ISSN: 2754-6667

Journal of Critical Care & Emergency Medicine

SCIENTIFIC Research and Community

Case Report

Open Access

Sodium Bicarbonate Irrigation for Dissolving Obstructive Bronchial Clots in a Polytrauma Patient: A Case Report

Hana Bahraldeen Felemban[1*], Elman Azizov Firudin[2], Feras Fahad Alris[2], Zeinab Abdelrahman Khalid[3], Mohammed Elmukhtar Abdelgadir[3], Bandar Farhan Alruwaili[4], Al-Nagem Sampang Saidil[4], Ali Hussain Alabbad[4] and Bassam Shyhan Alshammari[5]

[1]Hana Bahraldeen Felemban, Prince Mutaib Bin Abdulaziz Hospital, General Surgery & Critical Care Consultant, Head of the Intensive Care Unit, Sakaka-Aljouf, Saudi Arabia

[2]Elman Azizov Firudin, Prince Mutaib Bin Abdulaziz Hospital, Registrar Critical Care, Sakaka-Aljouf, Saudi Arabia

[2]Feras Fahad Alris, Prince Mutaib Bin Abdulaziz Hospital, Registrar Critical Care, Sakaka-Aljouf, Saudi Arabia

[3]Zeinab Abdelrahman Khalid, Prince Mutaib Bin Abdulaziz Hospital, Resident Critical Care, Sakaka-Aljouf, Saudi Arabia

[3]Mhammed Elmukhtar Abdelgadir, Prince Mutaib Bin Abdulaziz Hospital, Resident Critical Care, Sakaka-Aljouf, Saudi Arabia

[4]Bandar Farhan Alruwaili, Prince Mutaib Bin Abdulaziz Hospital, Respiratory Therapy, Sakaka-Aljouf, Saudi Arabia

[4]Al-Nagem Sampang Saidil, Prince Mutaib Bin Abdulaziz Hospital, Respiratory Therapy, Sakaka-Aljouf, Saudi Arabia

[4]Ali Hussain AlabbadPrince Mutaib Bin Abdulaziz Hospital, Respiratory Therapy, Sakaka-Aljouf, Saudi Arabia

[5]Bassam Shyhan Alshammari, Prince Mutaib Bin Abdulaziz Hospital, Registered Critical Care Nurse, Prince Mutaib Bin Abdulaziz Hospital, Sakaka, Saudi Arabia

ABSTRACT

The management of bronchial clots in polytrauma patients remains challenging, with limited efficacy of current methods. This case report details the successful use of sodium bicarbonate ($NaHCO_3$) irrigation to dissolve obstructive bronchial clots in a 27-year-old male with ARDS secondary to trauma. Pre-intervention, the patient exhibited severe hypoxemia with a P/F ratio of 50, requiring FiO_2 60% and PEEP 10 cmH_2O. Bronchoscopic irrigation with 8.4% $NaHCO_3$ dissolved organized clots resistant to saline lavage, facilitating their removal. Within 48 hours, oxygenation improved significantly, with a P/F ratio rising to 230. By day 11, the patient was successfully extubated and maintained stable respiratory parameters. This case highlights the potential utility of $NaHCO_3$ in addressing complex respiratory complications, warranting further research.

***Corresponding author**

Hana Bahraldeen Felemban, Head of the Intensive Care Unit at Prince Muteb bin Abdulaziz Hospital, Skaka-Aljouf, Saudi Arabia.

Received: December 31, 2024; **Accepted:** January 03, 2025; **Published:** January 10, 2025

Keywords: Sodium Bicarbonate, $NaHCO_3$, Bronchoscopy, Bronchial Clot, Trauma, Polytrauma, Hypoxemia, Acute Respiratory Distress Syndrome, ARDS

Introduction

Hypoxemia is a critical complication in polytrauma patients and a precursor to acute respiratory distress syndrome (ARDS). ARDS is characterized by severe inflammation, increased pulmonary vascular permeability, and reduced lung compliance, leading to hypoxemia that is refractory to conventional oxygen therapy [1]. Early identification and management are essential to improve patient outcomes, particularly in cases where airway obstruction exacerbates oxygenation issues.

