Diagnosing Poisoning: Carbon Monoxide (CO)

1. Action to take:
   - ED - follow advice on TOXBASE. Contact NPIC for severe poisoning.
   - GP - follow advice on TOXBASE; refer to ED if required.
   - Test for CO poisoning.
How to diagnose carbon monoxide poisoning

See also the Diagnostic Algorithm on Page 5

The diagnosis of carbon monoxide poisoning can be difficult as it may imitate many other conditions, unless poisoning is suspected the diagnosis may be missed. The onset of symptoms is often insidious and may not be recognized by either the patient or the doctor. The most common symptoms and an indication of their approximate frequency in carbon monoxide poisoning are shown below:

- Headache: 90%
- Nausea and vomiting: 50%
- Vomiting: 30%
- Alteration in consciousness: 30%
- Subjective weakness: 20%

While a high exposure to concentrations of carbon monoxide leads to collapse, chronic exposure to lower concentrations may lead to the symptoms and signs of carbon monoxide poisoning. Apparent early clues of food poisoning of a whole family may be produced by carbon monoxide poisoning, migraine, transient vertigo and depression. Protracted exposure to concentrations that produce minor symptoms may, in some cases, be associated with lasting neurological effects including difficulty in concentrating and emotional lability. Complaints about such problems should be taken seriously by the doctor to the possibility of carbon monoxide poisoning.

Clinical signs

The source of CO may be in the home, in the car due to a leaking exhaust system, or in the workplace. Gas, oil, coal and wood heating appliances are the most common sources in the home. Carbon monoxide can also leak into a semi-detached or terraced house/apt from neighbouring premises.

The following are suggestive of domestic carbon monoxide poisoning:

- More than one person in the house affected.
- Symptoms disappear when the house is cleaned out, eg on holiday or at work, but recur on returning home.
- Symptoms related to cooking: oven, stove or grill use.
- Symptoms worse in winter, heating in use or fires lit.
- Yellow or orange instead of blue flames from gas appliances or boiler pilot lights.

Carbon monoxide levels are multiple – there may be more than one source of exposure.

Mechanisms of action of carbon monoxide

Carbon monoxide binds to haemoglobin with about 240 times the affinity of oxygen and shows a linear relationship with carboxyhaemoglobin dissociation curve. These effects combine to cause long-term damage in the body. In addition, carbon monoxide is transported dissolved in plasma and binds to intracellular and extracellular lipids and proteins. Binding to cytochrome A3 thought to play an important part in the toxicity of this gas.

Recent studies have shown that carbon monoxide may function as a transmitter substrate in the brain. It may be a toxicant affecting the function of a transmitters that are controlling permeability of the micro-vasculature and may indicate damage of arterial blood vessels and cells that line the capillary endothelium.

Carbon monoxide poisoning leads to leakage of fluid across cell membranes and this can be lethal. It is those who have been exposed to enough carbon monoxide to produce unconsciousness, delayed neurological damage due to leuko-encephalopathy may occur. Damage tends to be focused on those parts of the brain lying at the boundaries of the fields supplied by different cerebral arterial systems. As low as 20% of the population have a single cerebral vasculature, an important part in the toxicity of this gas.

The patient should be referred to the local Emergency Department for further assessment. COHb can be measured in blood by any clinical chemistry laboratory. Venous blood should be taken into a sample has been taken soon after exposure ended. COHb should be measured in venous blood only. The measurement if the patient has spent hours away from the source of carbon monoxide. CO levels in the blood decline with a half-life of about 6-8 hours, so measurements taken the day after the exposure may be misleading. Alternatively a monitor is not available, and carbon monoxide poisoning is suspected, the patient may be referred to the local Emergency Department for further assessment.

