Case Report

Accidental Chlorine Gas–Induced Acute Respiratory Distress Syndrome: A Case Series of Seven Patients from Bangladesh

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Abstract:

Chlorine gas is a potent pulmonary irritant capable of causing acute lung injury and acute respiratory distress syndrome (ARDS). Although accidental chlorine exposure is relatively common, severe hypoxemic respiratory failure requiring hospitalization is uncommon, and reports from Bangladesh are lacking. We describe the first reported Bangladeshi case series of seven patients admitted following accidental chlorine gas inhalation. All patients presented with acute respiratory distress and hypoxemia and received early supportive critical care, including supplemental oxygen or high-flow nasal cannula (HFNC) therapy, while one patient required brief non-invasive ventilation. Adjunctive treatment included intravenous methylprednisolone, bronchodilators, nebulized sodium bicarbonate, and antioxidants. None of the patients required invasive mechanical ventilation or extracorporeal membrane oxygenation, and all achieved complete clinical recovery without apparent residual complications. This case series highlights the importance of early recognition and prompt supportive management in achieving favorable outcomes and underscores the need for prospective studies to define the role of adjunctive therapies in chlorine-induced lung injury.

Keywords: *Chlorine gas, Corticosteroids, High-Flow Nasal Cannula (HFNC), Nebulized Sodium Bicarbonate.*

Introduction

Chlorine is a yellow-green, non-combustible gas with a pungent, irritating odor that is denser than air at ambient temperature. It is among the most widely produced industrial chemicals worldwide and is extensively used in the manufacture of solvents, pesticides, polymers, synthetic rubber, refrigerants, and plastics. In addition, chlorine serves as a bleaching agent in the pulp and paper industry and is widely employed for water disinfection and purification.[1,2]

Human exposure to chlorine gas occurs primarily through occupational and industrial settings, either as chronic low-level exposure or acute high-concentration exposure following accidental releases or improper handling. Owing to its widespread availability and high toxicity, chlorine has also been employed as a chemical warfare agent and in terrorist attacks.[3] Chlorine exposure also commonly occurs in domestic settings, particularly during the use or inadvertent mixing of household cleaning agents and disinfectants.[4]

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Acute chlorine gas inhalation primarily affects the respiratory tract, initially causing irritation of the eyes and upper airways, followed by cough, wheezing, chest tightness, dyspnea, and hypoxemia. Severe exposure may result in airway obstruction, bronchiolitis, reactive airways dysfunction syndrome (RADS), acute lung injury, and acute respiratory distress syndrome (ARDS).[2,4]

Chlorine gas release incidents occur worldwide, with most reported cases in developed countries resulting from industrial malfunctions, leaks, or explosions involving chlorine installations.[5,6] A retrospective surveillance study in the United States identified 865 chlorine gas release incidents across 16 states between 1993 and 2000, highlighting the substantial public health burden of accidental chlorine exposure.[5]

Following severe flooding, a chlorine leak occurred at a nearby water purification plant, in Dhaka Cantonment, Dhaka resulting in the accidental release of chlorine gas into an adjacent residential area. Because chlorine is denser than air, the gas accumulated close to the ground and entered the lower levels of a nearby residential building, exposing total 26 residents primarily on the ground and first floors to high concentrations. All 26 residents were immediately transferred to the Emergency Room of CMH Dhaka. Of these, 19 patients, who had minimal symptoms and did not require supplemental oxygen, were discharged home after several hours of observation. The remaining 7 patients subsequently developed acute respiratory symptoms and hypoxemic respiratory failure requiring supplemental oxygen. Their clinical presentation was consistent with chlorine-induced inhalational lung injury, necessitating hospital admission and intensive supportive care, as described in this case series.

To our knowledge, no published case reports of chlorine gas

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related health effects have originated from Bangladesh. We present the first reported case series of seven patients hospitalized following accidental chlorine gas exposure.

Cases:

Seven patients with clinically significant chlorine inhalation injury were admitted with hypoxemic respiratory failure. Their ages ranged from 19 to 47 years, and six were female. All patients demonstrated hypoxemia, with PaO_2/FiO_2 ratios ranging from 126.6 to 236.7, accompanied by bilateral pulmonary infiltrates consistent with acute inhalational lung injury. Cardiac biomarkers and echocardiographic findings showed no evidence of cardiac dysfunction or cardiogenic pulmonary edema. Based on the impaired oxygenation, characteristic chest radiographic findings, and absence of cardiac abnormalities, all patients were initially diagnosed with acute respiratory distress syndrome (ARDS) secondary to chlorine-induced inhalational lung injury, in accordance with the Berlin definition of ARDS.[6]