Bronchial clots, though less commonly reported, are a significant cause of airway obstruction in trauma patients. These clots, composed of fibrin-rich material, are particularly resistant to conventional fibrinolytic processes, complicating mechanical ventilation and exacerbating hypoxemia. Traditional clot management techniques, including saline lavage, mechanical retrieval, and cryoextraction, often fall short in addressing organized clots due to their dense and adherent nature [2,3]. This highlights the need for alternative strategies to ensure airway patency and restore effective gas exchange.

Sodium bicarbonate ($NaHCO_3$), widely used for its buffering capabilities in metabolic acidosis, has demonstrated promise as a clot-dissolving agent in other medical contexts, including urinary and gastrointestinal applications [4,5]. By chemically disrupting fibrin matrices, $NaHCO_3$ provides a novel, minimally invasive option for dissolving organized clots, potentially reducing the risks associated with mechanical methods.

This report presents the case of a 27-year-old male with ARDS secondary to polytrauma, successfully treated with sodium bicarbonate irrigation to resolve obstructive bronchial clots. This intervention highlights the potential utility of $NaHCO_3$ as an adjunctive therapy in the critical care setting, emphasizing the need for further research to establish its role in managing complex respiratory complications.

Case Presentation

A 27-year-old male was admitted to the emergency department following a severe traffic accident on February 8, 2024. He presented with altered consciousness, bleeding from the mouth and right ear, suggestive of a basilar skull fracture. Due to rapidly declining consciousness, he was intubated and mechanically ventilated, maintaining SpO_2 at 99%. Given the severity of his injuries, he was transferred to a Level 3 trauma center on day two of admission.

Upon arrival at the trauma center, the patient was hemodynamically unstable, requiring inotropic support. Computed tomography revealed multiple injuries, including an open left leg fracture and a subdural hematoma. He underwent emergent surgical evacuation of the hematoma to address intracranial hypertension.

Postoperatively, the patient was transferred to the intensive care unit. On February 13, 2024 (day 5 post-admission, Figure 5A), he remained mechanically ventilated with FiO_2 60% and PEEP 10 cmH_2O, maintaining SpO_2 at 97%. Chest CT showed progression of lung consolidations with air bronchograms, predominantly in the lower lobes. (Figure 1) Based on a PaO_2/FiO_2 ratio of 50 and chest imaging findings, the patient was diagnosed with ARDS.

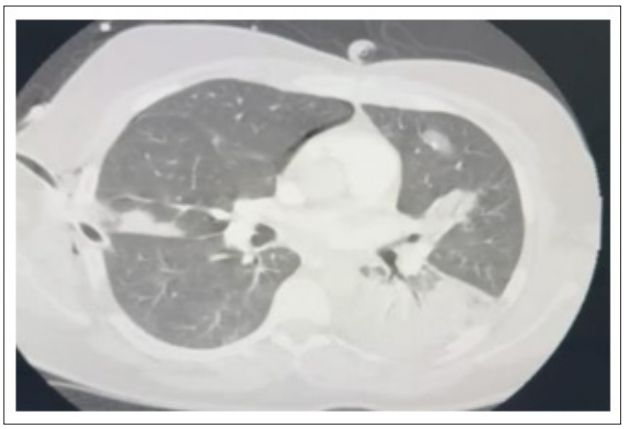

Figure 1: Computed Tomography (CT) Scan of the Patient Showing Lung Consolidation

On day 7 of admission, bronchoscopy was performed. The procedure revealed bilateral blood clots at the 20 cm level of the bronchus (Figures 2 and 3). Initial attempts to retrieve the clots using normal saline lavage proved difficult. Subsequently, $NaHCO_3$ irrigation was employed, which successfully dissolved the clots, facilitating their removal by suction. Tracheal lavage was collected for culture.(Figure 4) The patient tolerated the procedure well, and a post-bronchoscopy chest radiograph was ordered (Figure 5B) [6].

