

7 November 2008

## Recognising Carbon Monoxide Poisoning – 'Think CO'

Dear Colleague

A patient presents with tiredness and symptoms of food poisoning. They do not have gas central heating. Does carbon monoxide (CO) poisoning feature in your differential diagnosis, following up with breath and blood tests and a neurological examination? Or might you send the patient home to rest and keep warm, with potentially disastrous consequences?

There are approximately 50 accidental deaths per year in the UK from CO poisoning, and over 200 cases of recorded non-fatal injury – which can often lead to lasting neurological damage. Many more people are likely to suffer unknowingly from CO poisoning, and the impact on health may well be underestimated.

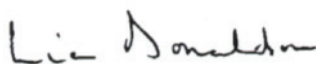
These deaths and accidents can be prevented by increasing awareness among the public and health professionals of the signs and symptoms of exposure to CO. 'Think CO – Think Carbon Monoxide.'

As well as a general lack of awareness among health professionals and the public of the risk of CO poisoning, there are many preconceived ideas that are potentially damaging the management of patients. For example, gas is not the only source of CO, and 'cherry red' skin is not a common sign of CO poisoning.

The Health Protection Agency (HPA) is, in consultation with the Department of Health (DH), the Royal College of General Practitioners (RCGP) and the College of Emergency Medicine (CEM), producing a diagnostic algorithm that will be made available to GPs and Emergency Physicians.

With national CO awareness week taking place this year on 17–23 November, a NHS information leaflet for patients and the public is attached to this letter; the leaflet will also be available in other languages and further copies can be obtained as indicated. By bringing this to your attention, we hope that cases of CO poisoning will be recognised as early as possible and the appropriate action taken.

We would be grateful if Nurse Executive Directors could arrange for this letter to be circulated to community nurses, midwives and health visitors working within their Trusts.



**Professor Sir Liam Donaldson KB**  
Chief Medical Officer



**Dame Christine Beasley CBE**  
Chief Nursing Officer

**From the  
Chief Medical  
Officer and the  
Chief Nursing  
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PL/CMO/2008/8,  
PL/CNO/2008/8

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### For Action

- Directors of Public Health
- Medical Directors of NHS Trusts
- General Practitioners
- Nurse Executive Directors
- Lead nurses at PCTs
- SHA Nurse Advisors
- Obstetricians
- Paediatricians
- Consultants in Accident and Emergency Medicine

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### For information

- Regional Directors
- Regional Directors of Public Health
- Chief Executives of SHAs
- Chief Executives of NHS Trusts
- Chief Executives of NHS Foundation Trusts
- Chairs of Primary Care Trusts
- Chairs of and NHS Foundation Trusts
- Chairs of NHS Trusts

## Summary

This letter brings together the most up-to-date information on carbon monoxide (CO) poisoning and updates the CMO/CNO letter of February 2002. It describes the signs and symptoms that should be looked for; explains the investigations that may be necessary to establish whether a case of CO poisoning has occurred; describes how cases should be managed; sets out the main sources of CO in the home; and provides sources of further advice and information.

## Background

Research for the Health and Safety Executive (HSE) in 2007 indicated that there was concern among some stakeholders that there may be under-reporting of CO poisoning, with 8% of the 597 homes surveyed experiencing dangerous levels of CO. Older people, children, pregnant women and their babies and those with breathing problems or cardiovascular disease are at increased risk. CO poisoning can result in lasting neurological damage.

## How to diagnose carbon monoxide poisoning

Recognising CO poisoning is not at all easy, as it may simulate many other conditions: unless poisoning is suspected, the diagnosis will be missed (see recent case studies on page 5).

The onset of symptoms is often insidious and may not be recognised by either the patient or the doctor. The commonest symptoms and signs, in order of frequency in CO poisoning cases, are shown below:

Headache	90% of cases
Nausea and vomiting	50% of cases
Vertigo	50% of cases
Alteration in consciousness	30% of cases
Subjective weakness	20% of cases

While chronic exposure to lower CO concentrations may lead to the symptoms and signs of influenza or food poisoning, exposure to high concentrations of CO leads to collapse and death within minutes.

What appears to be classic food poisoning of a whole family may in fact be the result of CO poisoning. Prolonged exposure to concentrations that produce only minor symptoms may, in some cases, be associated with lasting neurological effects such as difficulties in concentrating and emotional lability. Complaints about such problems should alert the doctor to the possibility of CO poisoning.

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### Recognising Carbon Monoxide Poisoning

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If you require further copies of this title visit:

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This letter is also available on the Internet at:

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## Clues to the diagnosis

The following are suggestive of domestic CO poisoning:

- more than one person in the house is affected;
- symptoms are better when away from the house, e.g. on holiday, but recur on returning home;
- symptoms are related to cooking, with a stove in use; and
- symptoms are worse in winter, with heating in use.