Investigations

Patients are available such as those used in smoking cessation clinics that measure carbon monoxide concentration in expired air and can estimate this value in COHb concentration in blood. These devices should be used where available, but must be used soon after likely exposure: there is no point in taking a measurement if the patient has already recovered from carbon monoxide. CO levels hours away from the source of carbon monoxide. CO poisoning is suspected, the patient may be referred to the local Emergency Department for further assessment.

COHb can be measured in blood by any clinical chemistry laboratory. Venous blood should be taken into anti-coagulant and sent to the local clinical chemical laboratory for analysis. COHb should be measured directly: measuring PO2 and calculating the % saturation of haemoglobin with oxygen will be misleading as the PO2 in COHb poisoning may well be normal. Suitable laboratory instruments are available, for example the radiometer co-oximeter. Prolonged exposure to high concentrations of carbon monoxide can be difficult as it may simulate many other conditions: unless high oxygen saturations are likely to be recorded due to the similar light absorbance of carboxyhaemoglobin and oxyhaemoglobin.

How to diagnose carbon monoxide poisoning: a primary care setting

Management of carbon monoxide poisoning

Management

Preventing further exposure is the most important thing you can do.

If you strongly suspect CO poisoning do not wait for the result of the analysis.

- Remove the patient and others from the source of carbon monoxide.
- Give 100% oxygen - A tightly fitting mask with an inhalation valve is necessary for the administration of 100% oxygen.
- Consider referring for hyperbaric oxygen treatment (see below).

If a natural gas appliance is suspected, advise a FREE safety check by calling 1800 79 79 79, or if you consider the situation an emergency and others may be at immediate risk, call Bord Gáis Networks on 1850 20 50 50.

- For other fuel types, contact the relevant safety expert for the fuel type: e.g. OPET (01 877 5450) for oil. For other fuel types, contact the fuel supplier or a qualified service agent for the appliance.
- Arrange checking of appliances, fluxes and chimney measurement of CO concentration in the house before allowing anyone back.
- Contact your local fire service.
- Contact your HSE local Department of Public Health to co-ordinate environmental health, safety, social and other services to protect your patient and others. Contact details can be found on the HSE website.
- Follow-up is important as further consequences of chronic exposure to CO may be delayed, or mild symptoms may persist, multiply or intensify.
- Recommend the purchase of a audible carbon monoxide alarm for installation in the home.
- Follow the advice on TOXBASE (www.toxbase.org) or refer to the National Poisons Information Centre (NPIC) on 01 837 9961 / 01 809 2566 for more detailed advice on the management of CO poisoning.
- Further information and advice on carbon monoxide causes, prevention and protection measures can be found at www.carbonmonoxide.ie

Indications for hyperbaric oxygen therapy (HBOT)

There is debate about the added value provided by hyperbaric oxygen. A COHb concentration of >20% should be an indication to consider hyperbaric oxygen and the decision should be taken on the basis of the indicators listed below.

- Loss of consciousness at any stage.
- Neurological signs other than headache.
- Myocardial ischaemia/arrhythmia diagnosed by ECG.
- Myocardial infarction/chromyolysis diagnosed by ECG.
- The patient is pregnant.

HBOT is also thought to be of use for extensive exposure to CO if neurological damage is suspected, its use should be on a case by case basis.
**How to diagnose carbon monoxide poisoning**

**See also the Diagnostic Algorithm on Page 3**

The diagnosis of carbon monoxide poisoning can be difficult as it may resemble many other conditions, unless poisoning is suspected the diagnosis may be missed. The most common symptoms and an indicator of their approximate frequency in carbon monoxide poisoning are shown below:

- **Headache** - 90%
- **Nausea and vomiting** - 50%
- **Vomiting** - 50%
- **Altered consciousness** - 30%
- **Subjective weakness** - 20%

While exposure to high concentrations of carbon monoxide leads to collapse, chronic exposure to lower concentrations may lead to the symptoms and signs of influenza, food poisoning (apparently classic case of food poisoning of a whole family may be produced by carbon monoxide poisoning), migraine, tension headaches and depression. Profound exposure to concentrations that produce only minor symptoms may, in some cases, be associated with lasting neurological effects including difficulty in concentrating and emotional liability. Complaints about such problems should direct the doctor to the possibility of carbon monoxide poisoning.

