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## CARBON DIOXIDE AS A POTENTIAL DANGER TO MEDICAL RESCUE TEAMS AT WORK – A CASE STUDY

DWUTLENEK WĘGLA JAKO POTENCJALNE ZAGROŻENIE  
W PRACY ZESPOŁÓW RATOWNICTWA MEDYCZNEGO – OPIS PRZYPADKU

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### ABSTRACT

Medical rescue teams might be exposed to the risk of accidental poisoning while performing rescue procedures. Exposure to the risk of lethal carbon dioxide (CO<sub>2</sub>) concentrations is a rare situation. This case study describes rescuing a patient who suffered from sudden cardiac arrest due to accidental CO<sub>2</sub> poisoning. The victim was finally evacuated and resuscitated, but the circumstances of the rescue operation point to the need to equip ambulances with carbon dioxide detectors and hermetic oxygen masks. Med Pr 2017;68(1):135–138

**Key words:** environmental exposure, carbon dioxide, cardiopulmonary resuscitation, medical rescuer, gas poisoning, grain dryer

### STRESZCZENIE

Zespoły ratownictwa medycznego mogą być narażone na ryzyko przypadkowych zatruc w trakcie wykonywania medycznych czynności ratunkowych. Do rzadkich sytuacji należy narażenie na śmiertelne stężenie dwutlenku węgla (CO<sub>2</sub>). W pracy opisano akcję ratunkową pacjenta, u którego doszło do nagłego zatrzymania krążenia z powodu przypadkowego zatrucia CO<sub>2</sub>. Ostatecznie udało się poszkodowanego ewakuować i zreanimować, ale okoliczności towarzyszące tej akcji sugerują konieczność wyposażenia karettek zespołów ratownictwa medycznego w detektory tlenu i dwutlenku węgla oraz szczelne maski tlenowe. Med. Pr. 2017;68(1):135–138

**Słowa kluczowe:** ekspozycja środowiskowa, dwutlenek węgla, resuscytacja krążeniowo-oddechowa, ratownik medyczny, zatrucie gazem, suszarnia zboża

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## INTRODUCTION

Carbon dioxide (CO<sub>2</sub>) is a colorless, odorless and non-flammable gas, soluble in water, with a molecular weight of 44 Da and density of 1.977 g/dm<sup>3</sup> (0°C, 1013 hPa). In the surrounding environment CO<sub>2</sub> is a product of combustion and fermentation of organic matter.

The CO<sub>2</sub> content in fresh air (averaged between sea-level and 10 kPa level, i.e., about the altitude of 30 km) varies between 0.036–0.039% (360–390 ppm), depend-

ing on the location. The CO<sub>2</sub> concentration is higher in mines, sugar refineries, distilleries, grain silos and drains. Carbon dioxide is an asphyxiant gas and not classified as toxic or harmful in accordance with the Globally Harmonized System of Classification and Labelling of Chemicals Standards of the United Nations Economic Commission for Europe within the meaning of the Organisation for Economic Co-operation and Development (OECD) Guidelines for the Testing of Chemicals. The maximum admissible concentra-

tion (MAC) for CO<sub>2</sub> and the short term exposure limit (STEL) are 9000 mg/m<sup>3</sup> and 27 000 mg/m<sup>3</sup>, respectively. The MAC for CO and the STEL are 23 mg/m<sup>3</sup> and 117 mg/m<sup>3</sup>, respectively.

The occupational exposure is very common in factories: in metallurgy, welding, production of fire extinguishers. Employers working in coolers and with dry ice, during production of carbonated water and in medicine – during preparation of carbonic acid bath – are also at risk of intoxication.

The symptoms and signs of CO<sub>2</sub> intoxication are primarily neurological. Poisoning with carbon dioxide is usually a combination of life-threatening hypoxia and hypercapnia, which leads to impairment in the level of consciousness ranging from drowsiness and confusion to even deep coma and respiratory acidosis. Intense hypercapnia may lead to cerebral edema and paralysis of the respiratory center. In concentrations of up to 1%, it will make some people feel drowsy. When breathing the air containing CO<sub>2</sub> at concentrations exceeding 5%, the gas causes shortness of breath, anxiety and stimulation of the respiratory center. Concentrations of 7–10% may cause dizziness, headache, visual and hearing dysfunction, and unconsciousness within a few minutes to an hour. Concentrations exceeding 10% cause hallucinations and impaired consciousness, including coma and convulsions. Concentrations of more than 20% cause death within several minutes whereas concentrations exceeding 30% cause instantaneous death.

