National Board of Examinations - Journal of Medical Sciences
Volume 3, Issue 11, Pages 1415–1423, November 2025
DOI 10.61770/NBEJMS.2025.v03.i11.011

CASE REPORT

Fatal Phosgene Inhalation: A Case Report

Vinukonda Enos Nikhil,[1,*] Mohit Kumar Moses Thathapudi[2] and Kattamreddy Ananth Rupesh[3]

[1]*Resident, Department of Forensic Medicine, Andhra Medical College, Visakhapatnam, Andhra Pradesh*
[2]*Assistant Professor of Forensic Medicine, Andhra Medical College, Visakhapatnam, Andhra Pradesh*
[3]*Assistant Professor of Forensic Medicine, Andhra Medical College, Visakhapatnam, Andhra Pradesh*

Accepted: 14-August-2025 / Published Online: 10-November-2025

Abstract

Phosgene ($COCl_2$) is widely used in the chemical industry for the manufacture of isocyanates, carbamates, insecticides, herbicides, chloroformates, and pharmaceutical compounds such as barbiturates. Historically, phosgene was also employed as a chemical warfare agent during World War I due to its potent respiratory asphyxiation effects. Nowadays, fatalities associated with phosgene inhalation typically result from accidental occupational exposure in industrial settings. We report two cases of fatal accidental phosgene inhalation at a pharmaceutical industry in Visakhapatnam city. A total of 33 individuals were exposed following a phosgene leak during the manufacture of the anti-retroviral drug lamivudine. Although all affected individuals received initial treatment and were discharged, two developed short term to delayed symptoms and subsequently succumbed to poisoning. Autopsy findings in both cases revealed laryngeal oedema; congested and heavy bluish discoloured lungs; congestion and petechial hemorrhages in the tracheal walls; mucosal erosions in the stomach; along with bluish discoloration and congestion of other viscera. Histopathological examination of the lungs showed congested blood vessels, alveolar spaces filled with inflammatory cells and eosinophilic material, disrupted alveolar septa, and pulmonary oedema. The chemical analysis of viscera detected phosgene and hence the cause of death was determined as phosgene poisoning. Phosgene is a potent respiratory irritant that triggers lipoxygenase-derived leukotriene synthesis, causing systemic inflammation and pulmonary edema. Industrial physicians must be vigilant, and strict safety protocols are essential to prevent accidental exposures. Timely hospitalization and appropriate treatment are critical, as delayed onset of symptoms may occur even after initial recovery.

Keywords: Phosgene, Occupational exposure, Industrial accident, Respiratory asphyxiant

*Corresponding Author: Vinukonda Enos Nikhil
Email: dr.enosnikhil@gmail.com

Introduction

Phosgene (Carbonyl dichloride, $COCl_2$, CAS No: 75-44-5, Molecular weight: 98.92 gm/mol) is a highly toxic, colourless gas with an odour resembling freshly cut hay. It was historically used as a chemical warfare agent in World War I, accounting for 80% of the 100,000 gas-related deaths [1,2]. It is used in the manufacture of pharmaceuticals, polycarbonates, dyes, isocyanates, pesticides, and polyurethane precursors [3]. Phosgene, typically a gas at ambient conditions, can be stored as a liquid under pressure or at low temperatures, and has also been utilized in certain ore separation processes. The manufacture of isocyanates consumes about 85% of the world's phosgene production. Phosgene can also be produced as a by-product of welding or combustion of chlorinated hydrocarbons like polyvinyl chloride (PVC) [3]. In the present scenario, phosgene remains an industrially significant chemical, with global production exceeding 5 billion pounds annually [3].

Phosgene is three times heavier than air, forming dense plumes that settle in low-lying areas. It has poor water solubility but hydrolyses in moisture to form hydrochloric acid and carbon dioxide, leading to severe tissue damage. Inhalation is the primary route of exposure in occupational settings. Phosgene exposure can occur in fires involving certain chlorinated organic compounds found in many household solvents, paint removers, and dry-cleaning fluids or wool, Polyvinyl chloride, and other plastics [1,4]. The estimated lethal dose of phosgene in humans is approximately 500 ppm/min. Equivalent fatal exposures include 3 ppm for 170 minutes or 30 ppm for 17 minutes [1,4]. OSHA PEL (TWA): 0.1 ppm (0.4 mg/m^3); OSHA STEL: none set; NIOSH REL (TWA): 0.1 ppm (0.4 mg/m^3); NIOSH ceiling (15-min): 0.2 ppm (0.8 mg/m^3); ACGIH TLV-C: 0.02 ppm (no TLV-TWA/STEL).