**Clues to the diagnosis**

The source of CO may be in the home, in the car due to a leaking exhaust system, or in the workplace. Gas, oil, coal and wood heating appliances are the most common sources in the home. Carbon monoxide can also leak into a semi-detached or terraced house/apartment from neighbouring premises. Clues to the diagnosis are:

- More than one person in the house affected.
- Symptoms disappear when away from the house e.g. on holiday or at work, but recur on returning home.
- Symptoms related to cooking, stoves or grill in use.
- Symptoms worse in winter: heating in use or fires lit.
- Yellow or orange rather than blue flames from gas appliances or boiler pilot lights.
- Smoke and/or excessive condensation accumulating in rooms due to faulty flues (though you cannot smell carbon monoxide you can smell other gases). Black sooty marks on the roof around gable, chimneys and flues.
- Food poisoning of a whole family may be produced by carbon monoxide poisoning.
- False sense of well-being.

**Clinical signs**

The cherry red skin colour produced when carbon monoxide (CO) concentrations exceed about 20% is rarely seen in life. Neurological signs must be looked for: a neurological examination, including tests of fine movement and balance (finger-nose movement, Romberg’s test, normal gait and heel-toe walking), a mini-mental state examination and testing of short term memory and the ability to subtract 7, 13 and 29. Tests of fine movement and balance (finger-nose movement, Rhomberg’s test, normal gait and heel-toe walking), a mini-mental state examination and testing of short term memory and the ability to subtract 7, 13 and 29.

**Management of carbon monoxide poisoning**

** Investigations**

Monitors are available such as those used in smoking cessation clinics that measure carbon monoxide concentration in expired air and convert this value into COHb concentration in blood. These devices should be used where available, but must be used soon after likely exposure: there is no point in taking a measurement if the patient has already left the scene of carbon monoxide poisoning.

CO levels hours away from the source of carbon monoxide poisoning is suspected, the patient may be referred to the local Emergency Department for further assessment.

COHb can be measured in blood by any clinical chemistry laboratory. Venous blood should be taken into anti-coagulant and sent to the local clinical chemistry laboratory for analysis. COHb should be measured directly: measuring PO2 and calculating the % saturation of haemoglobin with oxygen will be misleading as the PO2 in CO poisoning may well be normal. Several suitable instruments are available, for example the rapidometer co-oximeter.

**Mechanisms of action of carbon monoxide**

Carbon monoxide binds to haemoglobin with about 240 times the affinity of oxygen and causes a left-shift in the oxyhaemoglobin dissociation curve. These effects combine to make the longer delivery time in the fetus. In addition, carbon monoxide is transported in plasma and binds to intracellular haemoglobin and mitochondrial enzymes. Binding to cytochrome A3 is thought to play an important part in the toxicity of this gas.

Recent studies have shown that carbon monoxide may function as a neurotransmitter substance in the body, leading to a controlling permeability of the microvasculature and may inhibit the release of information from cells and tissue to the capillary endothelium.

**Carbon monoxide poisoning leads to leuko-encephalopathy**

**Indications for hyperbaric oxygen therapy (HBOT)**

There is debate about the added value provided by hyperbaric oxygen. A COHb concentration of >20% should be an indication to consider hyperbaric oxygen and the decision should be taken on the basis of the indicators listed below.