Table 1: Demographic, clinical, physiological, and laboratory characteristics, respiratory support, and clinical outcomes of the seven patients with acute chlorine inhalation injury

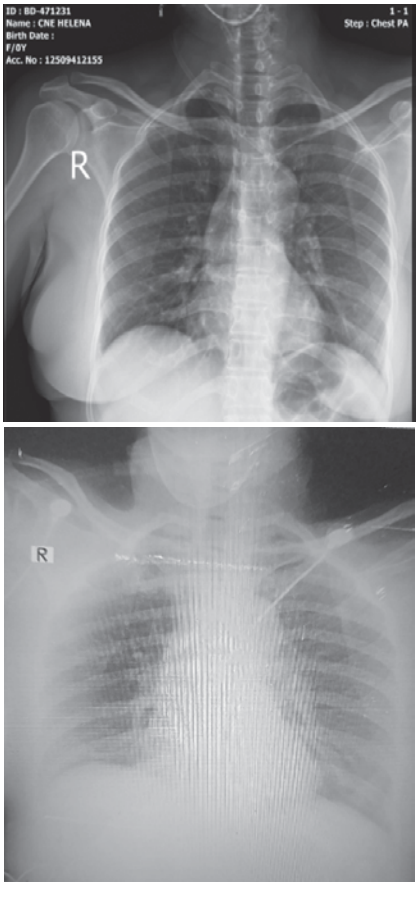
Variable	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Age/sex	47/F	37/F	20/F	40/F	30/F	19/F	41/M
Initial symptoms	Respiratory distress, blurred vision	Dyspnea, nausea, dysphagia, dizziness	Severe dyspnea, cough, dizziness	Dyspnea, nausea, vomiting	Dyspnea	Dyspnea, throat burning	Dyspnea, drowsiness
HR, bpm	100	102	80	106	115	108	82
BP, mmHg	100/70	100/60	110/70	90/60	100/60	100/60	110/80
RR, /min	22	26	26	30	18	26	20
SpO_2, %	98	90	90	98	95	95	98
Initial O_2 support	FM 8 L/min	FM 10 L/min	FM 8 L/min	FM 8 L/min	NC 3 L/min	FM 8 L/min	FM 5 L/min
pH	7.49	7.47	7.40	7.52	7.48	7.51	7.44
$PaCO_2$, Torr	32.7	34.8	37.6	32.5	34.3	33.0	34.4
PaO_2, Torr	83.1	77.2	81.1	77.3	78.1	85.7	80.4
HCO_3^-, mmol/L	25.1	25.4	23.0	26.7	25.3	26.7	23.1
FiO_2	0.53	0.61	0.53	0.53	0.33	0.53	0.41
PaO_2/FiO_2	156.8	126.6	153.0	145.8	236.7	161.7	196.0
WBC, $\times 10^9$/L	12.0	19.0	9.2	11.0	11.4	12.2	16.2
Platelets, $\times 10^9$/L	396	455	262	265	213	464	266
Creatinine, mg/dL	0.93	0.63	0.87	1.06	1.26	0.81	0.79
Procalcitonin, ng/mL	0.03	0.05	<0.05	0.03	0.20	0.05	<0.05
LVEF, %	62	65	62	60	69	62	64
Maximum respiratory support	FM O_2	BiPAP → HFNC	HFNC	HFNC	O_2	HFNC	FM/NC O_2
NIV	No	Yes	No	No	No	No	No
IMV	No	No	No	No	No	No	No
Hospital stay, days	14	10	10	9	6	8	7
Outcome	Discharged	Discharged	Discharged	Discharged	Discharged	Discharged	Discharged

Abbreviations: BP, blood pressure; FiO_2, fraction of inspired oxygen; FM, face mask; HFNC, high-flow nasal cannula; HR, heart rate; IMV, invasive mechanical ventilation; LVEF, left ventricular ejection fraction; NC, nasal cannula; NIV, non-invasive ventilation; $PaCO_2$, arterial carbon dioxide tension; PaO_2, arterial oxygen tension; RR, respiratory rate; SpO_2, peripheral oxygen saturation.

The clinical course was generally favorable with supportive management. Five patients required high-flow nasal cannula (HFNC) therapy, while one patient (Case 2) required brief non-invasive ventilation with BiPAP followed by HFNC; the remaining patients were managed with supplemental oxygen alone. None required invasive mechanical ventilation. Case 2 had a history of bronchial asthma and hypothyroidism, Case 5 had bronchial asthma and diabetes mellitus, and Case 6 had iron-deficiency anemia. Case 7 was notable for drowsiness and disorientation at presentation. All patients received supportive therapy, including oxygen supplementation, corticosteroids, nebulized sodium bicarbonate, and other adjunctive treatments as described in the manuscript. All patients improved clinically and were discharged home after a hospital stay of 6–14 days.