The severity of phosgene toxicity is dependent on several factors, including the dose, duration, and route of exposure, as well as the individual's age, health status, and preexisting medical conditions [4,5]. Phosgene exerts its toxic effects through protein acylation, disrupting enzyme function and the blood-air barrier. There is no biological marker that predicts the onset of phosgene induced pulmonary injury with certainty. In general, the exposure occurs in industrial settings, fires involving chlorinated compounds, and atmospheric emissions. Due to its delayed onset of symptoms, increased awareness is needed not only among safety personnel and industrial workers but also among healthcare professionals for prompt recognition, effective management, and timely emergency response.

Case report

The present incident of phosgene gas exposure occurred following a chemical spillage at a pharmaceutical unit involved in the manufacturing of the anti-retroviral drug lamivudine. Among the 33 individuals exposed inhalationally (over a period of approximately two hours), a 23-year-old male succumbed at home approximately 21 hours after exposure (patient A), while another individual, a 35-year-old male (patient B), was referred to the emergency department of a tertiary care centre; approximately 22 hours post-exposure. On admission, the patient was in severe respiratory distress and unconscious, with a Glasgow Coma Scale (GCS) score of 6T (E1, VT, M5). On Examination vitals are as

follows: PR:98 bpm, RR-24 rpm, BP- 90/60 mm of Hg on inotropes, Spo2- 80% on ventilator. Laboratory investigations revealed the following parameters: RBS: 106 mg/dl, PT: 15.1 Sec, Hb: 21.9 g/dl, WBC count: 30,200 cells/cu.mm, RBC Count: 7.8 cells/cu.mm, arterial pH of 7.1, partial pressure of oxygen (PaO_2) at 54 mmHg, partial pressure of carbon dioxide ($PaCO_2$) at 50 mmHg, bicarbonate (HCO_3^-) level of 12.7 mmol/L, and troponin I level of 91 meq/mL.

Arterial blood gas (ABG) analyses performed at two subsequent time intervals revealed progressively worsening values. At the first interval, the pH was 6.98, with a pCO_2 of 108 mmHg, pO_2 of 9 mmHg, and HCO_3^- of 16.1 mmol/L. At the second interval approximately three hours later, the pH further declined to 6.95, with a pCO_2 of 100 mmHg, pO_2 of 31 mmHg, and HCO_3^- of 14.1 mmol/L. Despite medical management, he succumbed to the toxic effects of phosgene gas 34 hours after exposure.

Subsequent police investigation revealed serious lapses in safety and reporting protocols. It was discovered that the management directed the workers to clean the chemical spillage without providing any personal protective equipment (PPE) (the ideal PPE in such situation is Fully encapsulating Level A chemical-protective suit with positive-pressure SCBA, chemical-resistant gloves, and boots). Furthermore, it is learnt that the incident was deliberately concealed and not reported to the appropriate authorities. Following initial first aid at the facility, the exposed workers were sent home without referral to higher medical centres for definitive care. Approximately nine hours after exposure, the two highly affected individuals began experiencing severe symptoms, prompting them to seek hospital care. Hence, a negligence case was registered by the police under 106(1), 125(a), 125(b), 239, 286 BNS and both the cases were sent for autopsy. It is noteworthy that both the deceased were young males without any comorbidities as per available history.

At autopsy, in both cases, laryngeal edema was noted. The trachea and bronchi showed congestion, purpura, and petechial hemorrhages in the walls. The lungs were bluish discoloured, heavy, congested, and oedematous, indicative of pulmonary edema (Figures 2-3). Mucosal erosions were noted in the stomach. The liver, kidneys, and spleen were congested. Along with the routine viscera samples involving the liver, kidneys, stomach, small intestine contents, blood; the entire left lung tied at hilum was placed in a plastic bag and sent to the Regional Forensic Science Laboratory (RFSL) immediately for assessment of inhalational poisoning. The right lung and the whole heart (Figure 1) were sent for histopathological examination.