- Loss of consciousness at any stage.
- Neurological signs other than headache.
- Myocardial ischaemia/arrhythmia diagnosed by ECG.
- Myocardial infarction or myocardial ischaemia diagnosed by ECG.
- The patient is pregnant.
- HBOT is also thought to be of use for extensive exposure to CO if neurological damage is suspected, its use should be on a case by case basis.
How to diagnose carbon monoxide poisoning

The diagnosis of carbon monoxide poisoning can be difficult as it may resemble many other conditions, unless poisoning is suspected the diagnosis may be missed. The onset of symptoms is often insidious and may not be recognized by either the patient or the doctor. The most common symptoms and an indication of their approximate frequency in carbon monoxide poisoning are shown below:

- Headache - 90%
- Nausea and vomiting - 50%
- Vomiting - 20%
- Alteration in consciousness - 30%
- Subjective weakness - 20%

While exposure to high concentrations of carbon monoxide leads to collapse, chronic exposure to lower concentrations may lead to the symptoms and signs of anaemia, fluid poisoning, apparent cardiac arrest, and food poisoning of a whole family may be produced by carbon monoxide poisoning, ingestion, irritation and damage to the brain. Prolonged exposure to concentrations that produce only minor symptoms may, in some cases, be associated with lasting neurological effects including difficulty in concentrating and emotional liability. Complains about such problems should be taken by the doctor to the possibility of carbon monoxide poisoning.

Carbon monoxide poisoning is multiple - there may be more than one source of exposure. Carbon monoxide can also leak into a semi-detached or terraced house/apartment from neighbouring premises.

The following are suggestive of domestic carbon monoxide poisoning:

- More than one person in the house affected.
- Symptoms disappear when you move away from the house, e.g. on holiday or at work, but recur on returning home.
- Symptoms related to cooking, oven, stove or grill in use.
- Symptoms worse in winter, heating in use or fires lit.

Carbon monoxide sources are multiple - there may be more than one source of exposure.

Clinical clues to the diagnosis

The cherry red skin colour produced when carboxyhaemoglobin (COHb) concentrations exceed about 20% is rarely seen in life. Neurological signs must be looked for: a neurological examination, including tests of fine motor movements and balance, a mini-mental state examination and testing of short term memory and the ability to subtract 7, rarely, from 100, are key to determining a chronic poisoning event.

Carbon monoxide is produced continuously in the body as a by-product of haem breakdown. To lead to a normal baseline COHb concentration of about 0.5% in pregnancy and especially in haematologically abnormal cases this can rise towards 5%. Cigarette smoking leads to COHb concentrations of up to about 13% in heavy smokers. In pregnancy and especially in haemolytic anaemias this normal baseline COHb concentration of about 0.5%. In pregnancy and especially in haematologically abnormal cases this can rise towards 5%. Cigarette smoking leads to COHb concentrations of up to about 13% in heavy smokers.

Management of carbon monoxide poisoning - a primary care setting

Investigations

Monitors are available such as those used in smoking cessation clinics that measure carbon monoxide concentration in expired air and can express this value in COHb concentration in blood. These devices should be used where available, but must be used soon after likely exposure: there is no point in taking a measurement if the patient has already been exposed to carbon monoxide. CO levels hours after the end of the exposure in the blood decline with a half-life of about 6.9 hours, so measurements taken the day after the surgery may be misleading. Alternatively, a monitor is not available, and carbon monoxide poisoning is suspected, the patient may be referred to the local Emergency Department for further assessment. COHb can be measured in blood by any clinical chemistry laboratory. Venous blood should be taken into anti-coagulant and sent to the local clinical chemical laboratory for analysis. COHb should be measured directly: measuring PO2 and calculating the % saturation of haemoglobin with oxygen will be misleading as the PO2 in CO poisoning may be normal. Several suitable instruments are available, for example the radiometer co-oximeter. Pulse oximetry in cases of suspected carbon monoxide poisoning is not recommended because high oxygen saturations are likely to be recorded due to the similar light absorbance of carboxyhaemoglobin and oxyhaemoglobin.

A measurement of expired CO is useful in diagnosis. Blood COHb is also useful. Expired CO and blood COHb provide good prognosis and the need for hyperbaric therapy. For interpretation of results and detailed advice on CO poisoning see TOXBASE and/or call the National Poisons Information Centre (NPIC).