Case 1

A 47-year-old female reported to the emergency and casualty center of Combined Military Hospital (CMH) Dhaka with complaints of accidental inhalation of gas with respiratory distress, blurring of vision since morning. Her chest radiographs and HRCT scan are shown below.



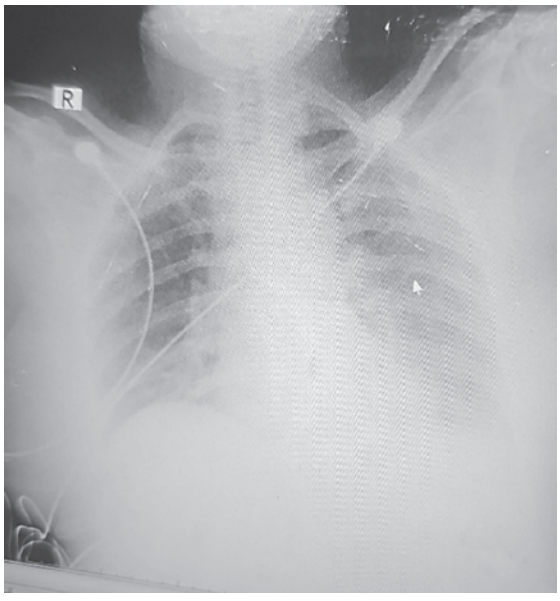


Figure 1: Serial chest radiographs following acute chlorine gas exposure. (A) Initial chest radiograph demonstrating mild bilateral patchy bibasal air-space opacities. (B) Repeat radiograph showing progression to bilateral diffuse perihilar and lower-zone alveolar infiltrates. (C) Further worsening with extensive bilateral pulmonary opacification

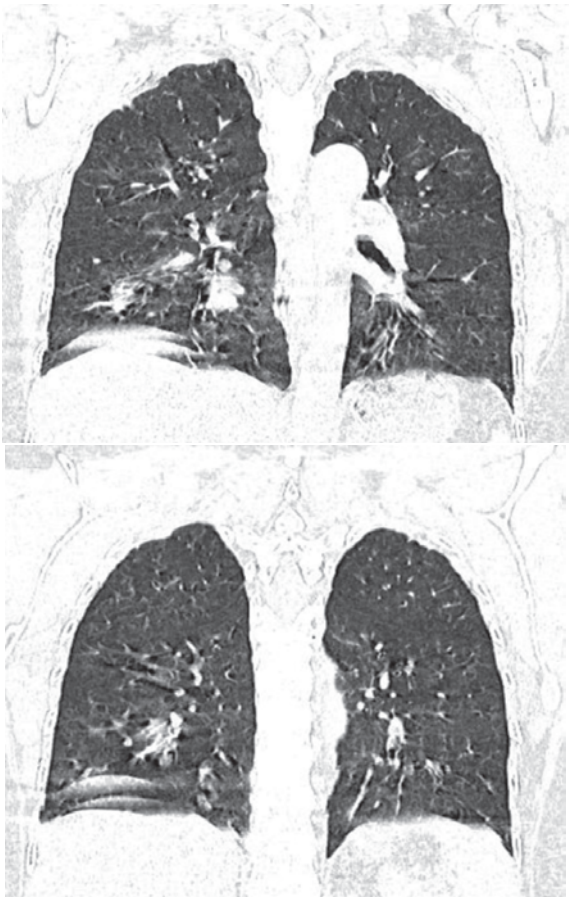


Figure 2: HRCT chest showing ground glass opacities are noted in posterior basal segment of both lower lobes.

The patient was initiated on injectable broad-spectrum antibiotics, Injection methyl prednisolone, nebulized sodium bicarbonate solution, nebulized salbutamol and antioxidants. With conservative management, the patients' pulmonary status gradually improved. Later patient was discharged home on hospital day 14.

Case 2

A 37-year-old female reported to the emergency and casualty center of Combined Military Hospital (CMH) Dhaka with complaints of shortness of breath, nausea, dysphagia, dizziness following accidental inhalation of chlorine gas. Her chest radiographs are shown below.

