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SUBMERSION IN INDUSTRIAL POWDERS THAT LEAD TO TRACHEAL IMPACTION AND AN UNUSUAL INTUBATION

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☐ **Abstract—Background: Silica, also known as quartz, is a naturally occurring compound that has many common uses, such as for glass, pottery, and concrete. Similarly, bentonite, another natural compound found in many clays, has been used for a variety of purposes from cat litter to bulk laxatives. Both are known for their fluid-absorptive properties. The long-term effects of exposure such as developing silica pneumoconiosis are well studied; acute inhalational injuries of similar substances are also documented. Case Report: We discuss the difficult airway case of a 32-year-old man who presented to the emergency department (ED) in cardiac arrest after he was buried in a mound of powdered silica and bentonite due to an industrial accident. The combination of the naturally fluid-absorptive properties of silica and bentonite, and the moist environment of the oropharynx, led to a unique circumstance. Most foreign bodies in the airway can be remedied, at least in part, by standard irrigation for decontamination. However, irrigation of dry bentonite and silica would produce a clay-like substance that could occlude the trachea, leading to an avoidably more difficult airway presentation. Why Should an Emergency Physician Be Aware of This?: The difficulties experienced with his intubation can serve as a learning point to other providers who encounter a similar presentation. In the event that the inhaled substance is known to be fluid-absorptive, deviation from standard irrigation for decontamination may permit avoidance of a tracheal impaction, and facilitate establishment of a definitive airway. When there is suspicion for the potential of tracheal impaction, proceeding with bronchoscopy either in the ED or operating room as quickly as possible rather than continuing attempts at intubation may deliver the patient a definitive airway in a more timely fashion.** © **2019 Elsevier Inc. All rights reserved.**

☐ **Keywords—difficult airway; submersion; inhalation; aspiration; decontamination; industrial accident**

INTRODUCTION

Silica and bentonite are both naturally occurring compounds that are used in industry for their fluid-absorptive properties. Silica, or silicon dioxide (SiO_2), is commonly found in nature as quartz. Its commercial uses include glass, pottery, and concrete, for which its absorptive ability makes concrete powders turn thick and viscous upon exposure to moisture. Bentonite exists in several varieties and is primarily composed of volcanic ash. In dust form its ability to absorb liquids is exploited in products such as cat litter and bulk laxatives. It is also integral in a variety of cosmetic substances. When exposed to water, bentonite turns into a clay.

The long-term effects of exposure to silica dust are well studied, and include the risk of developing silica pneumoconiosis, chronic obstructive pulmonary disease, and lung malignancy (1–4). The only toxic effects of long-term exposure to bentonite seem to be related to the silica component found in combination products, as opposed to bentonite itself (5).

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Several case reports describe acute inhalational injuries of similar materials such as concrete dust and gypsum powder in adult patients, though neither led to difficult intubations (6,7). More abundant reports exist in pediatric literature, and they include cases of aspiration of sand, though again, no difficulty intubating the patients was demonstrated (8–13). Here we report on the first known case of powder immersion and aspiration, which precipitated cardiac arrest and contributed to a difficult airway problem.

CASE REPORT

A 32-year-old African American man employed at a local industrial refinery was brought by ambulance to the Emergency Department (ED) of an urban, academic hospital. One hour prior to reaching the hospital, he was cleaning the roof of a silo filled with a mixture of silica and bentonite, when the roof collapsed, resulting in his complete submersion in the powder. This led to airway obstruction and traumatic asphyxia, due to the combined effects of the powder in his trachea and the general effect of the submersion, which prevented thoracic expansion with attempted inhalation. After 10 min in the silo, he was extricated and found to be pulseless and apneic. Black, clay-like material was noted in his eyes, nose, and mouth. He received bystander cardiopulmonary resuscitation followed by advanced cardiac life support level care upon emergency medical services arrival. During his prehospital resuscitation, in which he received three doses of epinephrine and remained in pulseless electrical activity, paramedics placed a King supraglottic airway and were able to ventilate sufficiently. He achieved return of spontaneous circulation after 10 min of advanced cardiac life support resuscitation. Upon presentation at our facility, the patient was immediately taken to the decontamination room and thoroughly irrigated, as the material contained in the silo was unknown at the time. All clothing was removed for full exposure, and his entire body, including his face, was rinsed with a hose until all of the clay-like material was removed. During this process the patient was ventilated by bagging through the King airway. He had no known past medical history.