It is recommended that a normal concentration of COHb does not disprove CO poisoning unless the sample has been taken soon after exposure ended.

Mechanisms of action of carbon monoxide

Carbon monoxide binds to haemoglobin with about 245 times the affinity of oxygen and causes a substantial drop in the oxygen dissociation curve. These effects combine to produce the diminished blood flow in the tissues. In addition, carbon monoxide is metabolized in the liver and brain to produce acetoacetic acid and acetoacetyl CoA. Binding to cytochrome A3 is thought to play an important part in the toxicity of this gas. Recent studies have shown that carbon monoxide may function as a transmitter substance in the body helping in the binding of a key controlling permeability of the micro-vessels and may play an important role in the dilation of coronary arteries and the pulsatility of oscillation.

Carbon monoxide poisoning leads to leakage of fluid across the intracellular and intercellular spaces, and it is those who have been exposed to enough carbon monoxide to produce carbon monoxide poisoning, delayed neurological damage due to leukoencephalopathy may occur. Damage tends to be focused on those parts of the brain lying at the boundaries of the fields supplied by the two cerebral arterial systems, e.g. the basal ganglia and the brain stem, and small areas in the frontal and parietal lobes. Neurological damage seems to be the result of raised levels of carbon monoxide. Damage tends to be focused on those parts of the brain lying at the boundaries of the fields supplied by the two cerebral arterial systems, e.g. the basal ganglia and the brain stem, and small areas in the frontal and parietal lobes. Neurological damage seems to be the result of raised levels of carbon monoxide. The half-life to haemoglobin is about 245 times the affinity of oxygen and causes a substantial drop in the oxygen dissociation curve. These effects combine to produce the diminished blood flow in the tissues. If you strongly suspect CO poisoning do not wait for the result of the analysis.

Management

Preventing further exposure is the most important thing you can do.

If you strongly suspect CO poisoning do not wait for the result of the analysis.

- Remove the patient and others from the source of carbon monoxide.
- Give 100% oxygen - A tightly fitting mask with an inflated face-seal is necessary for the administration of 100% oxygen.
- Consider referring for hyperbaric oxygen treatment (see below)

- If a natural gas appliance is suspected, advise to arrange a FREE safety check by calling 1800 79 79 79 or, if you consider the situation an emergency may be as immediate risk, call Gardaí on 1000 or 999.
- For other fuel types, contact the relevant safety service for the fuel type (NPIC) on 01 837 9964 / 01 809 2566 for more detailed advice on the management of CO poisoning.
- Further information and advice on carbon monoxide causes, prevention and protection measures can be found at www.carbonmonoxide.ie

Indications for hyperbaric oxygen therapy (HBOT)

There is debate about the added value provided by hyperbaric oxygen. A COHb concentration of >20% should be an indication to consider hyperbaric oxygen and the decision should be taken on the basis of the indications listed below.

- Loss of consciousness at any stage.
- Neurological signs other than headache.
- Myocardial ischaemia/arrhythmia diagnosed by ECG.
- Prolonged blood pressure drop.
- Cerebral oedema.
- Myocardial ischaemia/arrhythmia diagnosed by ECG.
- Prolonged blood pressure drop.
- Cerebral oedema.
- Fever.
- Inflamed face-seal is necessary for the administration of 100% oxygen.
- Consider referring for hyperbaric oxygen treatment (see below)

- If a natural gas appliance is suspected, advise to arrange a FREE safety check by calling 1800 79 79 79 or, if you consider the situation an emergency may be as immediate risk, call Gardaí on 1000 or 999.
- For other fuel types, contact the relevant safety service for the fuel type (NPIC) on 01 837 9964 / 01 809 2566 for more detailed advice on the management of CO poisoning.
- Further information and advice on carbon monoxide causes, prevention and protection measures can be found at www.carbonmonoxide.ie

- Loss of consciousness at any stage.
- Neurological signs other than headache.
- Myocardial ischaemia/arrhythmia diagnosed by ECG.
- The patient is pregnant.