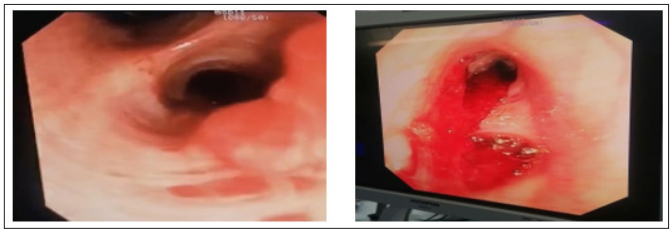

Figure 2,3: Bronchoscopy Image Showing Blood Clots at a Level of 20 cm

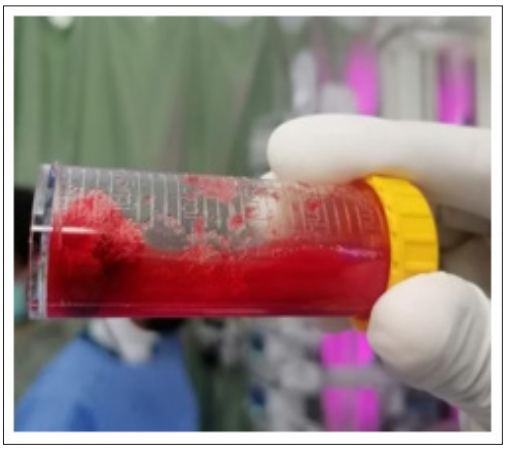

Figure 4: Clots Came from Patient during Bronchoscopy

By February 15, 2024 (day 7 post-bronchoscopy Figure 5C), the patient showed signs of improvement. While still requiring mechanical ventilation in pressure-control mode, his FiO_2 was reduced to 40% and PEEP to 9 cmH_2O. His P/F ratio improved to 230. Sedation was maintained with low-dose midazolam and fentanyl (150 µg/hr). His condition remained stable on days 9 and 10 (February 16-17), with blood gas analysis showing acceptable values (pH 7.48, PCO_2 38 mmHg, HCO_3 28.3 mEq/L, P/F ratio 186). Ventilator support was transitioned to Adaptive Pressure Ventilation - Controlled Mandatory Ventilation Mode, with FiO_2 30% and PEEP 8 cmH_2O. On day 11, the patient was successfully extubated.

Table 1: The Patient's Key Respiratory Parameters

Day	Mode of Ventilation	FiO_2 (%)	PEEP (cmH_2O)	pH	$PaCO_2$ (mmHg)	PaO_2 (mmHg)	P/F Ratio
3	CMV	100	10	7.32	48	50	50
4	CMV	100	10	7.28	52	45	45
5	CMV	100	10	7.25	55	50	50
7	PCV	60	10	7.35	45	65	108
8	PCV	50	9	7.40	40	90	180
9	APV-CMV	40	9	7.42	38	100	250
10	APV-CMV	30	8	7.48	38	110	367
11	Extubated	-	-	-	-	-	-

Table 1: The Following Table Summarizes the Patient's Key Respiratory Parameters over the 11-day Period. The Patient Initially Experienced Severe Hypoxemia, Reflected by the Low PaO_2 and P/F Ratio on days 3-5, Requiring High FiO_2 (100%) and PEEP 10 cmH_2O while on Controlled Mandatory Ventilation. Following Bronchoscopy and Clot Removal on day 7, his Oxygenation Significantly Improved, allowing for Gradual Weaning of FiO_2 and PEEP. The Improvement in P/F Ratio from 50 on day 5 to 108 on day 7, and Further to 367 by day 10, Demonstrates the Effectiveness of the Intervention. The Transition to Adaptive Pressure Ventilation - Controlled Mandatory Ventilation Mode further Facilitated Respiratory Recovery, Culminating in Successful Extubation on day 11. The $PaCO_2$ Values Indicate Initial Hypercapnia, which resolved with improved Ventilation. The pH also normalized following the procedure.