Chemical analysis of viscera was qualitatively positive for phosgene. Histopathology of the heart was unremarkable, while the histopathological examination of the lungs revealed congested blood vessels, alveolar spaces filled with inflammatory cells and pink eosinophilic material, disrupted alveolar septa, and pulmonary edema (Figures 4-6). Based on the autopsy and histopathological findings, along with the chemical analysis of viscera, and taking into account the inquest and accident analysis conducted by the Chief Inspector of Factories, Visakhapatnam, the cause of death was opined as death due to phosgene poisoning in both the cases.

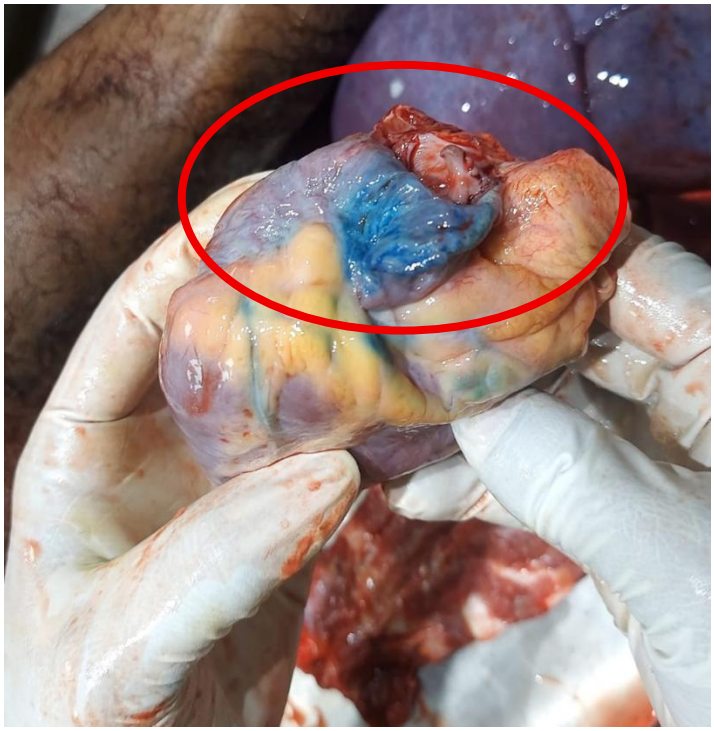

Figure 1. Bluish tinge on the outer surface of left auricle of the heart (patient A)

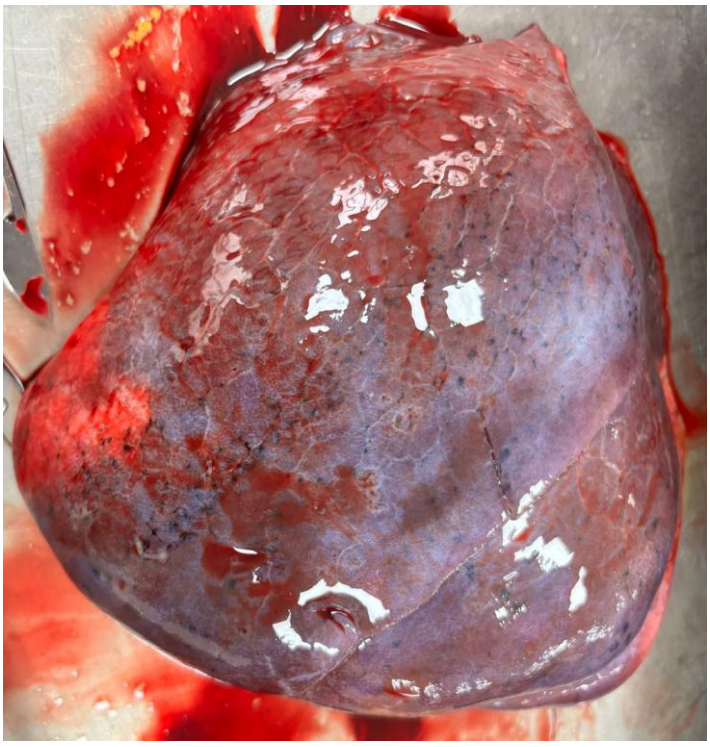

Figure 2. Heavy and voluminous right lung (patient B)

