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CASE REPORT

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First aid treatment and airway management for chemical burns combined with inhalation injury: A case report

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Abstract

Chemical burns account for a small percentage of burn patients, and there are even fewer burn patients suffering from chemical burns combined with inhalation injury. As chemical substances corrode the airway, which leads to persistent necrotic shedding of the respiratory mucosa and scarring contracture as the airway heals, a proportion of patients develop airway stenosis, requiring more aggressive treatment or even surgery. A 38-year-old female chemical factory worker sustained an inhalation injury due to exposure to reactive substances (liquid and smoke) during production. She developed third- to fourth-grade airway stenosis and dyspnoea 2 months postinjury. Interhospital consultation led to referral to the Second Affiliated Hospital of Xi'an Jiaotong University for tracheotomy and endotracheal stent implantation. Postoperative dyspnoea improved, and regular follow-up was performed. The treatment process of this patient has provided us with valuable experience in the initial management and respiratory tract care of chemical burn patients.

KEYWORDS
airway management, airway obstruction, burns, case report, inhalation, tracheotomy

INTRODUCTION

Approximately 11 million people suffer burns worldwide each year, resulting in 180,000 deaths.[1] The rates at which people suffer burns varies according to geographic location, economic status, social environment, and level of industrialization,[2] while chemical burns account for only 3% of all burn admissions.[3] Most injury-causing chemicals are acidic or alkaline substances. These substances are highly corrosive, causing serious skin damage and progressive tissue destruction and increasing the difficulty of treatment, patient prognosis, and recovery time. In some cases, burns from these substances cause disability and death. However, to date, there are few epidemiological data on chemical burns, and cases involving the treatment of complications such as corrosive chemical gas burns with inhalation injuries are relatively rare. Therefore, on the basis of a chemical burn case combined with inhalation injury, this study aims to share the understanding and treatment experience of tracheal stenosis caused by chemical burn, especially chemical inhalation injury, with clinical colleagues. By explaining the patient treatment process, outcome, and prognosis after injury, including the first aid treatment of the respiratory tract, treatment complications, burn treatments, and the discovery and treatment process of the patient's airway stenosis, this case highlights the need for safe practices during chemical production.

CASE REPORT

A 38-year-old woman, working as a chemical plant worker in a district of Luoyang City, Henan Province, China, was physically fit. On June 15th, 2023, at approximately 7:00 p.m., the patient stood on a two-metre-high steel platform wearing protective gear during chemical production to monitor phosphorus trichloride and octyl ester reactor tank instrumentation.

FIGURE 1 The laryngoscopy showed severe oedema of the epiglottis and glottis.

A large amount of smoke and liquid droplets from the reactor tank suddenly spilled out, and the patient experienced burning pain in both eyes, tearing, loss of vision, and burning skin. The patient became unconscious and was rescued from the scene in approximately 10 minutes. During prehospital emergency treatment, the patient was found to have scattered burns on her limbs, trunk, perineum and sacrococcygeal area, with laboured breathing, increased secretion, vomiting, hypoxemia, and bleeding from a skin tear of approximately 3 cm on the left frontal area and behind the ear.

Laryngoscope-guided transoral intubation was immediately performed, intubation revealed severe oedema of the epiglottis and glottis(Figure 1). Upon admission to the EICU, the patient was subjected to fibreoptic bronchial examination of the airway mucosa. Mucosal oedema, a sharp bulge, and mucosal pallor with more yellowish-white secretions attached to the wall of the airway were noted. On the second day after injury, the patient's nasal cavity discharged approximately 3-cm long strips of yellowish–white necrotic tissue (Figure 2). A tracheotomy was performed at 18:00 on June 16th, 2023, and on the fifth day after injury, bronchoscopy revealed necrotic dislodged tracheal mucosa of varying lengths, the longest of which was approximately 10 cm. However, the patient's oxygenation and respiratory monitoring indicators were within the normal range. On July 11th, the patient's respiration was stable, oxygenation was satisfactory, and the patient was able to forcefully cough and bring up sputum. Swallowing and feeding were normal, and the tracheotomy cannula was removed in favour of high-flow oxygen via the nose. The patient's fibreoptic bronchoscopy examination revealed that the amount of necrotic tissue in the bilateral bronchial tubes gradually decreased, and multiple types of nodular granulation tissue progressively proliferated. The patient was discharged on August 23rd, 2023. After discharge, dyspnoea appeared and gradually worsened, and on September 5th, 2023, the patient presented at the Second Affiliated Hospital of Xi'an Jiaotong University. The diagnoses were as follows: inhalation airway injury and tracheal stenosis. Tracheotomy was performed

FIGURE 2 Second day after injury. Long strips of yellow-white tissue were discharged from the patient's nasal cavity.