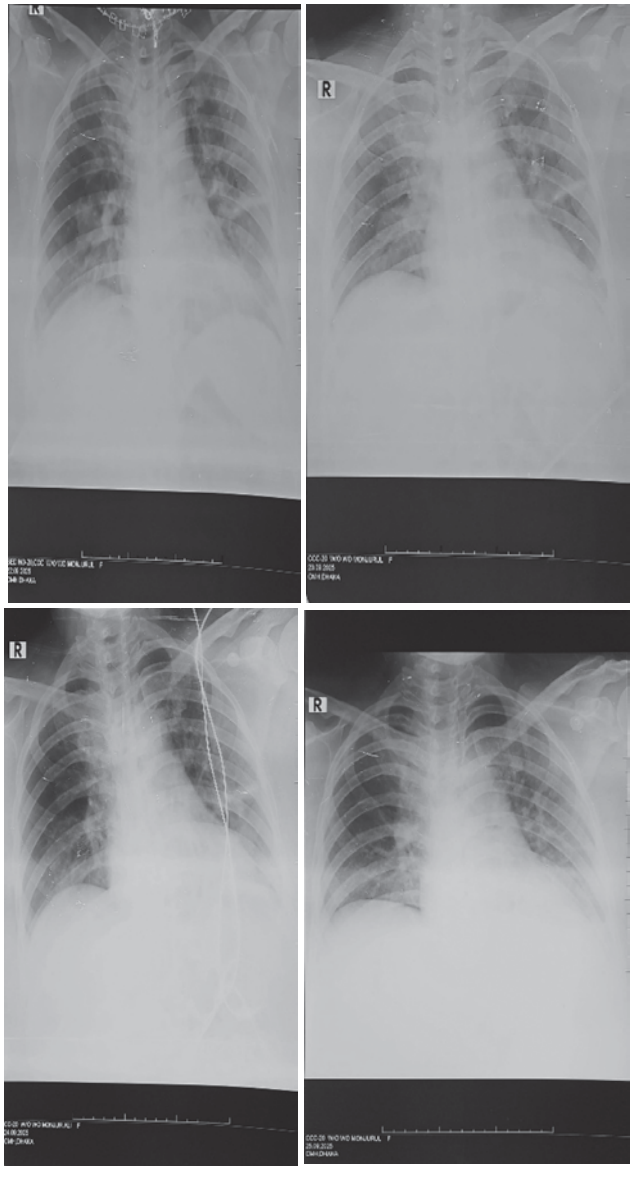


Figure 3: Serial chest radiographs showing bilateral patchy perihilar and basal air-space opacities, followed by progression to diffuse bilateral alveolar infiltrate, with subsequent interval radiographic improvement during recovery.

The patient was initiated on injectable broad-spectrum antibiotics, Injection methyl prednisolone, nebulized sodium bicarbonate solution, nebulized salbutamol and antioxidants. The patient needed bilevel positive airway pressure BiPAP with 100% oxygen followed by high-flow nasal cannula (HFNC) for humidified oxygen support for severe hypoxia. With supportive treatment, the patient's respiratory status and radiographic findings gradually improved. Later patient was discharged home on hospital day 10.

Case 3

A 20-year-old female reported to the emergency and casualty center of Combined Military Hospital (CMH) Dhaka with complaints of severe shortness of breath, cough and dizziness following accidental inhalation of chlorine gas. Her chest radiographs are shown below.

