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# Respiratory Emergencies and Management of Mining Accidents

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Abstract

The rapid detection of the reasons for mining accidents that lead to emergency situations is vital for search and rescue work. The control of fire and gas leakage provides an immediate approach for rescue works for deaths or injuries and the detection of who needs resuscitation outside of the mine. The evacuation and recovery operations should be directed by continuous monitoring of the mine environment due to fire and explosion risks. The main toxic gases in mines are carbon monoxide (CO) and carbon dioxide ($CO_2$); the flammable gases are methane ($CH_4$), CO, and hydrogen ($H_2$); the suffocating gases are $CO_2$, nitrogen ($N_20$), and $CH_4$; and the toxic gases are CO, nitrogen oxides (NOx), and hydrogen sulfide ($H_2S$).

**KEYWORDS:** Carbon monoxide, inhalation, mining accident, toxic gases

Rapid detection of emergencies or the reasons for accidents in mines is important for deciding the precautions to be taken before, during, and after an accident and the methods to be followed.

In order to answer the question "How serious is the emergency?," it is necessary to determine the damage caused by the explosion, the color of smoke, the presence of visible flame, the types and levels of gases that have emerged, the state of ventilation, communication with the victims, and the field of vision. Evaluation of the accident site can help predict the extent of injury to the victims, escape from the accident site, and safe work environment for the rescue team. Identification of the reason for the accident, control of fire and gas leakage, and determination of individuals who have died, are injured, and who need resuscitation help to set an emergency approach outside the mine [1,2].

The safety of the accident site must be ensured during rescue operations. Presence of flammable and toxic substances or gases necessitates the use of respiratory equipment and creates limitation on the time for which one can stay in the mine for rescue.

The detection of possible places where victims can be stuck in the accident site, the situations that they can be exposed to, the possibility of their escape from that place, the duration of being stuck, and rescue conditions must be evaluated rapidly.

In a mine, the risks of fire and explosion must be monitored continuously. Considering the possible risks, evacuation and rescue procedures must be directed with effective communication systems.

Outside a mine, atmospheric state evaluation and periodic gas measurement must be performed. The measurement must be continued until 100 m away from the entry of the mine. The amount of fresh air in the mine can help determine the need for mask and respiratory equipment during rescue operations. The conditions at the entry and exit points of the accident site must be planned considering the risks.

Advanced life support can be needed for evacuated victims considering the risks of some health problems such as respiratory failure, crush syndrome, and bleeding.

Corpses of dead victims must be removed and the rescue team must use protective clothes and mask during this process.

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**The rescue vehicle in a mine should contain the following:**

- Self-contained breathing apparatus (SCBA)
- Escape apparatus
- First-aid equipment
- Fireproof clothes
- Resuscitation devices
- Gas detectors
- Stretchers

**The rescue vehicle outside a mine should contain the following:**

- Compressed air breathing apparatus (CABA)
- First-aid equipment
- Synthetic hangers, steel ropes
- Pneumatic lifting equipment to be used during rescue operations
- Lighting equipment
- Respirators
- Industrial gloves, work wear
- Tools for cutting and digging
- Ventilation fans

The main toxic gases released in a mine are CO and $CO_2$. Sulfur dioxide, hydrogen chloride, cyanides, halogens, and hydrogen sulfide ($H_2S$) are other gases that occur in the mine environment. Following mine accidents, the levels of these gases must be determined as soon as possible and necessary precautions must be taken while performing rescue operations. The breathing apparatus can protect the rescue team from CO, $CO_2$, and $H_2S$. If the levels of CO, $H_2S$, and $CO_2$ are over 50 ppm, 10 ppm, and 1.25% respectively, the rescue team must use breathing apparatus in all environments. No limitation is encountered when experienced rescue teams use the breathing apparatus. However, $CO_2$ can create irritation on the skin and $H_2S$ can cause irritation in the eyes and on the skin at high concentrations, which are disturbing for the rescue team. In cases in which the oxygen concentration decreases to ≥18%, the ability to see in the dark is expected to be impaired [1,2].

Flammable gases in a mine: Methane ($CH_4$), carbon monoxide (CO), hydrogen ($H_2$)

Suffocating gases: Carbon dioxide ($CO_2$), nitrogen ($N_2$), methane ($CH_4$)

Toxic gases: CO, nitrogen (N) oxides, hydrogen sulfide ($H_2S$)

Suffocating gases are generated as a result of mineral oxidation in a mine, deterioration of wood, replacement of oxygen with other gases, situations such as fire and explosion, and decrease in oxygen levels on account of respiration. The concentration of $O_2$ in air is 21%; when it begins to decrease to below 19% while breathing normally, respiration becomes considerably difficult. Dizziness, wooziness, and visual impairment begin at a concentration below 15% and loss of consciousness and death are seen below 9% [3,4].

Carbon dioxide forms as a result of combustion of any substance including carbon. When the $CO_2$ concentration increases over 3% in the air, the person has difficulty in breathing. At a concentration of 5%–6%, frequent and difficult breathing and headache are experienced. At a concentration over 15%, loss of consciousness induced by the narcotic effect is expected. When the concentration is over 18%, suffocation and death are seen [4,5].

Carbon monoxide is among the most toxic gases in a mine. It is an important component of the smoke emerging in the air. It creates tissue hypoxia by binding to hemoglobin with a high affinity. When the concentration of carbon monoxide is lower than 0.04%–0.06% in the air inhaled, normal respiration can be performed for several hours without being noticed. On the other hand, exposure to a concentration above 0.20%–0.40% for less than an hour is dangerous. A concentration of 0.40% and above causes death in less than an hour. The victim should be given oxygen support within a short time, kept away from the accident environment, and given respiratory support and hyperbaric oxygen therapy when necessary.

The primary clinical findings according to the CO level include nausea, tiredness, tachypnea, confusion, and clumsiness at the level of 10%-20%; dizziness, drowsiness, nausea, vomiting, impaired vision, and inability to make decisions at the level of 31%-40%; fainting, changes in consciousness, amnesia, and tachypnea at the level of 41%-50%; and crisis, coma, apparent acidosis, and death at the level of 51%-60% [3-5].

Hydrogen sulfide is another toxic gas. It is generated during combustion of gunpowder, explosion of substances including sulfide, and drainage of water in flooded areas. It smells like a rotten egg. It can cause a burning sensation and irritation in the eyes, difficulty in breathing, brain fog, and death [4,5].

Sulfur dioxide is a toxic gas released with the explosion of sulfuric ore. It creates an irritating effect in the upper respiratory tract. At levels over 20 ppm in the inhaled air, it causes cough and irritation in the eyes and upper respiratory tract. One can stand only for a minute if its concentration is above 150 ppm [4,5].

Nitric oxide and other nitrogen oxide derivatives are released in nitrogen explosions and from diesel engine exhaust. If they are over the level of 25 ppm in the air, irritation of the throat and cough occur. At the level of 200 ppm and over, death occurs in a short time [4,5].

Methane gas is generated in a mine and as a result of rotted plants underwater. Since it is lighter than air, it rises up. When methane gas decreases the concentration of oxygen below 12% in a mine, respiratory distress and asphyxia are seen. Methane gas is not toxic, but it poses a risk of explosion and fire at increased concentrations [4,5].

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