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Chemical Emergency Medical Guideline

Information and recommendations for healthcare professionals

Metal carbonyls

CAS No.: 13463-39-3 ; 13463-40-6

GHS symbols:

GHS06
Acute toxicity

GHS08
Health hazard

Signal word: Danger

Hazard statements:
For detailed information on the H statements for the individual substances within this group, it is recommended to consult the relevant safety data sheets provided by the distributor or official databases (e.g. https://echa.europa.eu/de/search-for-chemicals).

Overview

- These guidelines are based on information about the metal carbonyls nickel tetracarbonyl and iron pentacarbonyl. Recommendations for other metal carbonyls are similar in many respects. However, these guidelines do not cover any special considerations that may apply to other metal carbonyls.
- Before the paramedic/emergency doctor on site approaches a patient, who has been or is exposed to metal carbonyls, it must be ensured that there is no danger to themselves from metal carbonyls.
- There is no danger from contact with patients who have only been exposed to metal carbonyl vapors. However, a patient who is wet with liquid metal carbonyls or metal carbonyl solutions, or whose clothing is wet with them, may endanger other people through direct contact or through outgassing metal carbonyls.
- Metal carbonyls irritate all tissues, especially the respiratory tract. Exposure can result in eye and skin irritation, coughing, chest pain and shortness of breath. Bronchospasm and signs of toxic pulmonary oedema (shortness of breath, cyanosis, sputum and coughing) may occur.
- There is no known specific antidote. Treatment depends on the extent of exposure and the symptoms.

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1. Information about the substance

Metal carbonyls:
Nickel tetracarbonyl - $Ni(CO)_4$, CAS 13463-39-3
Iron pentacarbonyl - $Fe(CO)_5$, CAS 13463-40-6
Synonyms: nickel carbonyl, tetracarbonyl nickel; iron carbonyl, pentairon carbonyl.
At room temperature, nickel tetracarbonyl and iron pentacarbonyl are colorless to yellowish liquids. Metal carbonyls have a musty, moldy odor. When heated to decomposition, they release toxic metal oxide fumes and carbon monoxide.
Nickel tetracarbonyl is used in the refining of nickel as a catalyst. Iron pentacarbonyl has been used as an anti-knock agent in fuels.

2. Exposition

2.1. Inhalation

Inhalation is the most important route of exposure to metal carbonyls. The odor of metal carbonyls does not provide a clear warning of dangerous concentrations. Irritation of the respiratory tract, including toxic pulmonary oedema, cyanosis, headaches and dizziness, may occur.

2.2. Skin/eye contact

Direct contact with liquid metal carbonyls or vapors may cause skin or eye irritation.

2.3. Ingestion

Accidental ingestion of metal carbonyls is unlikely, but may cause irritation to the mouth, throat, esophagus and stomach.

3. Acute health effects

3.1. Dose-response relationship

Nickel tetracarbonyl concentration		**Effect/effects**
0.001 ppm	-	PEL (OSHA, USA)
0.5 – 3.0 ppm	-	Odor threshold (low – high)
2.0 ppm	-	IDLH (NIOSH, USA)
30 ppm	-	Estimated lethal concentration in humans
Iron pentacarbonyl concentration		**Effect/effects**
0.1 ppm	-	TLV-TWA (ACGIH, USA)
0.2 ppm	-	TLV-STEL (ACGIH, USA)

PEL: Permissible Exposure Limits → Limit value for the amount or concentration of a substance in the air. This is usually based on a time-weighted average (TWA) over eight hours.
IDLH: Immediately Dangerous to Life and Health
NIOSH: National Institute for Occupational Safety and Health
TLV: Threshold limit value → Air concentration below which it is assumed that almost all workers can be repeatedly exposed to this concentration day after day throughout their working lives without any adverse health effects.
TWA: Time-weighted average
ACGIH: American Conference of Governmental Industrial Hygienists
TLV-STEL: Threshold Limit Value-Short-Term Exposure Limit → Average concentration over 15 minutes to which workers may be exposed up to four times per day with at least 60 minutes between successive exposures without adverse health effects

3.2. Respiratory tract

Exposure to metal carbonyls causes irritation of all tissues. However, symptoms of irritation of the throat and lungs predominate and can lead to chest tightness, coughing, shortness of breath and bloody sputum.

