w śmiertelnym zatruciu fosforkiem glinu: aspekty kliniczne i kryminalistyczne

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Abstract

Aim: Aluminum phosphide poisoning poses significant challenges both in clinical and forensic settings due to its high fatality rate and diverse clinical manifestations. While the clinical symptoms of aluminum phosphide toxicity are well-documented, certain autopsy findings, particularly a rare greenish discoloration of organs, remain poorly understood.

Methods: A prospective observational study was conducted over an eight-month period to analyze the occurrence of unusual green discoloration of tissues during autopsies in aluminum phosphide poisoning cases. This study aimed to document the frequency, distribution, and potential mechanisms behind this rare phenomenon, providing insights into its clinical and forensic implications.

Results: A total of 110 suspected poisoning cases were examined, of which 47 were confirmed as aluminum phosphide poisonings. Among these, three cases demonstrated gradual greenish discoloration of organs such as the heart, stomach, brain, and kidneys. Despite the presence of this unique discoloration, histopathological examination revealed no microscopic pigmentation or histological anomalies. The discoloration varied in terms of the organs involved, intensity, and the speed of onset, presenting distinct patterns across the cases.

Conclusions: The etiology of this discoloration remains unknown, suggesting that biochemical or metabolic processes might play a role. This rare phenomenon underscores the need for further research to elucidate the underlying mechanisms, and highlights the importance of documenting such observations in forensic reports.

Keywords

poisons; autopsy; forensic toxicology; toxicology; poisoning

Streszczenie

Cel: Zatrucie fosforkiem glinu stanowi poważne wyzwanie zarówno w praktyce klinicznej jak i sądowej ze względu na wysoką śmiertelność i różnorodne objawy kliniczne. Podczas gdy objawy kliniczne zatrucia fosforkiem glinu są dobrze udokumentowane, pewne ustalenia sekcyjne, w szczególności rzadkie zielonkawe przebarwienia narządów, pozostają słabo poznane.

Metody: Przeprowadzono prospektywne badanie obserwacyjne trwające osiem miesięcy w celu przeanalizowania występowania nietypowego zielonego przebarwienia tkanek podczas sekcji zwłok w przypadkach zatrucia fosforkiem glinu. Celem tego badania było udokumentowanie częstości, dystrybucji i potencjalnych mechanizmów stojących za tym rzadkim zjawiskiem i dostarczenie wglądu w jego kliniczne i sądowe implikacje.

Wyniki: Przebadano łącznie 110 podejrzewanych przypadków zatrucia, z czego 47 potwierdzono jako zatrucia fosforkiem glinu. Spośród nich trzy przypadki wykazały zielonkawe przebarwienie narządów, takich jak serce, żołądek, mózg i nerki. Pomimo obecności tego wyjątkowego przebarwienia, badanie histopatologiczne nie wykazało żadnej mikroskopowej pigmentacji ani anomalii histologicznych. Przebarwienia różniły się pod względem objętych nimi organów, intensywności i szybkości wystąpienia, prezentując odrębne wzorce w różnych przypadkach.

Wnioski: Etiologia tych przebarwień pozostaje nieznana, co sugeruje, że rolę mogą odgrywać tu procesy biochemiczne lub metaboliczne. To rzadkie zjawisko wymaga dalszych badań w celu wyjaśnienia mechanizmów leżących u jego podstaw i dokumentowania takich obserwacji w raportach medyczno-sądowych.

Słowa kluczowe

trucizny; autopsja; toksykologia sądowa; toksykologia; zatrucie

Introduction

Aluminum phosphide poisoning continues to pose a significant challenge in clinical practice and forensic medicine due to its high mortality rate and varied clinical manifestations [1]. Aluminum phosphide is a highly toxic pesticide commonly used to protect stored grains from pests [2,3]. It is also known as the 'rice tablet' because of its common use in rice fields [4]. The ingestion of aluminum phosphide can cause severe toxicity and is usually fatal. Upon ingestion, aluminum phosphide reacts with moisture in the gastrointestinal tract, releasing phosphine gas, which is the primary toxic agent responsible for the clinical manifestations of poisoning. The toxic effects of phosphine gas primarily affect the cardiovascular and respiratory systems, leading to severe toxicity and often fatal outcomes [5].