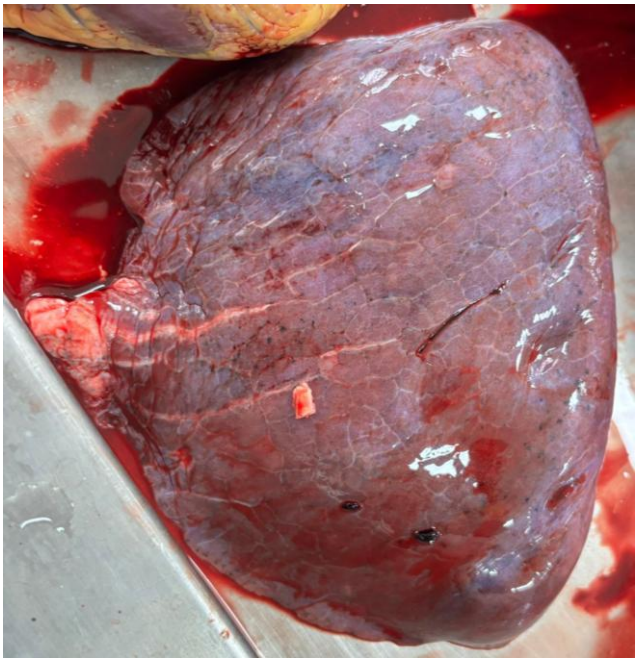

Figure 3. Heavy and voluminous left lung (patient B)

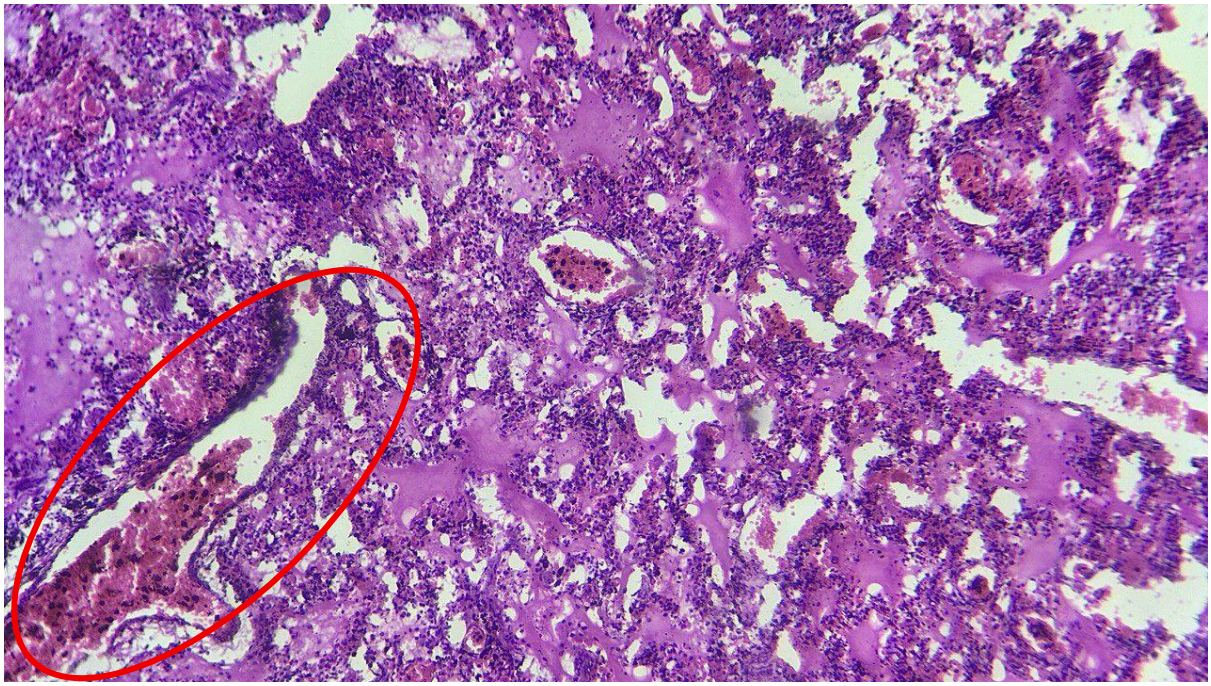

Figure 4. HPE Lung, H & E 100X, Congested blood vessels (patient A).