Inflammation and severe damage to the lungs may occur. After significant inhalation exposure, pneumonia and toxic pulmonary edema may occur with a delay of up to 24 hours. Dizziness, headaches and muscle weakness may also occur after inhalation.

3.3. Skin contact / Eye contact

Skin contact with metal carbonyls can cause irritation, redness and inflammation.
Eye contact can result in irritation with immediate pain, tearing, eyelid oedema, inflammation of the conjunctiva and cornea, clouding of the eye surface and secondary glaucoma.

3.4. Possible consequences

After exposure to high concentrations, some individuals may develop bronchial asthma or non-specific bronchial hypersensitivity. Impaired lung function and respiratory symptoms due to bronchial constriction may persist.

4. Measures

4.1. Self-protection of first aiders

If there is a suspicion that the area which the helper must enter contains metal carbonyls in potentially dangerous concentrations (see above), a self-contained breathing apparatus and a chemical protection suit must be worn.
There is no danger from contact with patients who have only been exposed to metal carbonyl vapors. A patient who is wet with liquid metal carbonyls or metal carbonyl solutions, or whose clothing is wet with them, may endanger other people through direct contact or through outgassing metal carbonyls.

4.2. Rescue

Patients should be removed from the danger zone immediately. If they are unable to walk unaided, they should be removed from the danger zone quickly using suitable means, taking care to protect themselves. The "A, B, C procedure" has absolute priority.

A) Clear the airways (check for blockages caused by the tongue or foreign objects)
B) Ventilation (check the patient's breathing, if necessary, begin ventilation with adequate self-protection, e.g. breathing mask)
C) Circulation (begin resuscitation for any person who does not respond to verbal commands and is not breathing normally)

4.3. Cleaning

Patients who have only been exposed to metal carbonyl vapors and show no signs of skin or eye irritation do not require any special cleaning measures, unlike all others.
If possible, patients should assist with their own cleaning. If liquid metal carbonyls or metal carbonyl solutions have been exposed and clothing is contaminated, it must be removed and securely wrapped.
In the event of exposure to metal carbonyls, rinse the eyes and affected areas of hair/skin with water or neutral saline solution for at least 15 minutes. Remove any contact lenses, if possible, without causing additional danger to the eye. Other important emergency measures should be continued during this time.

4.4. Initial treatment (preclinical or clinical)

Empirical therapy; no specific antidote available.

The following measures are recommended if the concentration of metal carbonyls is 0.1ppm or higher, if symptoms such as eye irritation or pulmonary symptoms are present, or if the concentration of the exposure cannot be estimated but exposure is very likely to have occurred:

- Oxygen administration
- Administration of 8 sprays of beclomethasone (800µg beclomethasone dipropionate) from a metered dose inhaler.

If there are signs of airway constriction (e.g. bronchospasm or stridor)

- Nebulization of adrenalin (epinephrine): mix 2mg adrenalin (2ml) with 3ml NaCl 0.9% and administer via a nebulizer mask
- Administration of a ß2-selective adrenoceptor agonist, e.g. four puffs of terbutaline or salbutamol or fenoterol (one puff usually contains 0.25mg terbutaline sulphate; or 0.1mg salbutamol; or 0.2mg fenoterol); this can be repeated once after 10 minutes.

Alternatively, 2.5mg salbutamol and 0.5mg ipratropium bromide can be administered via a nebulizer mask.
If inhalation is not possible, administer terbutaline sulphate (0.25mg to 0.5mg) subcutaneously or salbutamol (0.2mg to 0.4mg over 15 minutes) intravenously.
Intravenous administration of 250mg methylprednisolone (or an equivalent steroid dose).

