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CASE REPORT

Occupational poisoning by carbon monoxide aboard a gas carrier. Report on 8 cases

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ABSTRACT

Objectives

— *To determine the accidental factors and the clinical symptoms in eight cases of occupational poisoning of port workers by carbon monoxide.*

— *To consider the primary prevention of this serious pathology occurring at work.*

Methods

— *To analyze the circumstances of the exposure to carbon monoxide in the employees in the naval repair sector.*

— *To indicate the systemic failures causing this accidental poisoning, the means for early diagnosis and appropriate treatment, and to discuss the prevention of such accidents.*

Results. *The poisoning occurred in eight mechanics and electricians working without any protective means in a gas carrier tank in dry dock. The employees, unaware of carbon monoxide exposure, stayed for 45 minutes in an atmosphere polluted with carbon monoxide concentrations of over 500 ppm. The main complaints were of headache, muscular weakness, and drowsiness. No post-interval syndrome was found three weeks after poisoning. The levels of carboxyhaemoglobin varied from 1.8 to 31.2%. Early normal pressure oxygen therapy reduced the symptoms. No delayed syndrome was found three weeks after poisoning.*

Conclusions. *The inclusion of poisonous gas in gas-free certification, adherence to maritime harbour regulations, greater respect for working instructions in hazardous environments, and the use of detectors appropriate to the conditions for each ship would avoid exposure and decrease the risk of poisoning.*

Key words: carbon monoxide poisoning, naval occupational exposure to CO and H2S, gas carrier tank

INTRODUCTION

At present, the transportation of hydrocarbons is mainly by sea. Carriage of natural gasses, such as methane, from main extraction sites, such as Algeria, to Europe is done by gas tankers. In 2005, 150 gas tankers were at sea*. While transporting, loading, and

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unloading hydrocarbons the risk of explosion is high. During maintenance work and naval repairs there is a risk of exposure to a number of toxic products on board.

In this study, we describe acute occupational poisoning by carbon monoxide while working in the tanks of a gas carrier.

This type of mass poisoning is unusual in this field. Nevertheless, a description of the underlying circumstances allows us to analyze the problem in occupational practice and to find the reasons for the pollution of the tanks by carbon monoxide. A clinical description of the eight cases of the maritime workers affected is discussed as the starting point of primary prevention of this serious occupational pathology.

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BACKGROUND

Naval repair work may require that employees enter the compartments of a ship used for the transportation of gas. The leading civil repair shipyard in France is located in the city of Brest.

On the day of the accident, eight men arrived at work in perfect health, and had to carry out some repairs in the tank of a gas carrier. About 45 minutes after entering the tank, they all detected an unusual and pungent smell described as the odour of rotten eggs. This atypical smell stopped them from continuing their work and they left the tank.

The affected workers were mechanics and electricians with an average age of 33 years. The sudden onset in the work place and the appearance of clinical symptoms as described below led to a suspicion of occupational poisoning. The fact that there were multiple cases caused many other colleagues to ask for assistance. An accident at work was reported.

Table 1. Carboxyhaemoglobin rates and clinical signs and symptoms in 8 patients

AGE in years	% Hb CO	Clinical signs
33	16.6	Headaches, drowsiness, motor system disorders, confusion, dizziness, nausea, muscular weakness
31	10.9	Headaches
42	9.2	Headaches, muscular weakness
24	7.4	Headaches, muscular weakness
21	4.8	Headaches, Nausea
48	4.5	Nausea
42	4.3	No signs
22	2.1	Drowsiness

CLINICAL FINDINGS

Once on deck, they started to complain of headaches, nausea, muscular weakness, dizziness, and other neurological symptoms. Half of the employees described at least two symptoms.

After reporting sick on board, the employees were taken to hospital by ambulance. At first, clinical examinations, specifically neurological examinations, were normal. Cardio-respiratory parameters were also normal for all patients.

With regard to other tests, standard chest X-ray and ECG were normal, but slightly elevated rates of carboxyhaemoglobin were noted (Hb CO varying from 2.1 to 16.6%) (Table 1). Carboxyhaemoglobin rates were determined almost three hours after the exposure.

The patients were hospitalised for 24 hours and treated with normal pressure oxygen therapy. Twenty days later, all the affected employees were seen by the company doctor. No clinical signs of post-interval syndrome were revealed, and no acute or short-term complications were associated with the initial symptoms.

ENVIRONMENTAL SURVEILLANCE AND INVESTIGATION RESULTS

In order to make a diagnosis of multiple occupational poisoning by carbon monoxide, an estimation of the carbon monoxide concentration in the air of the tank was carried out using a portable device, a Draëger X-am 7000. The investigation was performed, jointly, by the rescue and fire service and the port-agreed chemistry service.

The values of the atmospheric samples were as follows: 500 ppm of carbon monoxide, 2 ppm of H2S, and 20.9% of O2. Therefore, carbon monoxide poisoning was confirmed according to the criteria of the Committee for Public Hygiene in France (Comité Supérieur d'Hygiène Publique de France) [1].