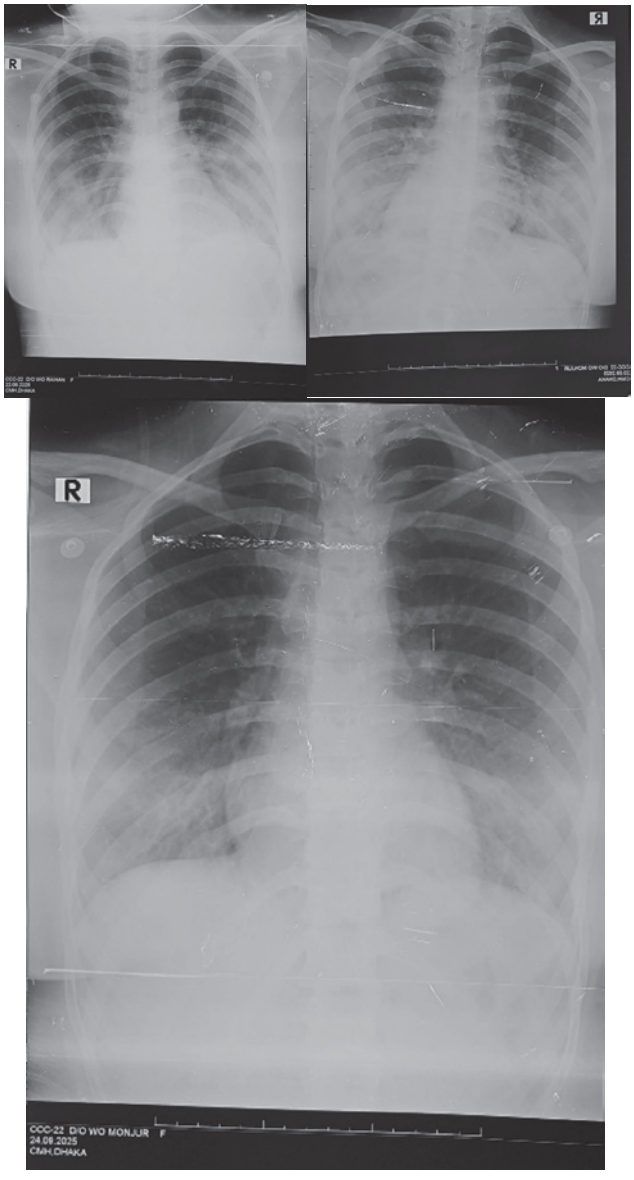


Figure 4: Serial chest radiographs demonstrating bilateral patchy bi-basal and perihilar air-space opacities, followed by gradual radiographic resolution

The patient was initiated on injectable broad-spectrum antibiotics, Injection methyl prednisolone, nebulized sodium bicarbonate solution, nebulized salbutamol and antioxidants. The patient needed HFNC with humidified oxygen. The patients showed gradual improvement in lung function with supportive conservative treatment. Later patient was discharged home on hospital day 10.

Case 4

A 40-year-old female reported to the emergency and casualty center of Combined Military Hospital (CMH) Dhaka with complaints of shortness of breath, nausea, vomiting following accidental inhalation of chlorine gas. Her chest radiographs are shown below.

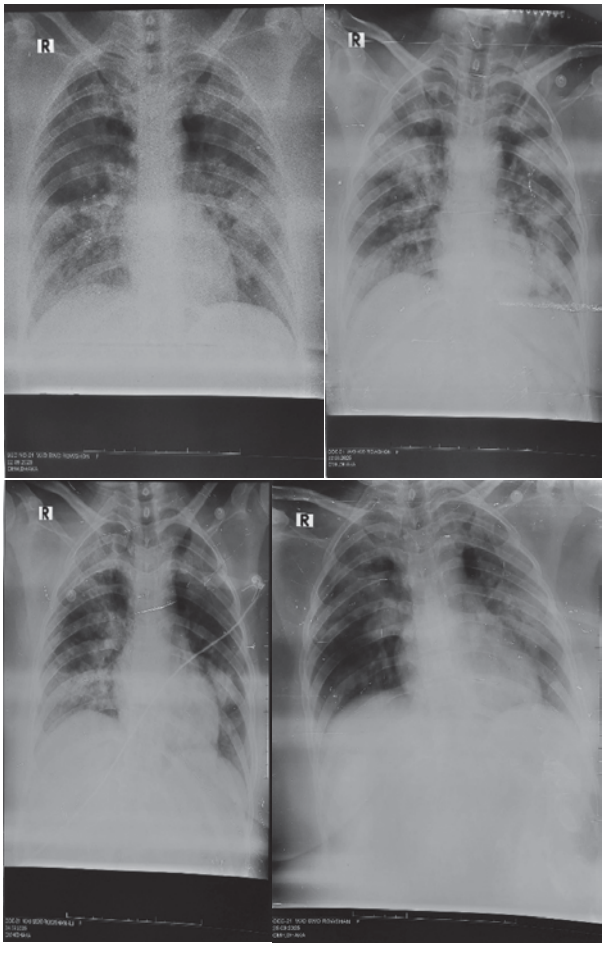


Figure 5: Serial chest radiographs demonstrating bilateral patchy bi-basal and perihilar air-space opacities, followed by progression to diffuse bilateral multifocal alveolar infiltrates. Subsequent radiographs demonstrated interval radiographic improvement.

The patient was initiated on injectable broad-spectrum antibiotics, Injection methyl prednisolone, nebulized sodium bicarbonate solution, nebulized salbutamol and antioxidants. The patient required high-flow nasal cannula (HFNC) support for hypoxemia. Conservative treatment resulted in progressive improvement in pulmonary function and respiratory status. Later patient was discharged home on hospital day 9.

Case 5

A 30-year-old female reported to the emergency and casualty center of Combined Military Hospital (CMH) Dhaka with complaints of shortness of breath following accidental inhalation of chlorine gas. Her chest radiographs are shown below.