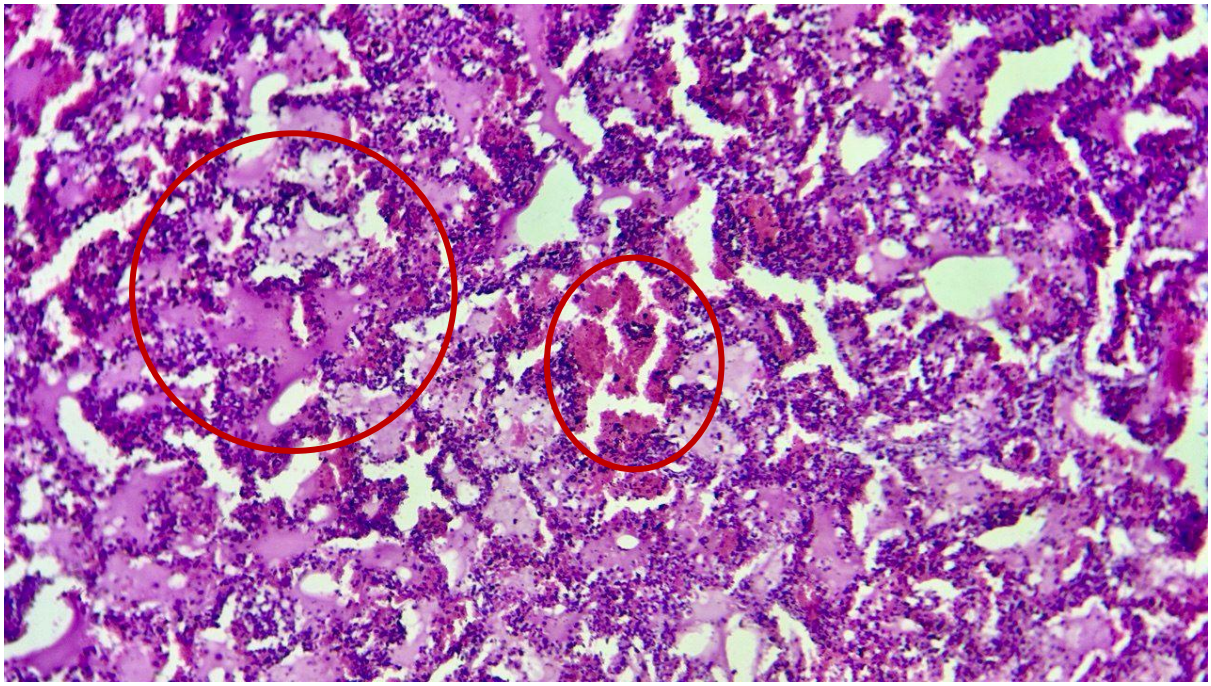

Figure 5. HPE Lung H & E 100X, Alveolar spaces filled with inflammatory cells, pink eosinophilic material in alveolar spaces (patient B).

