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Survey on an acute occupational poisoning event caused by simple asphyxiating gas

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Objective. To provide a basis for the effective prevention of the same type of poisoning events through analyzing the causes of an occupational acute simple asphyxiating gas poisoning incident.
Method. Descriptive epidemiological method was used to investigate the related personnel of the poisoning incident, detect poisonous and harmful gases in the air of the scene, and collect and analyze the clinical data of patients.
Result. The poisoning incident led to 1 death and 2 poisoning. All of them were male. The dead patient was 38 years old, and two injured patients were 37 and 31 years old, respectively. The day after the accident, the contents of phenol, toluene, hydrochloric acid and oxygen were determined in the reactor where the accident occurred. The results showed that the maximum concentration of phenol, toluene and hydrochloric acid (CM) was 0/m³, which did not exceed the occupational exposure limit of harmful factors in the workplace stipulated by GBZ2.1–2007. Also, the oxygen content was 10.0%, which was lower than the oxygen content in normal air.
Conclusion. *This is an acute simple asphyxiating gas poisoning incident caused by the employing unit managers and operators' weak awareness of occupational hygiene and safe operation. The employing unit managers and operators should strengthen occupational safety training, strictly implement the occupational health management system, and prevent such incidents.*
Key words: *gas poisoning; asphyxia; occupational safety*
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Исследование случая острой асфиксии при отравлении парами химических веществ на производстве

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Цель исследования — разработать основы эффективного предупреждения типичных интоксикаций путем анализа причин несчастного случая на производстве — острой асфиксии (гипоксии).
Методы. Использован описательный эпидемиологический метод для исследования случая отравления персонала, определения вредных веществ в воздухе на рабочем месте, сбора и анализа данных клинического обследования пострадавших.
Результаты. Три случая острой интоксикации произошли на частном предприятии по производству эпоксидных смол. После автоматической выгрузки продукта химической реакции (2 т фенола + 1,5 т дихлорбензола + 0,3 т толуола + соляная кислота) из реактора, чистки жидких остатков струей воды и вытеснения токсичных паров газообразным азотом, реактор был открыт для проведения внутри необходимых ручных работ персоналом. Сразу после входа в резервуар работники потеряли сознание и были извлечены из резервуара только через 40–50 минут. Двое пострадавших (37 и 31 года) выжили. Химический анализ воздуха в реакторе через сутки после инцидента показал отсутствие фенола, толуола и соляной кислоты и низкое (10%) содержание кислорода.
Заключение. *Случай острого отравления (асфиксии) вызван слабой подготовкой руководства и операторов в области гигиены труда и безопасной эксплуатации оборудования. Работодателям и операторам необходимо пройти надлежащее обучение по вопросам производственной безопасности, внедрять систему управления здравоохранением на производстве для предупреждения подобных случаев.*
Ключевые слова: *отравление парами, асфиксия, производственная безопасность*
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Introduction. On May 22, 2019, National Health Commission of the People's Republic of China issued the Statistical Bulletin on the Development of Health Careers in China in 2018. According to the report, by the end of 2018, 23497 new cases of occupational diseases were reported in China in 2018, including 1333 cases of occupational chemical poisoning [1]. Occupational poisoning refers to the state of illness caused by the direct and long-term effects of pathogenic substances in