Figure 5A: Chest X-ray Feb 13, 2024 D5 of Trauma Showing Consolidation

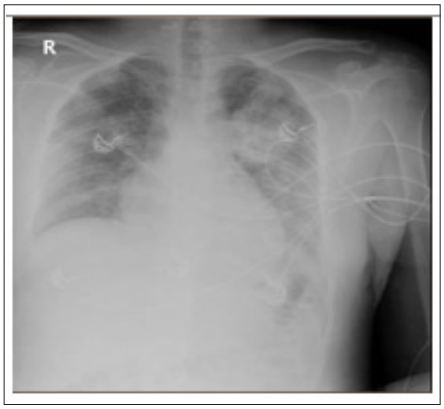

Figure 5B: Chest X-ray after Bronchoscopy Feb 14, 2024

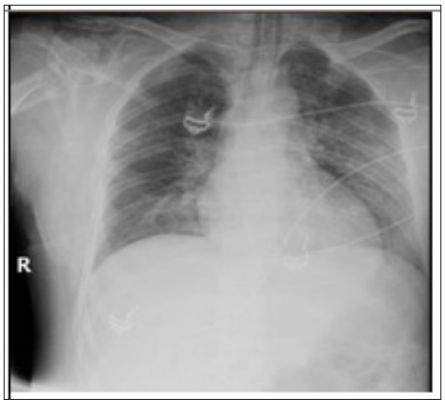

Figure 5C: Follow-up chest X-ray Feb 15, 2024, D 1 post. Bronchoscopy

Figure 5D: Follow-up chest X-ray Feb 20, 2024

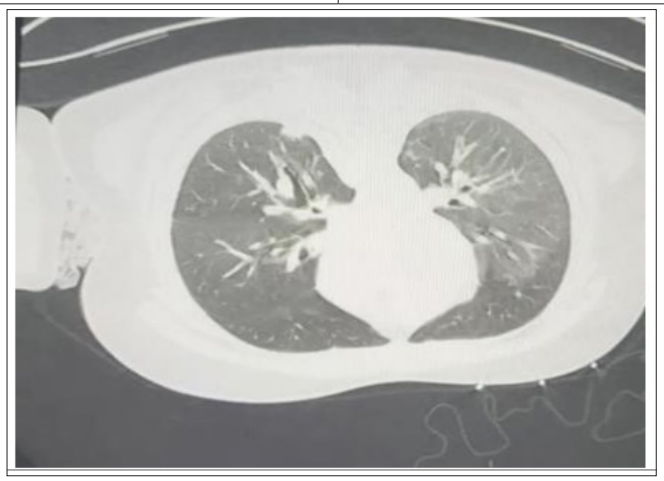

Figure 5E: Follow-up chest CT post Bronchoscopy showing Resolving or Previously Seen Consolidation

Figure 5: Radiological Images of the Progression of Patient Condition

Discussion

Mechanisms of Action

Sodium bicarbonate's high pH disrupts fibrin matrices, dissolving clots resistant to saline or mechanical methods [5]. Its alkaline environment alters the hydrogen bonding within the fibrin network, leading to destabilization of the clot structure. This action facilitates the chemical breakdown of the fibrin matrix, allowing the clot to disintegrate and enabling easier removal via suction or lavage [4].

Additionally, sodium bicarbonate acts as a buffering agent, neutralizing localized acidosis within the airway, which is commonly observed in trauma-induced bronchial clots. This buffering action further enhances the efficacy of clot dissolution by creating an environment less conducive to fibrin stabilization [6]. Unlike saline lavage, which relies solely on mechanical flushing, sodium bicarbonate actively breaks down the molecular integrity of the clot, making it particularly effective against dense, organized obstructions.

Importantly, $NaHCO_3$'s mechanism minimizes the risk of airway trauma that often accompanies mechanical or cryoextraction methods, preserving bronchial integrity while ensuring effective clot resolution [2].