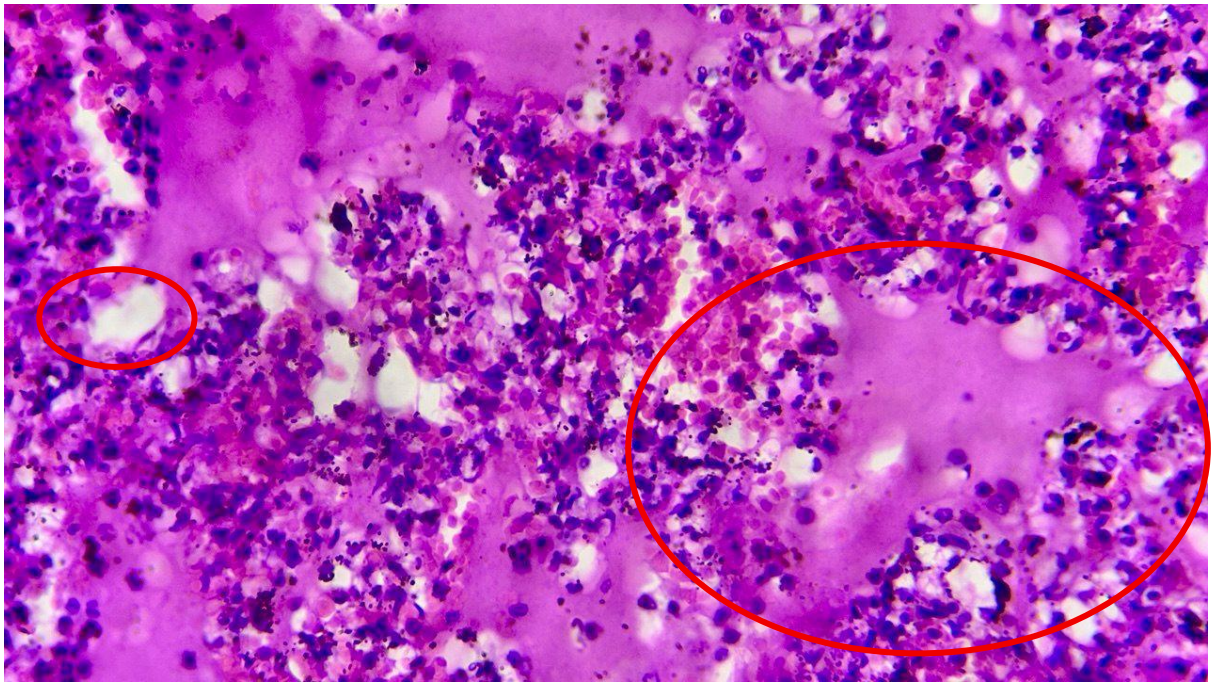

Figure 6. HPE Lung H & E 400X, Disrupted alveolar septa and pulmonary oedema (patient A)

Discussion

Phosgene ($COCl_2$) is a highly toxic respiratory asphyxiant. Upon inhalation, it reacts with moisture in the lungs to form hydrochloric acid (HCl) and carbon dioxide (CO_2). HCl damages the alveolar-capillary membrane, increasing permeability and leading to pulmonary edema. Toxicity arises via two primary mechanisms: hydrolysis and acylation. Hydrolysis results

in HCl and CO_2, but this accounts for only a portion of the damage under physiological conditions. The more harmful mechanism is acylation, wherein phosgene reacts with hydroxyl, thiol, amine, and sulfhydryl groups in proteins, lipids, and carbohydrates. This leads to oxidative injury, rapid glutathione depletion, and enhanced free radical damage. Furthermore, phosgene disrupts surfactant production, impairs gas exchange, and induces hypoxia [3]. The injury triggers an inflammatory response, exacerbating fluid accumulation and oxygenation impairment. Unlike immediate irritants such as chlorine, phosgene has a delayed onset of symptoms often up to 24 hours making early exposure deceptively mild.

At high concentrations, phosgene can cause severe pulmonary edema, acute respiratory distress syndrome (ARDS), and respiratory failure [1]. There is no specific antidote for phosgene poisoning. The treatment is primarily supportive, including oxygen therapy, mechanical ventilation, N-acetyl cysteine and corticosteroids to reduce inflammation [5].

In this industrial accident involving phosgene exposure, two out of the thirty-three exposed individuals succumbed to the delayed manifestation of toxic effects. The clinical presentation observed in the treated case (Patient B) included Type 1 respiratory failure, elevated haematocrit, leucocytosis, and pulmonary edema; findings consistent with those reported by Vaish et al. [2] in their case series. However, in contrast to the same case series, Troponin I levels were grossly elevated in Patient B, suggesting potential direct cardiac toxicity. Despite this, histopathological examination of the heart was unremarkable, which may be attributed to a shorter survival period in this case.

The ABG analysis in the present case showed severe respiratory acidosis with profound hypoxemia and partial metabolic compensation which is very typical of phosgene poisoning and is consistent with previous case reports [2-4]. The delayed onset non cardiogenic pulmonary oedema was evident in both the cases.

Bluish discoloration of the heart and lungs was a distinct finding in both cases of phosgene poisoning. In general, such discoloration is classically observed in methemoglobinemia, particularly due to nitrate, nitrite, or aniline poisoning [1]. In these poisonings, methylene blue is often administered as an antidote. It acts as an artificial electron carrier, reducing methaemoglobin back to functional haemoglobin via the NADPH-methaemoglobin reductase pathway. However, in the present cases, there was no history of methylene blue administration during management [6], suggesting that the observed discoloration was not related to methemoglobinemia or its treatment (methylene blue when administered at high doses can cause bluish discoloration of viscera).

While several clinical reports of phosgene poisoning document both survival and fatal outcomes, autopsy-based case studies are notably absent from the existing literature. This is one of the first reported autopsy case of phosgene poisoning in our region.

Phosgene-induced acute lung injury (P-ALI) is a condition in which inhalation of phosgene gas causes progressive pulmonary edema, respiratory distress, and hypoxemia that may lead to acute respiratory distress syndrome or death commonly associated with short-term phosgene inhalation. P-ALI is characterized

by pulmonary edema after 6–24 h of exposure, and its severity is dependent on the concentration × exposure duration. Fatalities associated with phosgene exposure predominantly occur in the early stage of severe P-ALI [7].