If there are signs of toxic pulmonary oedema (e.g. frothy sputum, moist rales)

- CPAP therapy
- Intravenous administration of 1000mg methylprednisolone (or an equivalent steroid dose)
  In case of (increasing) respiratory insufficiency, advanced airway management, e.g. endotracheal intubation or coniotomy if necessary.

Note: The efficacy of corticosteroid administration has not yet been proven in controlled clinical trials.

Skin contact with metal carbonyls may cause irritation; this should be treated symptomatically.
Exposure of the eyes may also cause irritation; this should also be treated symptomatically. Consult an ophthalmologist.

Patients with persistent respiratory symptoms, patients who have been exposed to a concentration of 0.1ppm or more, and patients without exposure measurements but with a high degree of suspicion of relevant exposure should be transported to a hospital with intensive care facilities.

For all asymptomatic patients who have been exposed to a metal carbonyl concentration of 0.05ppm or more, pre-emptive administration of 5 puffs of beclomethasone from a metered dose inhaler should be considered. Repeat administration is possible every 10 minutes with 2 puffs. These patients should be monitored for an appropriate period.

Note: The efficacy of corticosteroid administration has not yet been proven in controlled clinical trials.

4.5. Further procedure and treatment

In addition to taking medical history, performing a physical examination and checking vital signs, pulse oximetry, a chest X-ray and spirometry should be performed.

Routine laboratory tests should include complete blood count, glucose and electrolytes.
Radiological signs of pulmonary oedema – enlargement of the hila, typical, centrally accentuated, patchy shadows on the chest X-ray – are late signs that only become apparent 6 to 8 hours or even later after exposure. The X-ray is typically still normal at the initial presentation at the hospital, even after inhalation of a relevant dose.
Patients with a possible exposure concentration of 1.0ppm or more should be monitored for an appropriate period and undergo repeated follow-up examinations before any adverse health effects can be ruled out.

If oxygen saturation falls below 90%, arterial blood gas concentrations should be checked immediately and a chest X-ray repeated.
If blood gas concentrations deteriorate and/or the chest X-ray shows signs of toxic pulmonary oedema,

oxygen should be administered via a mask. If deterioration manifests (especially in the case of tachypnoea (>30/min) and a simultaneous decrease in carbon dioxide partial pressure), CPAP therapy should be started within the first 24 hours after exposure.

In the event of pulmonary oedema developing, fluid intake and excretion as well as electrolytes should be closely monitored. A positive balance should be avoided. To optimize fluid management, the insertion of a central venous catheter should be considered.

If signs of pulmonary oedema persist, intravenous administration of methylprednisolone (or an equivalent steroid) should be continued at intervals of 8 to 12 hours.
Prophylactic antibiotic administration is not routinely recommended but may be considered based on the results of sputum cultures. Pneumonia may occur as a complication of severe pulmonary edema.

4.6. Discharge of the patient / instructions for further rules of conduct

Clinically asymptomatic patients who have been exposed to metal carbonyl concentrations of up to 0.1ppm (depending on the duration of exposure) and who show no abnormal clinical findings and no signs of toxic effects after an appropriate follow-up period may be discharged under the following circumstances:

- Information and recommendations for patients with instructions for further action were provided verbally and in writing. The patient was advised to seek immediate medical attention if any health problems arise.
- The patient is aware of and understands the toxic effects of metal carbonyls.
- The attending physician has been informed that regular contact between the patient and the physician is possible in the following 24 hours.
- Heavy physical work should not be done in the following 24 hours.
- Do not smoke or be exposed to cigarette smoke for at least 72 hours; smoke can impair lung function.
- Patients with eye damage should be examined again after 24 hours.
- Spirometry should be repeated at regular intervals after discharge until the values have returned to the patient's baseline values prior to exposure.

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Administrative Information

Document Type	Chemical Emergency Medical Guideline
Number of Version	DE.1.0.0
Initial Publication	01.01.2026
Next Revision	2029
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