the production environment and the process of labor, which can damage the body function, structure and even cause death. In December 2013, the Classification and Catalogue of Occupational Diseases was revised. There were 132 kinds of legal occupational diseases in 10 categories and 60 kinds of occupational poisoning. Particular attention is paid to the fact that the vast majority of acute and fatal occupational diseases are concentrated in these diseases. In recent years, occupational poisoning incidents occur from time to time. The incidence of occupational poisoning is second only to that of occupational pneumoconiosis, other respiratory diseases and occupational diseases of ear, nose, throat and mouth. Occupational poisoning is caused by many factors. Limited space operation is one of the important factors [2]. With the development of China's economy and the continuous improvement of science and technology, limited space has been widespread in various fields of the development of modern society, such as all kinds of tanks, containers, sewer wells, underground pits, pipelines and so on [3]. Operating in limited space is a very dangerous job. A slight carelessness may lead to safety accidents, resulting in incalculable casualties and economic losses. In February 2019, an acute simple asphyxiating gas poisoning incident occurred in a county of Yueyang City, Hunan Province, which resulted in poisoning of three workers at the scene, one of whom died. Based on the occupational epidemiological investigation, clinical manifestations and laboratory test results, it is indicated that this is an acute simple asphyxiating gas poisoning event caused by hypoxia in limited space operation. The results of the survey are reported below.

1. Object and Method

Subjects of investigation

Relevant personnel of this poisoning incident include the person in charge of the enterprise and witnesses at the scene of the accident, the poisoned patients and their families, the local medical workers involved in the treatment and the medical staff of the poisoning Medicine Department of Hunan Prevention And Treatment Institute For Occupational Diseases

Investigation methods

Occupational epidemiological investigation was carried out on the above-mentioned subjects and the site of poisoning incidents according to the Notice on the Issuance of 15 Technical Schemes for Health Emergency Disposal of Sudden Poisoning Incidents issued by the General Office of the former Ministry of Health in 2011(hereinafter referred to as Technical schemes.

On-site inspection

According to the test method recommended by the technical scheme, the toxic and harmful gases such as phenol, toluene and hydrochloric acid in the air of accident site were detected by gas detection method and portable detector method. The oxygen content in reaction kettle was determined. The test results were analyzed according to «Occupational Contact Limit Value of Hazardous Factors in Workplace Part 1: Chemical Hazardous Factors» (GBZ 2.1–2007).

Clinical data

Medical records of poisoning cases were collected, including on-site treatment, clinical symptoms, signs, imaging examinations, laboratory examinations and treatment plans.

Diagnostic criteria

According to the General Principles for the Diagnosis of Occupational Acute Chemical Poisoning (GBZ 71–2013) and the Diagnostic Criteria for Respiratory Diseases of Occupational Acute Chemical Poisoning (GBZ 73–2009), the patients with poisoning were diagnosed.

2. Result

2.1. **Overview of events**

The accident happened in a county of Yueyang City, Hunan Province. Private high-tech enterprises, put into operation in March 2009, mainly produce epoxy resin. On February 20, 2019, a maintenance worker fainted in the reactor. Two workmates fainted in the reactor one after another when rescuing on the spot. After receiving the report, firefighters rescued three people from the reactor. Finally, one worker died before arriving at the hospital and two poisoned workers were sent to local hospitals for treatment. Two poisoned workers were transferred to the Poisoning Medicine Department of Hunan Prevention and Treatment Institute For Occupational Diseases after rescue in local hospitals. According to the General Principles for Diagnosis of Occupational Acute Chemical Poisoning (GBZ 71–2013) and the Diagnostic Criteria for Respiratory Diseases of Occupational Acute Chemical Poisoning (GBZ 73–2009), the two poisoned workers were diagnosed as acute occupational asphyxiating gas poisoning.

2.2. **Epidemiological Survey**

2.2.1. *Technological process and On-site environmental investigation*

Main process flow: 2000kg phenol (concentration unknown) +1500 kg dichlorobenzyl + 300kg toluene (concentration unknown, mainly plays a catalytic role, evaporation after heating), mixed in the reactor heated to 100 C, the product is epoxy curing agent + hydrochloric acid. The reactor has a diameter of 2 meters, a height of 3 meters, an oval top, a manhole of 40 cm x 60 cm, a nitrogen pipeline on the opposite side, no lighting facilities and no forced ventilation equipment. The reactor is washed regularly at ordinary times, and the time of water flushing and nitrogen replacement is more than 24 hours. Investigators arrived at the poisoning site the next