Despite extensive research and clinical experience, certain aspects of aluminum phosphide poisoning remain poorly understood. One such phenomenon is the occurrence of a peculiar greenish discoloration of the organs observed during autopsy in a subset of poisoning cases. The existing literature demonstrates that certain cases treated with methylene blue show similar color changes in organs. However, such changes are not observed in cases of aluminum phosphide poisoning [6,7,8,9,10]. Greenish tissue discoloration can also occur in other types of poisoning or medical conditions, such as hydrogen sulfide poisoning, putrefaction, etc.

Aim: In this expanded observational study, we aimed to investigate a series of aluminum phosphide poisoning cases that exhibited an unusual greenish discoloration of organs during autopsy. Through a detailed analysis of clinical histories, autopsy findings, and ancillary investigations, we sought to shed light on this unique phenomenon and stimulate further research into its underlying mechanisms and implications for forensic practice and toxicology.

Materials and Methods

Study Design: This was a prospective, observational, cross-control study designed to systematically document and analyze the occurrence of greenish discoloration in tissues during autopsies of suspected poisoning cases. The study aimed to identify the frequency, distribution, and potential underlying mechanisms of this discoloration in cases of aluminum phosphide poisoning. It was conducted over an eight-month peri-

od, from April 2023 to November 2023, in the Department of Forensic Medicine and Toxicology of a tertiary care hospital.

Inclusion Criteria: All autopsy cases with a suspected history of poisoning were included in the study if they met the following criteria:

- A confirmed or strongly suspected history of aluminum phosphide ingestion based on circumstantial evidence, clinical history, or forensic examination.
- Cases in which forensic science laboratory (FSL) reports confirmed the presence of aluminum phosphide as the toxic agent.
- Cases where complete clinical records, including the type and content of poison, treatment received (including the administration of methylene blue or other potential discolorants), and autopsy findings, were available.

Exclusion Criteria: The following cases were excluded from the study:

- Decomposed bodies where tissue integrity was compromised, making it difficult to assess color changes accurately.
- Cases with incomplete clinical histories or missing forensic laboratory reports.

Data Collection: Detailed data were collected for each case, including:

- Circumstantial details surrounding the poisoning incident, including the suspected or confirmed type of poison and its content.
- Clinical interventions received prior to death, with particular attention to the administration of methylene blue or other agents known to cause discoloration.
- Comprehensive autopsy findings, focusing on the presence and progression of greenish discoloration in various organs.

Chemical and Histopathological Analysis: In all cases of suspected poisoning, tissue samples were collected and sent to the Forensic Science Laboratory (FSL) for chemical analysis. This analysis aimed to detect and confirm the presence of toxic substances, with a specific focus on identifying aluminum phosphide as the primary toxic agent. For cases in which greenish tissue discoloration was observed, additional tissue samples were collected for histopathological examination. The samples were fixed in formalin and processed using standard histological techniques. Microscopic analysis was performed to assess any cellular or structural changes that could correlate with the observed discoloration.

Documentation of Color Changes: In cases exhibiting greenish discoloration, a series of photographs were taken at regular intervals (e.g., every 5 minutes) during the autopsy to document the progression and intensity of color changes in various organs. This photographic documentation was critical for understanding the temporal dynamics of the discoloration and its potential correlation with exposure to aluminum phosphide.

Results

A total of 110 suspected poisoning cases were referred for medicolegal post-mortem examination during the study period and were included in this study. Forensic science laboratory (FSL) reports available for 62 of these cases, with 47 (75.9%) testing positive for aluminum phosphide poisoning. Notably, three of these 47 cases exhibited a distinctive phenomenon of gradual greenish discoloration of organs, including the heart, stomach, brain, and kidneys. The discoloration peaked approximately 30 minutes after observation, and remained unchanged until the examination was completed. In contrast, the other organs in these cases showed only mild color changes, and no color changes were observed in the control group.

Out of the three cases, one case involved a group suicide, where four family members ingested aluminum phosphide on the same day from the same source. Notably, only one member exhibited greenish discoloration of organs, while the other three, who served as controls, showed no such color changes. Additionally, among the cases with gradual greenish discoloration, one was found to have received methylene blue (10 mg intravenously) during treatment. In contrast, other cases of aluminum phosphide poisoning that also received methylene blue did not exhibit any color changes. The greenish discoloration in organs varied among the three cases, ranging from the involvement of just two organs to multiple organs.