Phosgene exposure in industrial environments can be effectively minimized by establishing a comprehensive Safety Management System (SMS) that includes systematic hazard identification, risk assessment (HIRA), and periodic safety audits. Engineering measures such as fully enclosed equipment, gas detectors, and adequate ventilation are necessary along with administrative controls like clear standard operating procedures (SOPs), regular employee induction and refresher trainings, and clearly laid out emergency protocols. Plant equipment must incorporate both primary and secondary containment systems and be constructed with materials suitable for phosgene handling. Routine inspections, gas leak detection mechanisms, and pressure relief systems play a vital role in mitigating accidental releases. Likewise, appropriate personal protective equipment and dedicated breathing air systems are essential during maintenance and emergency interventions [8,9].

Conclusion

Phosgene is widely used in the manufacturing industry but is a highly hazardous chemical capable of causing severe lung injury, with both immediate and short term toxic effects following accidental exposure. Safety engineers and industrial physicians should be aware of the short term and delayed toxicity of phosgene inhalation to prevent morbidity and mortality associated with the industrial accidents.

In spite of its industrial relevance, phosgene toxicity remains insufficiently studied, and its underlying mechanisms are not fully understood. Further research is needed to explore new therapeutic strategies and repurpose existing drugs for the treatment of phosgene-associated lung injury (P-ALI). The potential for direct cardiac toxicity due to phosgene exposure warrants further investigation. In addition, the bluish discoloration of viscera observed in phosgene poisoning cases is an area of academic interest that may provide insights into its systemic effects.

Limitations

Radiological investigations were not performed in the admitted case as the patient was on mechanical ventilation and succumbed within a few hours of admission. Chemical analysis of the viscera qualitatively detected the presence of phosgene; however, quantitative analysis was not conducted. There is no verifiable data available pertaining to exact duration (assumed as about two hours as per police version) and dose of exposure, and the exact pre-existing health status of the deceased (we inferred as without any comorbidities).

The data pertaining to survivors of the industrial accident including their management, clinical outcomes and long term follow-up were not available. Phosgene as the causative factor of morbidity and mortality has been established independently by both the inquiry commission and the autopsy data. However, the authors have no access to the inquiry report.

Conflicts of interest

The authors declare that they do not have conflict of interest.

Funding

No funding was received for conducting this study.

Ethical considerations

All concerns were addressed by the authors. Consent for forensic autopsy in both the cases was obtained from law enforcement authorities.

References

1. Pillay VV. Modern Medical Toxicology. 4th ed. Hyderabad: Paras Medical Publisher; 2013.
2. Vaish AK, Consul S, Agrawal A, Chaudhary SC, Gutch M, Jain N, et al. Accidental phosgene gas exposure: A review with background study of 10 cases. J Emerg Trauma Shock. 2013;6(4):271-5. doi:10.4103/0974-2700.120372
3. Hardison LS, Wright E, Pizon AF. Phosgene exposure: A case of accidental industrial exposure. J Med Toxicol. 2014;10:51–6. doi:10.1007/s13181-013-0319-6.
4. TY S, Sudha TYD, Sasanka K, et al. Accidental phosgene poisoning: A case report and short review of management. Cureus. 2023;15(7):e41679. doi:10.7759/cureus.41679.
5. Asgari A, Parak MR, Hasani Nourian Y, Ghanei M. Phosgene toxicity clinical manifestations and treatment: a systematic review. Cell J. 2024;26(2):91-7. doi:10.22074/CELLJ.2024.2011864.1405.
6. Modarai B, Kapadia YK, Kerins M, Terris J. Methylene blue: a treatment for severe methaemoglobinaemia secondary to misuse of amyl nitrite. Emerg Med J. 2002;19(3):270–1. Available from: http://dx.doi.org/10.1136/emj.19.3.270
7. Cao C, Zhang L, Shen J. Phosgene-induced acute lung injury: Approaches for mechanism-based treatment strategies. Front Immunol. 2022;13:917395. doi:10.3389/fimmu.2022.917395.
8. PubChem. Phosgene. Nih.gov.. Available from: https://pubchem.ncbi.nlm.nih.gov/compound/Phosgene
9. Indian Phosgene Council. Phosgene safety guidelines: general safety guideline, best industrial practices and medical approach. Mumbai: Indianchemicalcouncil.com. Available from: https://www.indianchemicalcouncil.com/docs/PHOSGENE-SAFETY-GUIDELINES.pdf