FIGURE 3 Montgomery safe-T-tube.

on September 9th, and a silicone Montgomery Safe-T-Tube was placed under the guidance of fibreoptic bronchoscopy via tracheotomy on September 14th (Figure 3). Three-dimensional imaging of the bronchi showed diffuse tracheal wall thickening, narrowing of the thoracic inlet of the trachea (Figure 4). During the operation, rigid stenosis of the trachea was observed. The patient's respiratory difficulties improved after the operation, and they could make a hoarse voice. On follow-up, the patient was in good general condition and underwent upper tracheal stenosis isolation and dilatation on April 28th, 2024, at the Second Affiliated Hospital of Xi'an Jiaotong University, where another silicone Montgomery Safe-T-Tube was placed, the long end of the T-Tube was placed in the main trachea under the vocal folds, and the extracorporeal opening of the tracheal stent was closed after the operation. The correction of tracheal stenosis was evaluated half a year after the operation, and the tracheal stent was removed to complete the treatment of tracheal stenosis, as conditions permitted.

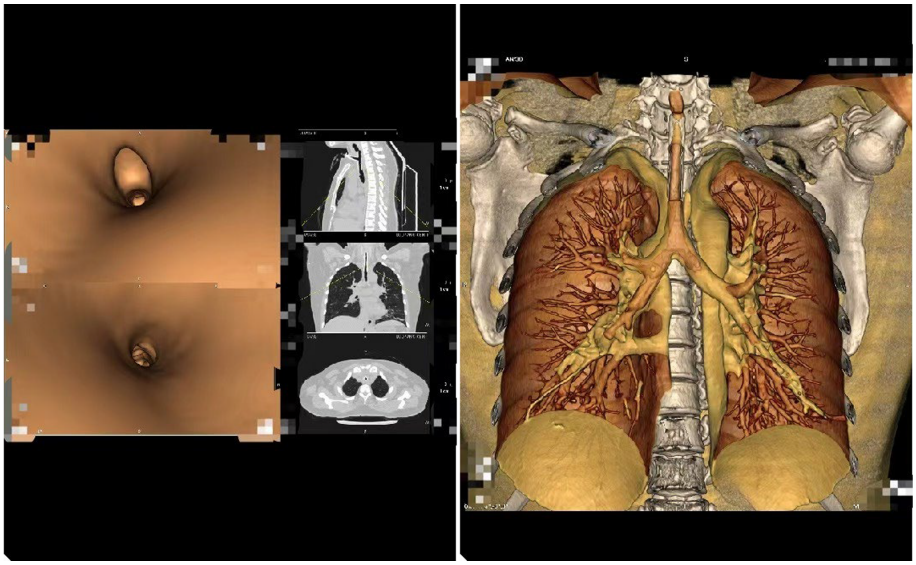

FIGURE 4 Three-dimensional airway reconstruction computed tomography (CT) image from September 2023. (A) The dumbbell-shaped trachea was observed below the vocal cords and above the apex of the heart. (B) Airway stenosis was observed where the tracheal T-tube was placed.

DISCUSSION

During the first medical contact after injury, it is necessary to assess whether the patient's condition requires opening the airway, evaluating the stability of consciousness, breathing, and circulation,[4] and immediately removing the injured tissue and rinsing the skin and mucosa of the injured site with a large amount of water. If the risk of respiratory oedema and airway obstruction in a short time is predicted, tracheal intubation and tracheotomy can be completed in time. In this study, the patient was exposed to smoke and droplets of corrosive chemicals for 10 min. When they were rescued, they experienced hoarseness, burning pain in the mouth and nose, an irritating cough, wheezing, and dyspnoea, all of which suggested an inhalation injury.[5,6] During initial tracheal intubation and bronchoscopy, the mucosa of the patient's upper and lower respiratory tracts was confirmed to have rapidly swollen, and was necrotic and exfoliated. Timely tracheal intubation and tracheotomy are the key to saving lives.[7,8] Compared with heat and flame inhalation injuries, oedema, necrosis and exfoliation of the airway mucosa in corrosive gas inhalation injuries occur faster, last longer, have a greater probability of tracheal stenosis, and are more difficult to address. The patient exhibited exfoliation of necrotic mucosal tissue in the upper respiratory tract 48 h after admission. Timely tracheotomy combined with fiberoptic bronchoscope alveolar lavage, atomization humidification, hormone application, sputum and necrotic tissue drainage, and ventilator-assisted breathing are crucial for maintaining respiratory tract patency, improving oxygenation, and providing life support. The exfoliation of the airway mucosa persisted for more than 4 months. From the patient's injury, inhalation of corrosive gases and extensive airway mucosal necrosis and exfoliation, it should be possible to predict impending airway stenosis in the scar proliferation stage. The artificial airway should not be removed, and the tracheotomy fistula should not be closed according to conventional judgements, such as consciousness, cough and sputum, oxygenation satisfaction, normal swallowing function, and stable vital signs. Five weeks after injury, the patient's tracheal mucosa healed and exhibited hyperplasia, scar formation, tracheal contracture, and airway stenosis above the carinal process below the glottis. After the inter-hospital consultation with experts from the Second Affiliated Hospital of Xi'an Jiaotong University, a tracheotomy was performed again, the stenotic airway was expanded, and a T-tube was implanted to improve the patient's tracheal stenosis symptoms. Therefore, understanding the cycle of tracheal mucosa exfoliation and scar formation and appropriately extending the duration of tracheotomy can reduce the risk of asphyxia due to airway stenosis and prevent the need for an additional tracheotomy. In addition, burn injuries result in increased vascular permeability and massive loss of body fluids and nutrients.[9] When more than 20% of the total body surface area is burned, burn shock is likely to occur, and fluid resuscitation is needed.[10] The patient did not exhibit evident hypovolemia and did not require additional fluid resuscitation or colloid infusion, possibly because the burn area of the patient's skin resulted in less tissue protein coagulation, tissue exudation, and body fluid loss after acidic chemical contact than after thermal injury. The patient's posterior circulation remained stable after admission.