In all three cases showing greenish discoloration of tissues, samples were collected for both chemical analysis and histopathological examination to identify any distinguishing observations. The chemical analysis confirmed the presence of aluminum phosphide poisoning. However, despite the gross observation of green discoloration, the histopathological examination revealed no microscopic pigmentation that could account for the observed color change.

The details of all three cases are described below, including the circumstances of the incidents, clinical course and autopsy observations.

Case 1

A 29-year-old female was brought for autopsy with a suspected history of suicidal poisoning. According to the police inquest and treatment summary, the patient ingested Celphos powder, which contains 56% aluminum phosphide mixed with water, at approximately 5:00 PM. Upon admission to a nearby hospital, she presented with symptoms of drowsiness, hypo-

tension, hypoxia, tachypnea, and bradycardia. Despite receiving gastric lavage, inotropic support, and mechanical ventilatory support, she did not survive and was declared dead at 12:44 AM the next day.

During the autopsy examination, the external findings revealed bluish discoloration of the nails and lips. Internally, both lungs exhibited congestion and edema. Upon internal examination, the stomach was congested, and a greenish bluish-colored fluid with an atypical smell was observed. All organs initially showed congestion upon examination. However, within a few minutes of exposure to the atmosphere during autopsy, a remarkable color change occurred (Figure 1), transitioning from red to green. Initially, the left kidney displayed more rapid greenish discoloration compared to the right kidney and other organs (Figure 1A-1F). While the external appearance of the brain appeared normal, upon cut sectioning, a mild greenish discoloration was observed along the wall of the lateral ventricle (Figure 1H). Similarly, the exterior of the heart appeared normal, but upon cutting, greenish discoloration was evident along the chordae tendineae and the internal surface of the chambers (Figure 1I). The liver surface appeared normal in color. After 5 minutes of exposure to the atmosphere, intensification of the green discoloration was noted across all organs. The left kidney became almost entirely dark green and the right kidney showed discoloration covering 60–70% of its surface area. Similar discoloration patterns were observed in the remaining organs, including the liver (Figure 1J). Additionally, the heart surfaces began to exhibit greenish discoloration after 20 minutes.

Case 2

A 24-year-old female was admitted to a private hospital with a history of ingestion of an unknown substance and presented with symptoms of vomiting and burning sensations at 7:30 PM. Upon admission, she was found to be drowsy with a Glasgow Coma Scale (GCS) score of E1M3V2, a blood pressure of 80/50 mmHg, and oxygen saturation of 89% with room air. Despite emergency treatment, she unfortunately succumbed to her condition at 11:30 PM. The following morning, the police brought her body for medicolegal postmortem examination. Upon examination, all organs showed signs of congestion, and the stomach contained 20 ml of greyish particle-mixed fluid with an atypical smell. Gradual greenish discoloration (Figure 2) was observed in the heart and brain, whereas all other organs retained their natural coloration.