Physical examination revealed a well-nourished African American man with vital signs that included blood pressure of 115/95 mm Hg, pulse of 89 beats/min, absent spontaneous respirations, oral temperature of 34.5°C (94.1°F), pulse oximetry of 92% oxygen saturation on 100% oxygen through the King airway, a height of 6′3” (1.905 m), and a weight of 220 lbs (100 kg). Pupils were 3 mm and fixed bilaterally, and he had a black, gritty substance in his eyes, nares, and oral cavity that was difficult to remove even with multiple suction attempts. The only sign of trauma was a small abrasion to the bridge of his nose. Lungs were clear bilaterally with bag valve respirations, and his cardiac examination revealed a regular rate and rhythm. His abdomen was soft and not distended. Peripheral pulses were 2 + and symmetric in all four extremities, which were without edema or deformity. Glasgow Coma Scale score was 3. The remainder of his examination was unremarkable.

Management turned to establishing a definitive airway. The King airway was removed, and preintubation assessment demonstrated a Mallampati score of II, thyromental space of three finger widths, and mouth opening space of three fingers. He was preoxygenated via bag valve mask, and nasal cannula remained in place during intubation for passive apneic oxygenation. No pretreatment medications or paralytics were used. Direct laryngoscopy with a bougie was chosen over video laryngoscopy because the presence of the black, gritty, clay-like substance in the oropharynx would be expected to obscure the video image. Foreign material was manually removed from the posterior oropharynx by using the Yankauer suction catheter tip as a scraper tool as the material was too viscous to suction. The same foreign material was noted throughout the oropharynx, extending down to the vocal cords, of which a grade II view was obtained. Although the bougie was passed through the vocal cords easily, a 7.5 endotracheal tube (ETT) was unable to be advanced, likely due to foreign material believed to also be present distal to the vocal cords. Attempts at advancing progressively smaller tube sizes over the bougie were unsuccessful, despite withdrawing, advancing, and corkscrewing the various ETTs by both the emergency medicine resident and attending. In between intubation attempts, the patient did not become hypoxic, and remained easy to ventilate. A 5.5-sized ETT was the smallest diameter tube that could be advanced over the bougie, but was also unable to be passed through the vocal cords. Emergent cricothyrotomy was considered but predicted to be unsuccessful as the obstruction was likely distal to the cords.

The Anesthesiology service was consulted to assist in airway management, but their efforts also proved to be unsuccessful at passing an ETT past the vocal cords. The anesthesiologist recommended securing the 5.5 ETT above the vocal cords, pending emergent transfer to an operating room for emergent bronchoscopy by a member of the Otorhinolaryngology (ENT) service.

Initial ED laboratory findings were consistent with hypoperfusion after cardiac arrest. Chest radiography demonstrates the 5.5 ETT with the tip approximately 9.4 cm from the carina, where it had been secured (Figure 1).

In the operating room, the ENT physician placed a flexible pediatric bronchoscope through the ETT and visualized the same black, granular substance distal to

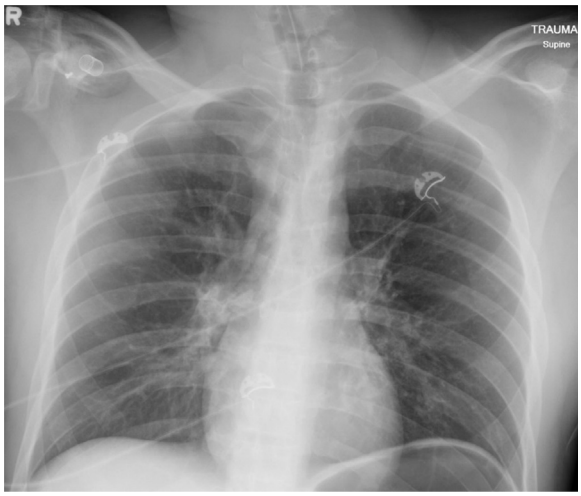

Figure 1. Chest x-ray study showing size 5.5 endotracheal tube with the tip approximately 9.4 cm from the carina, as far as could be advanced in the emergency department.

the vocal cords, coating most of the trachea and impacted as far as the mainstem bronchi. By performing multiple passes of suction and irrigation, as well as by using a basket stone retrieval device to help dislodge some of the substance, they were able to clear a sufficient portion of the silica and bentonite solids to advance a 7.5 ETT past the cords. The patient was then transferred to the medical intensive care unit, where steroid and antibiotic therapies were continued and treatment with nebulized acetylcysteine and albuterol were initiated. Despite these treatments he expired several days later due to the severity of his injuries, including hypoxic brain injury and multisystem organ failure related to prolonged hypoxia during his cardiac arrest.