HBO is also thought to be of use for extensive exposure to CO if neurological damage is suspected, its use should be on a case by case basis.

Further information and advice on carbon monoxide causes, prevention and protection measures can be found at www.carbonmonoxide.ie

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Diagnosing Poisoning: Carbon Monoxide (CO)

**Bibliography**


Hughes, T., Tracey, J. A case of Methane Chloride (Methane) poisoning. effects on cardiac haemodynamics. Human and Experimental Toxicology. 1991; 10(3):159-160.


**This fact sheet covers:**

- Sources of carbon monoxide poisoning
- How to diagnose carbon monoxide poisoning
- Clinical signs
- Management of carbon monoxide poisoning
- Sources of carbon monoxide
- Bibliography

**Sources of carbon monoxide**

- Carbon monoxide is produced by the incomplete combustion of carbon-containing fuels including gas, charcoal, petroleums, coal, coke, oil, tar, fuel oil and wood.
- Potential sources include the following: gas fires, wood stoves and room heaters.
- Carbon monoxide can be produced by the natural oxidation of wood pellets in storage even if the wood pellets are not recently burned.
- Gas fires per se are not a source of carbon monoxide unless there is a combustion process of some sort involved.
- Inadequate maintenance leading to poor combustion and partially blocked or damaged flues can also be a cause of indoor carbon monoxide accumulation.
- Carbon monoxide can also escape into properties via shared ventilation.
Diagnosing Poisoning: Carbon Monoxide (CO)

**Patient presenting with:**
- Headache, confusion, dizziness, drowsiness, diarrhea, or vomiting

**You are suspicious:**
- Could this be a case of CO poisoning?

**You are confident:**
- This is a case of CO poisoning

**Action to take:**
- GP - General Practice ED - Emergency Department

**1. Tools for CO**
- GP - breath test for initial CO if device is available. (Note: Only includes recent exposure; interpretation difficult in smokers.
- ED - follow advice on TOXBASE. Contact NPIC for severe poisoning.

**2. Management - Commence oxygen therapy**
- GP - note that symptoms may persist or develop later.
- ED - follow advice on TOXBASE. Contact NPIC for severe poisoning.

**3. Test for CO**
- GP - advice patient to see GP for follow-up. Note this advice in medical records.
- ED - breath test for exhaled CO if device is available. (Note: Only indicates recent exposure; interpretation difficult in smokers.

**4. Diagnostic algorithm**
- If patient does not improve, consider:
  - Contact HSE local Department of Public Health
  - Reconsider advice.
  - Contact NPIC for advice.

**Bibliography**


This fact sheet covers:
- Sources of carbon monoxide
- How to diagnose carbon monoxide poisoning
- Clinical signs
- Management of carbon monoxide poisoning

**Sources of carbon monoxide**
- Carbon monoxide is produced by the incomplete combustion of carbon-containing fuel including gas (natural, bottled), coal, coke, wood, tar, oil, and diesel.
- Potential sources include the following: gas stoves, fires and other engines run without adequate ventilation. Barbeques can produce large amounts of carbon monoxide and can be very dangerous if used indoors or under cover. Portable generators are not recommended for homeowners, student accommodation or those from lower income groups. Carbon monoxide can occur in modern homes fitted with modern appliances.
- Gas leaks per se are not a source of carbon monoxide unless there is a combustion process of some sort involved. Inadequate ventilation leading to your combustion and partially blocked or damaged flues and chimneys can be the most obvious sources of indoor carbon monoxide accumulation.
- Mechanisms of action of carbon monoxide poisoning

**This fact sheet was developed by**

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- Bord Gáis Energé

**For further information or to download this fact sheet visit www.7099707070 or www.npisc.ie**