The following signs may be recognised in the home:

- black sooty staining on or around an appliance (e.g. a stove, boiler or fire), such as on the walls;
- the accumulation of smoke or excessive condensation in rooms owing to faulty flues – although you cannot smell CO, you may be able to smell other combustion products; and
- yellow or orange, instead of blue, flames from gas appliances or boiler pilot lights (excluding 'decorative' flame fires).

## Clinical signs

Neurological examination is key to determining a chronic poisoning event. It is therefore vital to conduct 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, serially, from 100.

Cherry red skin colour is not a common sign of poisoning. This is produced when carboxyhaemoglobin (COHb) concentrations exceed about 20% and is rarely seen in the living.

## Investigations

CO can be measured in expired air and as such is used in smoking cessation clinics. Monitors are available that convert CO concentration into COHb concentration from the standard equilibration curve. If such devices are used, they must be used quickly: there is no point in taking a measurement if the patient has spent hours away from the source of CO. Measurements taken the next day at the surgery may be misleading.

COHb can be measured in blood by any clinical chemistry laboratory. Venous blood should be taken into anti-coagulant and sent to the laboratory. COHb should be measured directly: measuring PO<sub>2</sub> and calculating the percentage saturation of haemoglobin with oxygen will be misleading as the PO<sub>2</sub> in CO poisoning may well be normal.

Recent advances in pulse oximeters allow them to take readings for CO levels. Whilst there are some concerns if a traditional pulse-oximeter is used, owing to the similar light absorbance of COHb and oxyhaemoglobin and the likely display of false high oxygen saturations, those designed for use in detecting blood CO levels (pulse CO-oximeters) are a useful aid to diagnosis.

Rapid measurement of expired air CO and pulse CO-oximetry are useful in diagnosis.

For interpretation of blood sample results and more detailed advice on CO poisoning refer to TOXBASE or contact the National Poisons Information Service (NPIS).

## Management

- Remove patient and co-habitants from source of CO.
- 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 therapy.
- Contact your local Health Protection Unit (HPU). They will co-ordinate Environmental Health, Safety, Social and other services to protect your patient and others.

## Indications for hyperbaric oxygen therapy (HBOT)

There is debate about the added value provided by HBOT. While this is advocated by some clinical experts, systematic reviews have not provided conclusive evidence of benefit. Advice on management of patients with serious CO poisoning, especially those with the following features, can be obtained from NPIS:

- the patient has lost consciousness at any stage;
- the patient has neurological signs other than headache;
- myocardial ischaemia/arrhythmia has been diagnosed by ECG; and/or
- the patient is pregnant.

HBOT should be used for the urgent treatment of CO poisoning (within 24 hours) as stated in the specialised service definition for HBOT (definition number 28).

HBOT is also thought to be of use in cases of extensive exposure to CO and if nerve damage is suspected. Expired air CO and blood COHb are poor guides to prognosis and the need for hyperbaric oxygen therapy. Its use should be on a case-by-case basis.

## Sources of carbon monoxide

CO is produced not just by gas but by the incomplete combustion of all carbon-containing fuels: gas (domestic or bottled), coal, coke, oil and wood. Stoves, fires and boilers, water heaters, paraffin heaters and room heaters are all potential sources. Caravans, boats and mobile homes are also at risk as they often use portable appliances which use these fuels, and engine or generator exhaust gases can also contain high levels of CO. During incomplete combustion, carbon, hydrogen and available oxygen combine to form carbon dioxide, water, heat and CO. Any disruption of the burning process or shortage of oxygen can increase CO production and accumulation to dangerous levels.

Inadequate installation or maintenance leading to poor combustion of fuel, inadequate removal of waste products because of blocked and partially blocked flues and chimneys, and insufficient ventilation are the main causes of CO poisoning. Such faults can occur in all types of property, and the idea that CO poisoning is restricted to poorer homes and student accommodation is false. Owner-occupied houses with newly installed oil-powered cooking ranges can also be the site of accidents.

CO can also seep into properties via shared flues and chimneys, and people may be poisoned by CO produced next door or in adjoining flats (above and below). Extraordinary errors, such as the venting of gas fires into cavity walls, can lead to poisoning of people living above those using the fire. Integral garages can also be a source of CO if car engines are run without adequate ventilation.

## Case studies

### 1. Acute poisoning

Ambulance crews attended a two-year-old child who was floppy and unresponsive and had difficulty breathing. Other members of the family were also feeling unwell. Three children and one adult were monitored for CO and had high levels of COHb in the blood; the children's levels were higher than the adult. Emergency gas engineers had recently isolated the heating boiler in the premises, as it was unserviceable; with no other source of heat, the family had burnt charcoal on a barbecue in the main family room, and this had produced the CO and caused the illness.