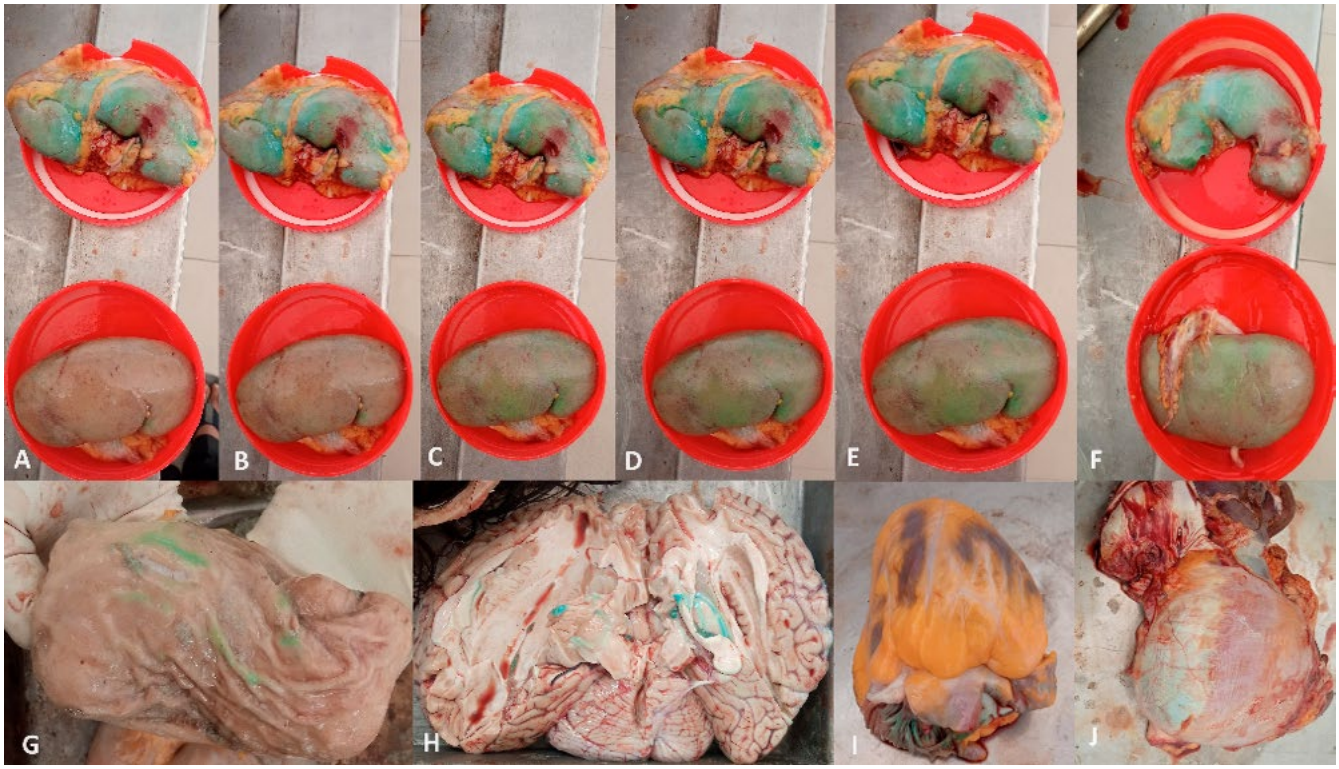

Figure 1. Greenish discoloration of organs. Gradual color changes of both kidneys (A-F), Stomach (G), Brain (H), Heart (I), Liver (J)
Rycina 1. Zielonkawe przebarwienie organów. Stopniowe zmiany koloru obu nerek (A-F), żołądka (G), mózgu (H), serca (I), wątroby (J)

Figure 2. Greenish discoloration of organs. Green color changes of Brain (A,B), Stomach (C), Heart (D,E), Multiple organs (F)
Rycina 2. Zielonkawe przebarwienie organów. Zielone zmiany koloru mózgu (A, B), żołądka (C), serca (D, E), wielu organów (F)

Case 3

A 14-year-old boy was admitted to a private hospital after ingesting Celphos powder, which contains 56% aluminum phosphide mixed with water, on his way to school. His father brought him to the hospital for treatment and he was admitted at approximately 5:30 PM. Upon examination, he was conscious but presented with low blood pressure (70/50 mmHg), pulse rate of 48 beats per minute, and SpO2 level of 85% with room air. He was administered 10 mg of methylene blue intravenously as part of his treatment. Despite receiving the necessary medical interventions, he did not survive and was declared dead at 2:50 AM. Postmortem examination revealed that the stomach contained greyish-green fluid with an atypical smell, although the mucosa appeared pink (Figure 3A). Over time, both the contents and mucosa of the stomach turned green in color (Figure 3B, 3C). Additionally, the brain and kidneys exhibited greenish color changes after being exposed to the environment for some time (Figure 3D).

Figure 3. Greenish discoloration of organs. Gradual color changes (A-C) of stomach, intestine, brain, heart and kidney (D)
Rycina 3. Zielonkawe przebarwienie organów. Stopniowe zmiany koloru (A-C) żołądka, jelit, mózgu, serca i nerek (D)

Discussion

Aluminum phosphide is commercially available in various forms, including dark brown or grayish 3 gm tablets, 0.6 gm pellets, and powder. These are typically stored in sealed, air-tight containers and marketed under several trade names: Alphos, Bidphos, Celphos, Quickphos, Phosphotex, Phosphume, and Phosphotoxin. Despite advancements in the medical management of aluminum phosphide poisoning, certain aspects, particularly some clinical and pathological findings, remain poorly understood. In our study, we observed an unusual greenish discoloration in various organs, the exact mechanism of which remains unclear.