The most frequent motor signs are muscle twitching and fine tremors of the extremities or face. Myoclonus and generalized convulsions may be observed. Reflex action changes. The intracranial pressure increases. The non-neurologic symptoms and signs of CO<sub>2</sub> intoxication are also cardiopulmonary. The initial period of hypertension goes to hypotension and shock. Tachycardia is very frequent.

Carbon dioxide poisonings have been described in the world literature since the 1950s [1–3]. These were usually accidental poisonings, where CO<sub>2</sub> had come from dry ice [4,5], a fermentation tank [6], liquid carbon dioxide that had been unintentionally opened [7], a tank containing sludge made of wine and activated charcoal [8], inspection of a concrete well [9]. There have also been cases of CO<sub>2</sub> poisonings due to suicidal attempts or even murders, where CO<sub>2</sub> had come from dry ice [10,11] or CO<sub>2</sub> cylinders [12].

Carbon dioxide poisonings require immediate first aid and calling medical emergency system services. In Poland the system of the State Emergency Medical Serv-

ices (EMS) was established in 2006 and it consists of hospital emergency departments (ED) and medical rescue teams, including basic (B) and specialist (S) rescue teams, with air rescue teams. Medical rescue teams provide their services only to patients who are in a state of emergency health hazard and outside hospital. In 2015 there were 1460 medical rescue teams in Poland [13].

Carbon dioxide poisonings represent a medical and organizational challenge to medical rescue teams. Below there is a case study of a victim who suffered from cardiac arrest due to CO<sub>2</sub> poisoning.

## CASE REPORT

At 8:47 a.m. a S medical rescue team was sent by a dispatcher to an unconscious 54-year-old man who had been repairing machinery in a grain silo (a maize warehouse) (Photo 1). In this case CO<sub>2</sub> was elevated as a result of fermentation of seed corn in a grain silo. According to the information reported to the dispatcher, the man suffered from an epileptic seizure.

The medical rescue team arrived at the place after 11 min. There were 3 men in the rescue team who arrived in a S ambulance: a doctor (D), paramedic/driver (P-1) and paramedic (P-2). Immediately did they start rescuing the patient. None of the witnesses of the event gave first aid to the patient. The D and P-2 went to the rescue zone. They climbed a ladder about 3 m down into a room that was 6 m long, 2.2 m wide and 2.6 m deep, where the patient was. After they had taken a few breaths, both of them felt sudden weakness, vertigo and nausea. They left the room and the patient inside. The P-1 called a fire brigade and informed them of the possible danger and problems of the other members



**Photo 1.** Technological shaft in a grain dryer  
**Fot. 1.** Szyb technologiczny suszarni zboża

of the S crew. In the meantime the P-2 returned to the ambulance and put on an oxygen mask without an oxygen reservoir (the flow rate at 12 l/min) for about 20 s and returned to the patient. Meanwhile the D held his breath, went down to the patient again and pulled him near the ladder. The P-1 took a spine board and belts, held his breath and climbed down the ladder to the patient. He used the belts to tie a knot and he returned outside.

The D and P-1 pulled the patient out of the room together and implemented the ABCDE scheme (Airway, Breathing, Circulation, Disability, Exposure Scheme). They confirmed cardiac arrest and diagnosed asystole. The patient received cardiopulmonary resuscitation (CPR) according to the European Resuscitation Council (ERC) guidelines 2010 [14]. The patient was being resuscitated for 40 min after he had been evacuated from the room. Asystole continued for 36 min. It was followed by pulseless electrical activity and finally the patient recovered ventricular rhythm with pulse. During the CPR the patient was administered 9 mg adrenaline intravenous (*i.v.*), 500 ml 0.9% sodium chloride (NaCl) *i.v.* and 40 mmol 8.4% sodium bicarbonate *i.v.* The patient had his trachea intubated 2 min after he had been evacuated from the room. The firefighters helped to resuscitate the patient.

After the return of spontaneous circulation the patient was transported in the S ambulance to the emergency department in a district hospital. The medical rescuers had temporary weakness, vertigo and nausea in a grain silo. Thereafter they felt well. While being transported, the patient was being ventilated with 100% oxygen. In the emergency department the patient attempted to remove the endotracheal tube. After a few minutes the patient was transferred to the care of an anaesthesiologist on duty and he was transported to the Department of Anaesthesiology and Intensive Care (DAIC).