DISCUSSION

This case presented a unique and difficult airway challenge, which we believe has not previously been published in the literature. An aspirated, water-absorbing mixture of silica and bentonite powder had solidified in the trachea upon exposure to the moist mucus membranes. Then, this was exacerbated by standard decontamination procedures of irrigation. This physically blocked the passage of an ETT through the vocal cords. Our team proceeded with an alternative difficult airway management plan, with initial attempts at suctioning the material from the oropharynx, use of a bougie device, and titration of progressively smaller-sized ETTs. Indeed, bougie devices have been shown to improve the success rate of all intubations anticipated to be difficult (14). It is worth noting that securing the tube above the cords was an unconventional approach, as this does not represent a definitive airway management plan. However, we were able to successfully ventilate the patient and prevent further hypoxia, pending transfer to the operating room for bronchoscopy. Other possible modes of airway management could have included replacement of the King supraglottic airway, which emergency medical services had secured successfully, or placing a laryngeal mask airway. Cricothyrotomy was considered to be unsuccessful, as the obstruction likely extended distal to the vocal cords. If ENT services had not been available at our hospital, a final course of action could have been bedside bronchoscopy by the emergency physician in an attempt to visualize and improve the tracheal obstruction.

Though seemingly uncommon from our literature review, there have been several documented cases of acute lung injuries due to inhalation or aspiration of powders similar to our case (6–13). Such cases are too infrequent to have studies delineating ideal care. The mainstay of literature in inhalation injuries comes from burn victims, where supportive respiratory care, including intubation and mechanical ventilation, is key. Supportive therapies such as steroids, which were given to our patient in the ED, and mucolytic agents and bronchodilators, such as the ones he received in the medical intensive care unit, still lack definitive evidence (15–17). Additional treatment with exogenous surfactant has been suggested in other case reports, but its efficacy is also unconfirmed (12). Literature on aspiration, of which gastric contents are the most commonly studied substances, similarly includes supportive respiratory care, but also consideration for antibiotics, which our patient did receive as well (17).

WHY SHOULD AN EMERGENCY PHYSICIAN BE AWARE OF THIS?

The primary "take-away" from this experience was that deviating from standard irrigation, intended to assist decontamination of the airway, would enable avoidance of the creation of a tracheal impaction, and would also facilitate establishment of a definitive airway. If an inhaled or aspirated substance is suspected to be absorptive of liquids, the injury is severe, and the patient does not already have a definitive airway established, we recommend forgoing any irrigation until intubation has been performed. However, if the material is unknown or the injury appears mild, the need for cleansing the patient of the substance must be weighed against the severity of suspected aspiration and the possibility of worsening the patient's airway. Secondly, if the service is available, early ENT involvement is recommended to facilitate washout of the oropharynx and trachea. If tracheal impaction is suspected, proceeding quickly—with bronchoscopy either in the ED or operating room—rather than making continued attempts at intubation, may deliver

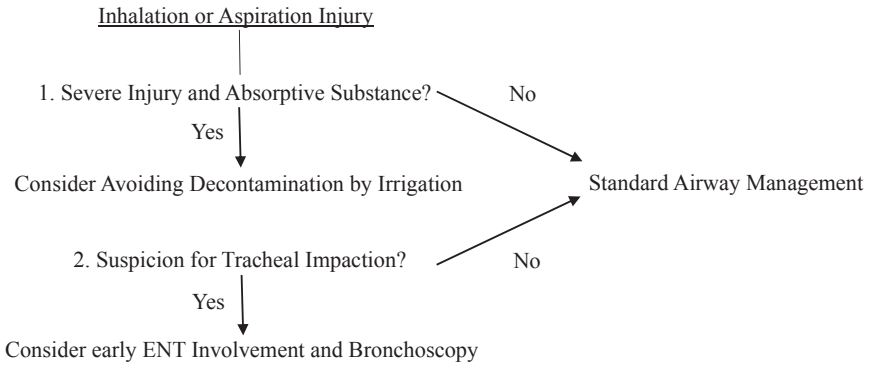

Figure 2. Inhalation or aspiration injury or submersion in nonliquid medium. ENT = otorhinolaryngology.

the patient a definitive airway in a more timely fashion. See Figure 2 for a simplified pathway graphic.

This case report details the first known incident of complete immersion in and aspiration of a powdered substance, which for our patient was silica and bentonite. The patient experienced cardiac arrest due to the immersion. Asphyxiation from the inhalation of the absorptive materials resulted in formation of a clay impacting his trachea and making passage of the ETT through the vocal cords impossible. He was treated by bronchoscopy and washout of the trachea and bronchi, which eventually allowed passage of an airway tube through the vocal cords. Though our patient's prolonged hypoxia due to the submersion in powder, resulting in asphyxiation, proved to lead to a fatal outcome, the experience derived from the intubation, and the principles observed, can serve as a teaching tool for physicians who might encounter similar situations in the future.

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