Differential diagnoses for postmortem findings should consider other conditions that could produce similar discolorations. Existing literature notes that certain cases treated with methylene blue exhibit similar organ color changes, though such changes are not documented in poisoning cases [6,7,8,9,10]. Hydrogen sulfide poisoning can cause green discoloration in all internal organs and, in rare cases, the brain, with hues ranging from blue-green to dark green [11,12,13]. Decomposition typically presents with external signs such as marbling, bloating, skin slippage, and purge fluid, alongside internal organ discoloration. Other differential diagnoses include purulent leptomeningitis or bile-pigment staining, particularly in areas where the blood-brain barrier is compromised in the setting of systemic hyperbilirubinemia/jaundice. However, these changes would not be expected to alter with exposure to air [10]. In our cases, the absence of both external and internal signs of putrefaction, along with the chemical analysis report, excluded the possibility of decomposition or hydrogen sulfide poisoning.

We also analyzed potential associations between the type of ingested substances, any additives consumed, or interactions with treatment, but found no clear correlation. One case was part of a group suicide where four family members consumed aluminum phosphide from the same source on the same day. Interestingly, only one individual exhibited organ discoloration, while the other three served as controls. Given that all four consumed the same poison, the discoloration is unlikely to be solely due to the aluminum phosphide, suggesting that individual metabolic differences or other compounds in the poison or treatment could have contributed to this phenomenon. In another case, treatment records indicated the administration of methylene blue, which has been implicated in similar discolorations in other contexts. However, other aluminum phosphide poisoning cases where methylene blue was administered did not exhibit any color changes, excluding a definitive association between methylene blue treatment and the green discoloration observed in our cases. Two cases involved the ingestion of aluminum phosphide in powder form under the brand name Celphos, containing 56% aluminum phosphide mixed with water. No additives or other agents were ingested, eliminating the possibility that the discoloration resulted from the concomitant ingestion of a colored substance.

The pattern of discoloration also differed across the three cases in terms of organ involvement, intensity, and speed of changes. In Case 1, the left kidney initially showed discoloration upon exposure to the environment, followed by the right kidney, lateral ventricles of the brain, and the heart. Eventually, the discoloration spread to the liver and stomach mucosa. In Case 2, only the heart and brain exhibited color changes, with no progression after 30 minutes. In Case 3, the mucosal surfaces of the stomach and intestines were the first to show discoloration, followed by a milder involvement of the brain and heart. The intensity of discoloration varied, with the kidneys showing the most pronounced changes in Case 1, while the heart and brain were most affected in Case 2, and the stomach and intestines in Case 3. Case 2 exhibited the most rapid onset of color changes compared to the other cases. This unique and varied presentation of greenish discoloration across different organs, along with differences in intensity and speed of progression, highlights the need for further research to understand the underlying mechanisms.

We also conducted a histopathological examination to further investigate this phenomenon. However, the examination of preserved samples revealed no microscopic pigmentation or specific histological changes that could explain the observed green discoloration. This finding suggests that the discoloration is not due to any detectable pigment at the microscopic level, highlighting the need for further investigation into the biochemical or metabolic processes responsible for this phenomenon.

The occurrence of green discoloration in these cases raises important questions for forensic and medical researchers, emphasizing the need for detailed studies to explore the pathophysiology of this rare presentation in aluminum phosphide toxicity. Moreover, documenting these findings in autopsy reports can facilitate retrospective analyses, contributing to a broader understanding of the clinical and pathological manifestations of aluminum phosphide poisoning.

Conclusion

While the ingestion of aluminum phosphide is well-documented to cause severe toxicity, including cardiovascular and respiratory failure, a lesser-known phenomenon of greenish organ discoloration has been observed during autopsy examinations. The presentation of these cases varied in terms of organ involvement, intensity, and rapidity of discoloration. The exact mechanisms behind this unusual discoloration remain largely unknown, highlighting a significant gap in our understanding of the pathophysiology of aluminum phosphide poisoning. This underscores the need for further research and a multidisciplinary approach, involving toxicologists, critical care physicians, and forensic pathologists, to enhance the clinical and forensic management of aluminum phosphide poisoning cases.

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