### 2. Chronic poisoning

An ambulance was called out to attend a 29-year-old woman who was feeling generally unwell and complaining of chest pains. When the ambulance crew arrived, they monitored the patient with a CO monitor which showed that she had elevated levels of COHb in the blood; her mother, who lived in the same flat, showed similar levels of COHb. The block contained six flats, and the residents were evacuated and monitored for CO poisoning; the residents in the flat below also had raised levels of COHb in their blood. All patients with raised CO levels were transported to hospital where they received treatment. The cause of the CO poisoning was traced to a faulty heating boiler at the original address.

## People to consult

For CO measurements in the house:

- *For gas:* Local CORGI (Council for Registered Gas Installers) engineer – call **0800 915 0485** (N.B. CORGI is the Health and Safety Executive appointed provider of the gas installer registration scheme until April 2009. After that, contact the HSE Gas Safety Line – see below).
- Health and Safety Executive Gas Safety Line – call **0800 300 363**.
- *For oil:* Local OFTEC (Oil Firing Technical Association) engineer – call **0845 658 5080**.
- *For solid fuel:* Local HETAS (Heating Equipment Testing and Approval Scheme) engineer – call **0845 634 5626**.
- Your local Health Protection Unit (HPU) (see below).

## Advice on the management of poisoning

Refer to TOXBASE or the National Poisons Information Service (NPIS) on **0844 892 0111** for the interpretation of blood sample results and for more detailed advice on CO poisoning.

Details of Local Health Protection Units are available on the Health Protection Agency website – [www.hpa.org.uk/hpucontactdetails](http://www.hpa.org.uk/hpucontactdetails)

## Last points

Audible CO alarms are available (European Standard EN 50291, showing a British Standards Kitemark or LPCB – Loss Prevention Certification Board logo) and should be recommended. These alarms are available in homeware or DIY stores, and the alarm manufacturer's instructions for installation and maintenance should be followed. You can also buy CO detection patches and 'black-spot' indicators, but these will not wake you and warn you if dangerous levels of CO develop. It is important to remember that fitting an audible CO alarm is not an alternative to having appliances, flues and chimneys serviced and tested.

## Leaflets and further information

1. *Carbon monoxide: Are you at risk?* New leaflet for the general public, available at [www.dh.gov.uk/publications](http://www.dh.gov.uk/publications)
2. Department of Health 'Keep Warm, Keep Well' campaign: [www.direct.gov.uk/keepwarmkeepwell](http://www.direct.gov.uk/keepwarmkeepwell)
3. NHS Choices information on CO poisoning: [www.nhs.uk/carbonmonoxide](http://www.nhs.uk/carbonmonoxide)
4. Health Protection Agency information on CO: [www.hpa.org.uk/carbonmonoxide](http://www.hpa.org.uk/carbonmonoxide)
5. *Gas Appliances – Get them checked. Keep them safe.* Leaflet produced by the Health and Safety Executive (HSE), available by calling the HSE information line on 0845 345 0055 or at [www.hse.gov.uk/pubns/indg238.pdf](http://www.hse.gov.uk/pubns/indg238.pdf)
6. HSE has also prepared a series of short videos on gas safety, which help to highlight typical scenarios and symptoms of CO poisoning: [www.hse.gov.uk/campaigns/worksmart/videos](http://www.hse.gov.uk/campaigns/worksmart/videos)

## Appendix

### **Mechanisms of action of carbon monoxide**

Carbon monoxide (CO) gas enters the blood system during normal breathing. Inhaled CO combines with haemoglobin to form carboxyhaemoglobin (COHb). Once this conversion occurs, the haemoglobin is no longer available to transport oxygen to other parts of the body. CO 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 reduce oxygen delivery to the tissues.

In addition, CO is transported dissolved in plasma and binds to intracellular myoglobin and mitochondrial cytochrome enzymes. Binding to cytochrome A3 is thought to play an important part in the toxicity of this gas.

Recent studies have shown that CO may function as a local transmitter substance in the body playing a role in controlling permeability of the microvasculature, and may increase adhesion of inflammatory cells and platelets to the capillary endothelium. CO poisoning leads to leakage of fluid across cerebral capillaries and thus to cerebral oedema. In those who have been exposed to enough CO 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 two cerebral arterial systems, e.g. the basal ganglia. Neurological damage seems to be the result of free radical generation and lipid peroxidation. It is possible that the binding of CO to cytochrome A3 reduces the capacity of cells to deal with free radicals.

CO bound to haemoglobin has a half-life of about 320 minutes under normal circumstances. This can be reduced by exposing the patient to 100% oxygen, which reduces the half-life to 80 minutes; or to 100% oxygen at 2 atmospheres pressure (hyperbaric oxygen), which reduces the half-life to 23 minutes. The half-life of CO bound to mitochondrial cytochromes may well be much longer than that of COHb, and hyperbaric oxygen has been suggested as being important in attacking this binding site. CO binds to fetal haemoglobin and shifts the already left-shifted oxyhaemoglobin dissociation curve further to the left. The half-life of CO in the fetus is longer than that in the mother.

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