DISCUSSION

Carbon monoxide is a colourless and odourless gas [2, 3]. It is the cause of many domestic or occupational poisonings. In the USA between 2001 and

Table 2. Carboxyhaemoglobin rates and clinical signs and symptoms

5–10%	Drowsiness, visual disorders
10–20%	Headaches, risk of death from coronary disease
20–30%	Nausea, headaches, dizziness
30–40%	Nausea, tachycardia, muscular weakness, drowsiness, brief unconsciousness
50–60%	Coma, convulsions, cardiorespiratory failure
> 60%	Death

Table 3. Clinical signs of H2S poisoning

0.1 ppm	Detectable odour
50–500 ppm	Ocular and respiratory irritant
500–700 ppm	General poisoning
> 1000 ppm	Death

2003 it was responsible for 15,200 (?) emergency consultations, and between 1999 and 2004 for 440 deaths per year [4]. The acute symptomatology linked with tissue anoxia is typical. In the described case, headaches, muscular weakness, and nausea were predominant. These warning signs are identical to those noted in the CDC study on 61,907 cases of non-fatal, unintentional, non-fire related poisoning. The patients reported headaches in 27.4% of cases, nausea in 14.6% of cases, and dizziness in 11.8% of cases. Even higher figures were reported by the French National Institute for Public Health Surveillance in a study in which headache was present in 75.9% of cases, nausea in 39.9% of cases, and dizziness in 28.7% of cases [1]. The fact that most of our poisoned employees described muscular weakness is probably linked to their exposure to high levels of carbon monoxide and the importance of muscular effort, in particular for the quadriceps, during frequent climbing of the tank ladder. The high proportion of patients having at least two symptoms, 50% in comparison to 29.4%, in the American study can be linked with the high values of carbon monoxide detected in the atmosphere of the tanks (500 ppm) [4]. The French threshold value for occupational exposure to carbon monoxide is 50 ppm in 8 hours [5]. In the USA, the Time Weight Average is 25 ppm [6]. At an environmental level, the WHO advocates exposure values of 9 ppm in 8 hours, 26 ppm in 1 h and 87 ppm in 15 minutes. The exposure rate that we found, 500 ppm in 45 minutes, is much higher than any international recommendations. The difficulty in detecting this gas in the environment is also noticeable. In the tank, the alerting sign was the particular smell of hydrogen sulphide, which is detectable from 0.1 ppm [7]. Without this sign, the outcome of this accident could have been fatal for the workers, so the requirement for electronic carbon monoxide detectors is all the more necessary. It is possible that the event was due to the combined effect of both gases, CO and H2S. H2S is well known to cause intracellular asphyxia, so its toxicity could enhance the effects of CO poisoning.

Occupational causes of carbon monoxide poisoning are less frequent than domestic ones. In a French study in 2006 on 4,892 recognized poisoning cases, 6.4% were occupational; this figure was 13.4% in an American study in 2004–2006 [1, 4]. They are mainly caused by engine exhaust gases (self-propelled trolleys, building devices) in poorly ventilated buildings. This is the first published case reported in the naval repair sector.

The reasons for this occupational exposure are numerous. Gas carrier tanks are treated by burning residual gas once they have been emptied of methane. All LNG-tankers must be inspected by an authorized port service before entering the naval repair zone. This service performs, as described in the Maritime Port Regulations*, a gas analysis in all confined-spaces. A defect in tank ventilation, demonstrated by high atmospheric rates of carbon monoxide, had been noted during the statutory analysis of the Maritime Harbour Regulations before this ship's entry to port [8]. In dry dock, another analysis was made and no increased gas level was noted. However, the sample used at this time did not reflect the atmosphere in the whole tank; with respect to those results, the port authorities gave the shipyard workers right of entry to this tank.

The other known cases in the maritime sector are those of a docker and a seafarer who both died after being poisoned by carbon monoxide while unloading wood pellets. Svedberg demonstrated a chemical reaction that generated carbon monoxide during the transportation of the pellets, and carbon monoxide rates of up to 11,510 ppm were measured in the stairs near the tanks [9].

The sources of respiratory exposure to poisonous gas are numerous on ships. They can be the result of transported products (liquefied gas, hydrocarbons), those used for the functioning of the ship (Freon from the cooling systems, ammoniac), or products of transformation (phosgene, phosphates). The International Harbour Regulations, available at a national and local level, strictly concern the risk of explosion on ships carrying hydrocarbons but they do not consider the toxicological risk for the employees on board or contractors. As this accident proves, the risk is real. It must be acknowledged and should be considered when atypical symptomatology appears in naval repair workers and seafarers. Moreover, we think it is essential that this should be considered in the regulations through the Maritime Harbour Regulations.

This acute carbon monoxide poisoning in the naval repair sector underlines the high toxicological risks to which the harbour employees are exposed.

Indeed, the short but intense exposure to this poison gas has led to specific symptomatology in this exposed population. Development of coordination of the safety between the captain of the ship and the harbour office, through the harbour certification and the naval repair companies, seems to be crucial in order to know about any residual gas found on board and to inform the operators. It is crucial that safety measures carried out by the captain of the ship, the harbour office, harbour certification, and naval repair companies are coordinated and operators are informed of residual gas levels found on board. Therefore, maintenance activities should be carried out with the appropriate detectors in advance. Workers should be informed that if the limits are exceeded, they should immediately leave the area of work.

*Réglement pour le transport et la manutention des marchandises dangereuses dans les ports maritimes. JO du 22 février2008; www.mer.gouv.fr/IMG/pdf/RPM_consolide_28-01-2008_clec8d2f-1.pdf.

CONCLUSIONS

- The clinical symptoms of acute poisoning to carbon monoxide are non-specific, but typically include headache, nausea, vomiting, and dizziness.
- Seafarers and employees in the naval repair sector might be at risk of occupational exposure to carbon monoxide in high concentrations.
- Occupational poisoning by gas or fluids must be suspected when clinical symptoms appear in an employee working in a closed space aboard a gas carrier.
- The prevention of risk of occupational poisoning in harbour employees by products carried on ships must be integrated into harbour regulations.
- Teams working in ships' tanks in which hydrocarbons were transported must be equipped with gas detectors to monitor the levels of the following gases: CO, H2S, and O2.

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