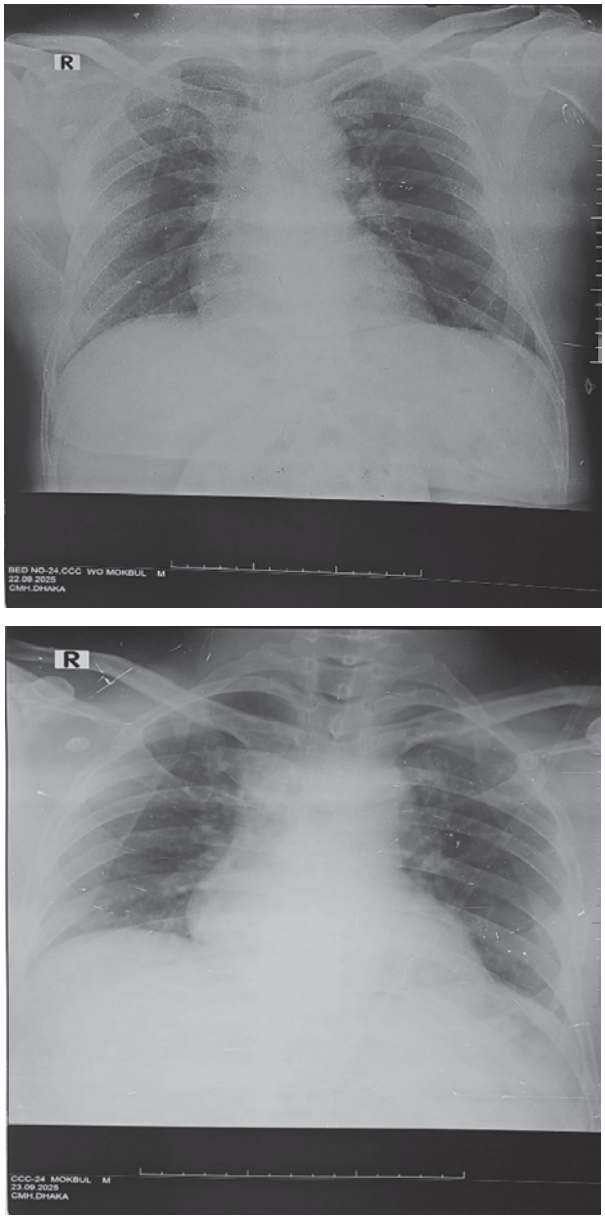


Figure 6: Serial chest radiographs showing mild bilateral perihilar and bibasal air-space opacities, with stable to improving radiographic appearance on follow-up

The patient was initiated on injectable broad-spectrum antibiotics, Injection methyl prednisolone, nebulized salbutamol, nebulized sodium bicarbonate solution and antioxidants. Gradual clinical and radiological improvement was observed following conservative management. Later patient was shifted to ward on hospital day 5 and discharged home on hospital day 6.

Case 6

A 19-year-old female reported to the emergency and casualty center of Combined Military Hospital (CMH) Dhaka with complaints of shortness of breath, burning sensation on throat following accidental inhalation of chlorine gas. Her chest radiographs are shown below.

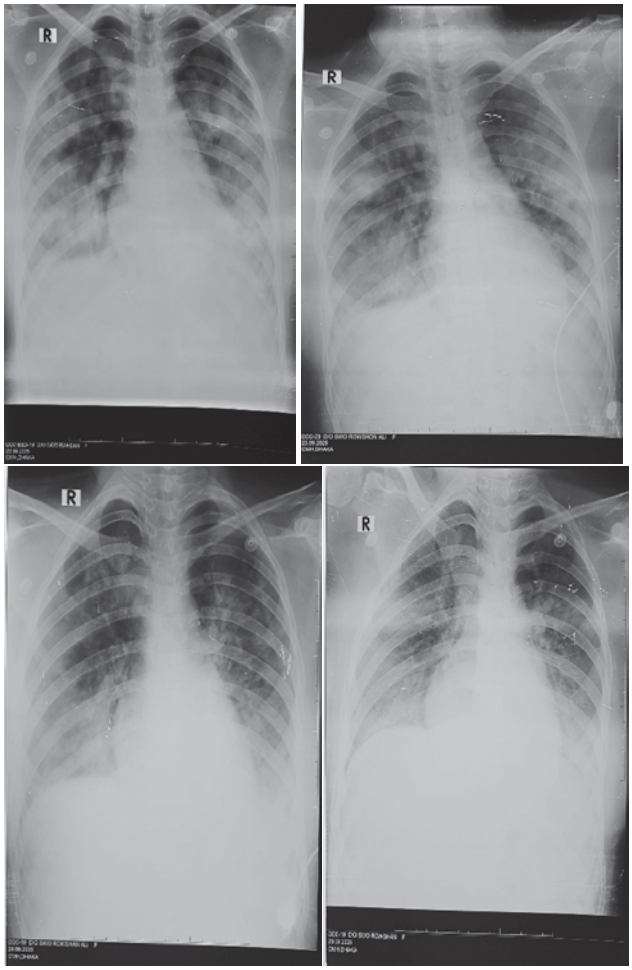


Figure 7: Serial chest radiographs illustrating bilateral bi-basal air-space opacities that progressed to diffuse bilateral patchy perihilar and lower-zone infiltrates, followed by gradual radiographic resolution after conservative treatment.