Throughout the treatment process, the case fully reflected the characteristics of emergencies and resulting long-term situations. Emergency aspects of the case include oedema, necrosis and exfoliation of the airway mucosa within a short time following injury, and the potential for

airway obstruction or death to occur at any time. At present, fiberoptic bronchoscopy is commonly used for the diagnosis of inhalation injury in clinical practice,[11] but it has limitations such as invasive examination, lack of indicators to quantify the severity of injury, and subjective judgement of the severity of injury. In resource-limited settings, CT examination can be used to assist the diagnosis. In addition, inhalation injury is usually related to burns on the face and neck. Direct injury to the face by chemicals or fire in a confined space indicates a high possibility of inhalation injury. The presence of carbon debris in the mouth or nasal cavity and charred nasal hair are also particularly suggestive of inhalation injury. In addition, the severity of airway obstruction can be determined by the presence of hoarseness, inspiratory wheezing, irritating cough, and increased respiratory rate. Patients who present with a history of inhalation injury should receive a thorough multidisciplinary airway evaluation with early otolaryngologic evaluation in severe thermal airway injury and valuate the need for early aggressive endoscopic surgery with mucosal reconstruction and endovascular stenting.[12] In future clinical practice and research, understanding the specific damage different chemicals can cause to the airway in different situations is critical, and could help clinicians better judge the condition in which patients present.

Conversely, long-term aspects of the case include the long duration of in-hospital airway management for this patient. Close monitoring and timely treatment are needed to prevent the occurrence of long-term complications. After the artificial airway is established, the condition of the airway, respiration rate, and blood oxygen saturation should be closely observed, and the patient should be monitored for complications such as food reflux, aspiration, aspiration pneumonia, subcutaneous emphysema and pneumothorax. In some patients who experience acute inhalation airway injuries, airway obstruction may continue to progress, leading to the development of recurrent airway stenosis. The newly-formed airway granulation tissue and airway fibrous scar also accumulate in alveolar ducts and alveoli. Obstructive bronchiolitis and organizing pneumonia may occur in later stages, and pulmonary fibrosis may form when the disease progresses. Therefore, in the process of long-term prognosis management, it is necessary to remove airway secretions in time, carry out continuous humidification and indirect lavage, actively prevent and treat infection, monitor lung function and observe the trachea through fiberoptic bronchoscopy. Through comprehensive treatment, the therapeutic effect can be improved, and the incidence of complications can be reduced.

AUTHOR CONTRIBUTIONS

Yaxin Shen, Liming Fu, Zhicheng Yue, Weiliang Shi, Chunyan Li, Chunjuan Zhang conceived and designed the study. Yaxin Shen, Liming Fu, Zhicheng Yue, Weiliang Shi, Chunyan Li, Chunjuan Zhang collected and interpreted all relevant clinical and laboratory data. Yaxin Shen, Liming Fu, Zhicheng Yue, Weiliang Shi, Chunyan Li, Chunjuan Zhang prepared the manuscript. Yaxin Shen, Liming Fu, Zhicheng Yue, Weiliang Shi, Chunyan Li, Chunjuan Zhang confirm the authenticity of all the raw data in this study. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

The authors declare that appropriate written informed consent was obtained for the publication of this manuscript and accompanying images.

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