Table / Таблица

Detailed results
Подробные результаты

Toxic species	Detection result	Occupational exposure limits for hazardous factors in the workplace (PC-STEL[a]), mg/m^3 Occupational exposure limits for hazardous factors in the workplace (MAC[b]), mg/m^3	
Phenol	0	10 (skin)	–
Toluene	0	50	100
Hydrochloric acid	0	–	7.5
Oxygen content, %	10	–	–

Test results of chemical poisons at bottom of reactor

Note: a. The allowable concentration of short-term contact, i.e. the allowable concentration of short-term contact (15 minutes) under the premise of PC-TWA compliance; b. the maximum allowable concentration, i.e. the concentration of toxic chemicals at the workplace, within a working day and at any time, should not exceed; and «–» means that there is no corresponding standard

day to investigate the situation, including reactor ventilation measures, production process and other related information, and determine the concentration of oxygen, phenol, toluene and hydrochloric acid in the reactor. On-site investigation: the reactor is dry without liquid residue. On-site air detection at the bottom of the reactor: the concentration of phenol, toluene and hydrochloric acid was within the normal range. Oxygen content was 10.0% detected in the field. There was no stipulated oxygen content in the exposure limit of harmful factors in domestic workplace. Oxygen content in normal air was 20.93% (table).

2.2.2. *Event Course.*

On February 17, 2019, the reactor stopped working after releasing the product. The manhole was not opened. Due to the damage of the temperature monitor of the reactor, on February 20, the repairman opened the manhole to flush the residual liquid and gas in the reactor with water. The cleaning time was about 30 minutes. Then the reactor was continuously purged by nitrogen replacement to replace the toxic gas. On February 20, the replacement time was about 6 hours. After replacement, the residual liquid and gas were not detected, oxygen content and concentration of toxic and harmful substances were not detected. The maintenance worker fainted immediately after entering the reactor from manhole. After fainting for more than ten minutes, the workers on the side found that, then the first worker immediately went down to rescue and immediately fainted in the reactor. Then, the second worker entered the reactor with a filter respirator (no air respirator), immediately lost consciousness after entering the reactor floor. 40 minutes later, three workers were rescued by firefighters.

2.2.3. *Treatment of patients.*

After being rescued from the reactor, the maintenance worker had no vital signs and died. The other two workers were in a shallow coma. They were sent to a nearby hospital for emergency treatment with «cause of consciousness disorder». The examination results indicated that they were hypoxemia and were given symptomatic treatment such as oxygen therapy and brain nursing. Ten hours after the accident, two workers were transferred by ambulance to the Poisoning Medicine Department of Hunan Prevention And Treatment Center For Occupational Diseases. Two workers were hospitalized with "40 minutes of consciousness disturbance, fatigue, dizziness and headache for 10 hours". On admission physical examination, both patients recovered from consciousness disorder, but showed signs of fatigue, dizziness and headache with central nervous system injury. Examination: blood gas analysis, partial oxygen pressure 69.00 mmHg, 74.00 mmHg. Methemoglobin was normal, myocardial enzymes, electrolytes and coagulation function were normal, and electrocardiogram was normal. Head CT+Lung CT: Brain Edema? Please combine clinical and review. In the early stage, it is impossible to determine whether there are phenol, toluene and hydrochloric acid residues in the reactor. Chemical phenol, hydrochloric acid burns and irritant gas poisoning are not excluded. Immediately bathing and changing clothes to remove toxic residues, high flow oxygen therapy, prevention of brain edema, prevention of pulmonary edema, prevention of secondary infections, maintenance of water and electrolyte balance, and promotion of brain cell recovery. After 14 days of active treatment in our department, the clinical symptoms of the two patients recovered, and the cranial CT and blood gas analysis returned to normal. Arrange discharge. According to the fact that two poisoned patients had the chance of simple asphyxiating gas contact, the clinical manifestation of central nervous system damage appeared in a short time, and the oxygen content of air sampling in poisoning site decreased. The diagnosis was simple asphyxiating gas poisoning.