The patient was initiated on injectable broad-spectrum antibiotics, Injection methyl prednisolone, nebulized sodium bicarbonate solution, nebulized salbutamol and antioxidants. The patient required high-flow nasal cannula (HFNC) support for hypoxemia. The pulmonary abnormalities progressively resolved with conservative treatment and supportive care. Later patient was discharged home on hospital day 8.

Case 7

A 41-year-old male reported to the emergency and casualty center of Combined Military Hospital (CMH) Dhaka with complaints of shortness of breath, drowsiness following accidental inhalation of chlorine gas. His chest radiographs are shown below.

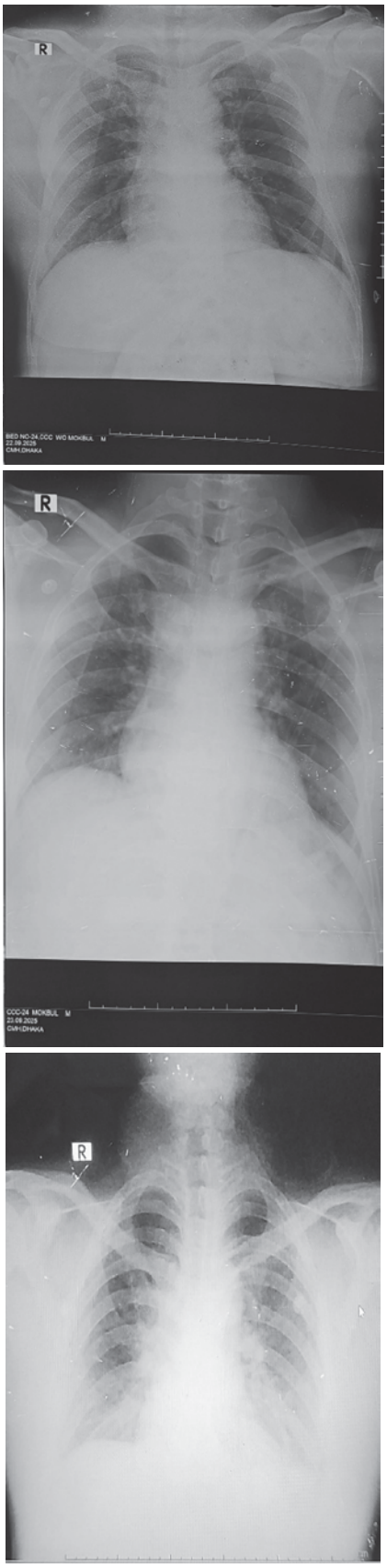


Figure 8: Serial chest radiographs demonstrating bilateral patchy perihilar and bi-basal air-space opacities.

The patient was initiated on injectable broad-spectrum antibiotics, Injection methyl prednisolone, nebulized sodium bicarbonate solution and antioxidants. The patient needed oxygen support via oxygen via face mask and nasal cannula for hypoxia. With supportive conservative management, the patients demonstrated steady improvement in respiratory function and lung findings. Later patient was discharged home on hospital day 7.

Discussion:

Chlorine poisoning may result from industrial or transportation accidents, swimming pool disinfection system failures, military exposure, or the misuse of household cleaning agents.[1,2] Chlorine poisoning occurs either from direct chlorine gas exposure or from chlorine released during reactions involving hypochlorite-containing products and acids.[2] The severity of chlorine toxicity is concentration- and exposure-dependent. Chlorine odor is detectable at approximately 0.2 ppm, mucosal irritation occurs at 3–15 ppm, prolonged exposure to 15–150 ppm may cause chronic respiratory injury, and exposure to 400–500 ppm for more than 30 minutes is potentially fatal.[7]

Management of acute chlorine inhalation primarily consists of supportive care, including humidified oxygen, bronchodilators, and corticosteroids (inhaled or intravenous). Additional therapies such as inhaled sodium bicarbonate and antioxidants have been used in selected cases to mitigate toxic lung injury and systemic inflammation. Experimental studies have identified TRPV4 inhibitors, dimethylthiourea, and rolipram as potential therapies for chlorine-induced lung injury; however, none has yet been translated into clinical practice.[8,9] The role of glucocorticoids in acute chlorine inhalation remains controversial, with limited high-quality evidence supporting their routine use. All patients received intravenous methylprednisolone and experienced favorable clinical outcomes; however, the contribution of corticosteroid therapy cannot be determined from this uncontrolled case series. Corticosteroids may attenuate chlorine-induced pulmonary inflammation and capillary leak; however, their efficacy requires confirmation in larger prospective studies.[8] Management of hypoxemia and respiratory failure following chlorine inhalation is primarily supportive and includes humidified oxygen therapy, non-invasive ventilation, invasive mechanical ventilation, and, in refractory cases, extracorporeal membrane oxygenation (ECMO).[8,9,10] In our series, three patients were managed with conventional supplemental oxygen, three patients required HFNC therapy, and one patient required brief non-invasive ventilation with BiPAP followed by HFNC. None of the patients required invasive mechanical ventilation or extracorporeal membrane oxygenation. All patients demonstrated marked clinical improvement, with hospital stays ranging from 6 to 14 days. These findings underscore the importance of early supportive management focused on optimizing oxygenation, controlling inflammation, preserving lung function, preventing pulmonary edema, and maintaining vital organ function.