Physiological Context

Bronchial clots in polytrauma patients are often highly organized, resisting natural fibrinolysis and conventional mechanical methods. Sodium bicarbonate's action relies on its ability to alter clot structure by breaking fibrin cross-links, an advantage over mechanical extraction, which risks mucosal damage or incomplete removal [2].

Comparative Efficacy

When compared to tranexamic acid, which acts primarily by inhibiting fibrinolysis, sodium bicarbonate provides direct enzymatic action on fibrin matrices, accelerating clot dissolution. Tranexamic acid is effective for diffuse bleeding but often less successful for large, organized clots due to limited penetration into the fibrin network [2].

Cryoextraction, another widely used method, involves freezing and mechanically extracting clots. While effective for large obstructions, it carries significant risks such as mucosal tearing and localized airway trauma, especially in fragile bronchial tissues [4]. Furthermore, cryoextraction requires advanced equipment and operator expertise, limiting its utility in resource-constrained settings.

Mechanical retrieval techniques, including the use of grasping forceps or suction catheters, are often employed for clot removal. However, these methods can lead to incomplete clot removal, prolonged procedure times, and increased airway trauma in cases involving dense or adherent clots [2]. Additionally, they rely heavily on the operator's skill and the availability of suitable tools.

Sodium bicarbonate, by contrast, offers a minimally invasive alternative that can be used alongside or in place of these techniques. Its ability to dissolve fibrin matrices chemically reduces the need for mechanical manipulation, lowering the risk of airway trauma and complications. Moreover, $NaHCO_3$'s simplicity and cost-effectiveness make it a viable option for widespread application, even in under-resourced healthcare settings. This case highlights its particular efficacy in organized bronchial clot management, where conventional methods may fail or pose additional risks.

Clinical Implications

The rapid improvement in oxygenation (P/F ratio increase from 50 to 230) underscores the efficacy of $NaHCO_3$ in managing bronchial obstructions. This outcome is particularly notable in cases where conventional methods, such as saline lavage or mechanical extraction, have limited success. $NaHCO_3$ offers a minimally invasive approach that minimizes the risks of airway trauma associated with mechanical techniques.

Furthermore, the use of $NaHCO_3$ aligns with a broader goal of enhancing ARDS management strategies by addressing airway obstructions that exacerbate hypoxemia. In resource-limited settings, the accessibility and cost-effectiveness of sodium bicarbonate make it a viable alternative to more specialized interventions like cryoextraction, which requires advanced equipment and expertise.

This case also illustrates the versatility of $NaHCO_3$ in dissolving fibrin-rich clots, suggesting potential applications beyond trauma-induced obstructions, including post-surgical clot management and treatment of mucus plugs in chronic respiratory conditions. By integrating $NaHCO_3$ into existing clinical protocols, healthcare providers can potentially reduce the duration of mechanical ventilation, improve patient outcomes, and lower overall healthcare costs.

Limitations and Risks

Despite its success, $NaHCO_3$ irrigation carries potential risks, including airway irritation, transient systemic pH alterations, and rare cases of hypernatremia if excessive volumes are used [6]. Proper dilution, volume control, and monitoring during the procedure are essential to mitigate these risks.

Future Directions

Future studies should include randomized trials comparing $NaHCO_3$ to traditional methods, focusing on efficacy, safety, and cost-effectiveness. Investigations into optimal concentration, delivery techniques, and long-term outcomes are also warranted. Exploring its use in broader respiratory conditions, such as mucus plug management or endobronchial mass dissolution, could further expand its clinical utility.

Conclusion

Sodium bicarbonate irrigation represents a novel and effective therapeutic approach for managing organized bronchial clots in critically ill patients. This case underscores its potential as a complementary intervention in ARDS management, particularly in scenarios where conventional techniques fail or carry higher risks. Its minimally invasive nature, cost-effectiveness, and demonstrated efficacy in resolving severe airway obstructions make it a valuable addition to the therapeutic arsenal. Nevertheless, further research is necessary to establish standardized protocols, evaluate its long-term safety and efficacy, and explore broader clinical applications in respiratory care.

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