3. Analysis of Accident Causes.

According to the accident scene investigation and the poison contact history of three patients, it can be considered that this is an acute occupational poisoning accident which resulted in 1 death and 2 injuries caused by simple asphyxiating gas poisoning due to violation of safety production operation rules in the production process. The causes of the accident were analyzed as follows: (1) The reactor was washed with water and replaced with nitrogen. Nitrogen was a simple asphyxiating gas, which could significantly reduce the oxygen content in the reactor. When the oxygen content in the air dropped below 16%, people would have hypoxia symptoms; when the oxygen content dropped below 10%, people would have different degrees of consciousness disorder or even death. Sudden death may occur when the content is below 6%. The enterprise cleans regularly, and the time of water flushing and nitrogen replacement is more than 24 hours. According to GB–30871, after cleaning or replacement, good air circulation should be maintained in the confined space, and natural ventilation should be carried out by opening manholes, hand holes, material holes, air doors, smoke doors and other facilities connected with the atmosphere. When necessary, forced ventilation or duct air supply should be adopted. Before duct air supply, the medium and air source in duct should be analyzed and confirmed. Within 30 minutes before the operation, gas analysis should be carried out in the reactor. Only after qualified analysis can the reactor enter. Workers entering confined space should take individual protective measures; for confined space where harmful substances may be released, continuous monitoring should be carried out; when abnormal conditions occur, operations should be stopped immediately, all person should be evacuated, on-site treatment should be carried out, and operations can be resumed only after qualified analysis. There should be special guardianship outside the confined space, and guardians should not leave during the operation; when working in the confined space with greater risk, there should be additional guardians and keep in touch with the operators in the confined space at any time [4]. On-site rescue should first ensure the safety of staff, and on-site rescue and investigation work requires more than two people to cooperate. Entering severe hypoxic environment (such as coma/death cases or dead animals, or rapid on-site detection of oxygen content below 18%) requires the use of self-contained air breathing apparatus (SCBA) and the wearing of oxygen gas alarms; seat belts (ropes) must be fastened and communication tools carried. In this accident: the reactor of the enterprise is closed type, and the natural ventilation with single hole is adopted after replacement. On the day of the accident, the replacement time is shortened from 24 hours to about 6 hours. The natural ventilation in the reactor is insufficient, and there is no mechanical ventilation device. Before the workers work, there is no individual protective measures. The oxygen content and toxic and harmful gas content in the reactor are not detected. The first worker was found after fainting for more than ten minutes and died after missing the golden time for treatment. The second and third workers in the field were rescuing blindly under known dangerous environment. Company leaders and on-duty employees lack awareness of the hazards of limited space operations, and the company has not formulated specific operating procedures for limited space operations. Enterprises do not have a Permit for Entry into the Internal Work of Equipment. Workers fail to comply with the company's Employee Safety Code.

4. Corrective action.

Based on the accident scene investigation and Law of the People's Republic of China on Prevention and Control of Occupational Diseases, the following rectification measures are proposed for the company:

1. Establish and improve the occupational safety, hygiene management system and specific operating rules to regulate workers' operating behavior.

2. Formulating emergency rescue plans for accidents. Emergency rescue facilities were equipped. According to the law, effective occupational disease protection facilities and personal protective equipment that meet the requirements of occupational disease prevention and control must be provided.

3. In accordance with the law, warning signs and warning instructions in Chinese should be set up in the conspicuous positions of the working posts.

4. Employees should be trained in occupational safety and hygiene according to law to popularize occupational safety and hygiene knowledge. They should be taught to strictly abide by the rules of occupational safety and hygiene management and operating. Before entering the airtight pipelines and containers, make sure that the air was ventilated sufficiently, the oxygen content in the air was determined, air respirators were worn and was guarded by concerned person to prevent similar accidents [5].

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