Emergency management of acute chlorine inhalation consists of prompt removal from the exposure source, airway stabilization, humidified oxygen therapy, and ventilatory support when indicated. Additional treatment is supportive, including bronchodilators, short-course corticosteroids, maintenance of fluid, electrolyte, and acid–base balance, and preservation of vital organ function. Routine antibiotic therapy is not recommended for acute chlorine inhalation in the absence of evidence of bacterial infection. In this case series, all patients received empirical antibiotics to prevent secondary bacterial infection, given the severity of the radiographic infiltrates and the high incidence of secondary bacterial infections observed in our setting. This practice is routinely followed in our ICU. The roles of prophylactic antibiotics and corticosteroids remain uncertain and warrant further investigation in prospective clinical studies. Nebulized sodium bicarbonate has been explored as a potential therapy to neutralize airway acidity following chlorine inhalation; however, its optimal dosing and clinical efficacy remain uncertain. In our case series, nebulized 7.5% sodium bicarbonate was administered at a dose of 2 mL diluted with 2 mL of sterile water every 6 hours in our institution. An experimental study demonstrated that antioxidant therapy reduced mortality by approximately fourfold in rats following chlorine gas exposure compared with untreated controls.[11] Relying on this finding, we administered injectable ascorbic acid to all patients during hospitalization. Likewise, emerging therapies, including TRPV4 antagonists, dimethyl thiourea, and rolipram, remain experimental and have not yet been validated for routine clinical use.[9]

The prognosis of chlorine gas–induced ARDS is generally favorable, with rapid and complete recovery in most patients. Previous studies have shown that pulmonary function often returns to normal, even after exposure to high concentrations of chlorine gas.[12,13,14] The patients in this case series were also discharged within 14 days after their rapid recoveries. However, there is also a case report where an asthma case that was found in a follow-up after a year was successfully treated,[15] and another report where workers who were exposed to chlorine during pulp mill processes experienced bronchial hyperresponsiveness and respiratory symptoms up to 18–24 months after the exposure.[13] This suggests the need for long-term follow-up, which was not done in our cases.

A major limitation of our study was the inability to quantify airborne chlorine concentrations at the exposure site. Objective exposure assessment is often challenging following accidental community chemical releases, yet accurate exposure measurements are crucial for correlating exposure intensity with clinical outcomes. These findings underscore the importance of timely environmental monitoring during such incidents to facilitate both appropriate public health interventions and accurate evaluation of health effects.

Conclusion:

Accidental chlorine gas inhalation can cause severe acute respiratory distress and hypoxemic respiratory failure, requiring hospitalization and intensive supportive care. Early recognition, prompt oxygen therapy, appropriate respiratory support, and multidisciplinary critical care were associated with favorable outcomes in our case series, with all patients

achieving complete clinical recovery without invasive mechanical ventilation. Although corticosteroids, nebulized sodium bicarbonate, antioxidants, and prophylactic antibiotics were used, their therapeutic roles remain uncertain and require validation in well-designed prospective studies. As the first reported case series of chlorine gas inhalation injury from Bangladesh, our findings highlight the need for increased awareness, timely environmental exposure monitoring, and standardized management protocols for accidental chlorine gas exposure.

Informed Consent

Written informed consent was obtained from all patients for publication of their clinical information and relevant images.

Ethical Approval/IRB

Ethical approval was obtained from the Ethical Committee/ Institutional Review Board of CMH Dhaka with Ser number: 259

Conflict of Interest

The authors declare that they have no conflicts of interest related to this work.

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Author Contributions

Author 1 contributed to the conception and design of the study, data collection, data analysis, and manuscript preparation. Author 2,3,4 contributed to clinical management, and critical revision of the manuscript. All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Data Availability

The data supporting the findings of this case series are available from the corresponding author upon reasonable request. Due to patient confidentiality and ethical considerations, individual patient-level data are not publicly available.

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