After neurological consultation in hospital the patient was assessed as 15 points in terms of the Glasgow Coma Scale (GCS), there was a lack of any neurological deficiency. During hospitalization the patient's circulation was stable and the patient did not require any catecholamines. Upon admission to the DAIC the patient's state was as pictured in the Table 1. The patient was treated at the DAIC for several days and he was discharged from hospital without any neurological damage.

The fire brigade measured the O<sub>2</sub> concentration in the room – 16%. The name of apparatus used by the fire brigade to determine the O<sub>2</sub> concentration is MultiPro (Sperian, USA). The MultiPro may be configured to simultaneously monitor oxygen, carbon monoxide,

**Table 1.** Laboratory tests of the patient who suffered from sudden cardiac arrest due to accidental CO<sub>2</sub> poisoning, upon admission to the Department of Anaesthesiology and Intensive Care (DAIC)

**Tabela 1.** Badania laboratoryjne pacjenta, u którego doszło do nagłego zatrzymania krążenia z powodu przypadkowego zatrucia CO<sub>2</sub>, wykonane po przyjęciu na Oddział Anestezjologii i Intensywnej Terapii (OAIiT)

Laboratory tests Badania laboratoryjne	Patient's blood Krew pacjenta
Arterial pH / pH tętnicze	7.105
Arterial partial pressure of carbon dioxide / Prężność dwutlenku węgla we krwi tętniczej (pCO <sub>2</sub> ) [mm Hg]	40.5
Arterial partial pressure of oxygen / Prężność tlenu we krwi tętniczej (pO <sub>2</sub> ) [mm Hg]	169.6
Bicarbonate ion / Wodorowęglany (HCO <sub>3</sub> ) [mmol/l]	15
Base excess / Nadmiar zasad (BE)	-10.2
Urea / Mocznik [mg/dl]	16.3
Sodium / Sód [mmol/l]	138.2
Potassium / Potas [mmol/l]	3.29
Creatinine / Kreatynina [mg/dl]	0.91
Calcium / Wapń [mmol/l]	4.65
Alanine aminotransferase / Aminotransferaza alaninowa (ALAT) [IU/l]	71
Aspartate aminotransferase / Aminotransferaza asparaginowa (AspAT) [IU/l]	234
Total protein / Białko całkowite [g/dl]	6.9
Glucose / Glukoza [mg/dl]	228
C-reactive protein / Białko C-reaktywne [mg/l]	2
Haemoglobin / Hemoglobina [g/dl]	12.2
Hematocrit / Hematokryt [%]	0.36
Red blood cells / Erytrocyty [10 <sup>6</sup> /μl]	3.34
Mean corpuscular volume / Wskaźnik średniej objętości krwinki czerwonej [fl]	109.1
White blood cells / Leukocyty [10 <sup>3</sup> /μl]	6.18
Platelets / Płytki krwi [10 <sup>3</sup> /μl]	160

hydrogen sulfide and combustible gases and vapors. The MultiPro uses electrochemical toxic gas sensors. In the other countries the fire brigades are also equipped with the same apparatus MultiPro and additionally the others e.g., Dräger X-am 5600 (Drägerwerk AG & Co. KGaA, Germany), Measurement System Analysis (MSA) multi detector (MSA, USA). In Poland the medical rescue teams are not equipped with hermetic oxygen masks. In the other countries the fire brigades are equipped with such pieces of equipment.

## CONCLUSIONS

The study has presented the case of CO<sub>2</sub> poisoning complicated by sudden cardiac arrest. It is an interesting presentation concerning possible hazards to medical rescue teams. Thanks to the dedication of the emergency services the patient was successfully resuscitated. Nevertheless, it involved the exposure of the rescue team to the risk of CO<sub>2</sub> poisoning. Medical rescue teams are not equipped with hermetic oxygen masks, which would isolate the rescuers from the toxic environment. It is noteworthy that medical rescue teams and firefighters do not arrive at the scene of an accident at the same time. Thus, there is the increased risk of exposure of the rescue team to harmful factors which are difficult to detect (in this case – CO<sub>2</sub>). Due to the fact that waiting even for a short time for the victim to be evacuated from the zone of exposure to toxic gases may be decisive to the victim's survival, it is recommended that the issue of additional rescue equipment in ambulances should be taken into consideration.

The conclusion is that medical rescue teams should be equipped with CO<sub>2</sub> detectors and hermetic oxygen masks.

Accidental CO<sub>2</sub> poisoning may be a reversible cause of cardiac arrest. The case study presents the hazard to medical rescue teams and firefighters. Equipping medical rescue teams with toxic gas detectors should be taken into consideration.

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