**11 November 2010**

## CARBON MONOXIDE POISONING: NEEDLESS DEATHS, UNNECESSARY INJURY

Dear Colleague

Carbon monoxide poisoning should be a problem of the past, but unfortunately, this is not so. A considerable number of people are still dying from accidental acute carbon monoxide poisoning and many more than previously realised are injured from sub-lethal poisonings, which can often lead to lasting neurological damage in victims. These victims are exposed to CO in their homes, but are also at risk from exposure in holiday residences, including caravans.

We know that every year, there are still approximately 50 accidental deaths from acute CO poisoning in England and Wales and that there are over 200 non-fatal poisonings which require hospital admission. However, there is new data which suggests that there is a similar order of magnitude of non-fatal poisonings in people who attend A&E, are treated for carbon monoxide poisoning, but who do not require admission to hospital – this is of great concern as CO poisoning can lead to chronic health problems. The number of people exposed to CO, but who are unaware of the cause and do not present at their GPs surgery or local hospital is still not known but is likely to be many more.

Yet these deaths and accidental poisonings can be prevented: through greater public awareness and in particular, increased vigilance amongst health professionals of the signs and symptoms of exposure in their patients. This is why we have attached a copy of a diagnostic algorithm tool produced by the Health Protection Agency, Department of Health, Royal College of General Practitioners and College of Emergency Medicine to assist you in diagnosing

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PL/CMO/2010/02, PL/CNO/2010/02

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- 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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CO poisoning. A NHS information leaflet for patients and the public is also available (link provided at the end of this letter) giving guidance on preventing CO poisoning and what to do if they suspect they have been poisoned. Do use these free items, order hard copies if required and make sure that you correctly advise your patient. Unfortunately, on occasions in the past, colleagues have advised patients to stay at home and keep warm when the symptoms they presented with were in fact those of CO poisoning – the result can be fatal.

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 Trust. We are sure that the tool and leaflet will also be appreciated by your team

**Professor Dame Sally Davies**
**Interim Chief Medical Officer**

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**Requests for further copies**

Write to: Department of Health
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## Summary

This letter brings together the most up-to-date information on CO poisoning and updates the CMO/CNO letter of November 2008. It describes the signs and symptoms which should be looked for; explains the investigations which may be necessary to establish whether CO poisoning has occurred; describes how cases should be managed; sets out the main sources of CO in the home and gives sources of further advice and information.

## Background

Carbon monoxide is a colourless, odourless gas that causes the accidental deaths of approximately 50 people each year. Around 200 people each year in England and Wales are seriously injured by CO and new data suggests that a similar number of people are treated but not admitted to hospital each year from accidental poisoning by CO. Poisoning by CO is almost certainly under-diagnosed and there could well be a large number of people being exposed and suffering the ill effects of exposure. Older people, children, pregnant women and their babies and those with breathing problems or cardiovascular disease are at increased risk. 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.

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

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

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

Apparently classic cases of food poisoning of a whole family may be produced by carbon monoxide poisoning. Prolonged exposure to concentrations that produce only minor symptoms may, in some cases, be associated with lasting neurological effects. These include difficulties in concentrating and emotional lability. Complaints about such problems should alert the doctor to the possibility of carbon monoxide poisoning.

## Clues to the diagnosis

The following are suggestive of domestic carbon monoxide poisoning:

- 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: stove in use; and
- Symptoms worse in winter: heating in use.

The following signs may be recognised in the home:

- Black sooty staining on or around an appliance (e.g. stoves, boilers and fires) such as on the walls;
- Smoke or excessive condensation accumulating in rooms due to faulty flues: though you cannot smell carbon monoxide, you can often smell other combustion products;
- Yellow or orange, instead of blue, flames from gas appliances or boiler pilot lights.

## Clinical signs

Neurological examination is key in determining a chronic poisoning event and 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, serially, from 100, are vital.

The cherry red skin colour is not a common sign of poisoning. This is produced when COHb concentrations exceed about 20% and is rarely seen in life.

## Investigations

Carbon monoxide can be measured in expired air. Breath analyzers are used in smoking cessation clinics and should be used in surgeries which have such devices. There are also analyzers which 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 $PO_2$ and calculating the % saturation of haemoglobin with oxygen will be misleading as the $PO_2$ in CO poisoning may well 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 false high oxygen saturations are likely to be recorded due to the similar light absorbance of carboxyhaemoglobin and oxyhaemoglobin.

- Rapid measurement of expired air CO is useful in diagnosis.
- Blood COHb is also useful.
- Expired air CO and blood COHb are poor guides to prognosis and the need for hyperbaric treatment.

## Management

- Remove patient and relatives 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 treatment;
- Arrange checking of appliances and flues and measurement of CO concentration in the house before allowing anyone back; and
- Contact social services, if necessary.

## 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; or
- The patient is pregnant.

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

## Sources of carbon monoxide

Carbon monoxide is produced not just by malfunctioning or poorly flued gas appliances but by the incomplete combustion of all carbon-containing fuels: gas (domestic or bottled), coal, coke, oil, biofuel 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 exhaust gasses from vehicle engines and generators of electricity 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 its accumulation to dangerous levels.

Inadequate installation or maintenance of fossil fuel and wood-burning appliances 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 poisoning. Such faults can occur in all types of property and the idea that carbon monoxide 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.

Carbon monoxide can also seep into properties via shared flues and chimneys and people may have been poisoned by carbon monoxide produced by an appliance in a neighbouring property. Dangerous 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 carbon monoxide if car engines are run without adequate ventilation.

## Advice on the management of poisoning

Follow advice on TOXBASE (www.toxbase.org) or refer to the National Poisons Information Service (NPIS) on 0844 892 0111 for more detailed advice on the management of CO poisoning and interpretation of blood sample results.

Contact your Local Health Protection Unit – they will co-ordinate services for your patient. Contact details can be found on the Health Protection Agency website: http://www.hpa.org.uk/web/HPAweb&Page&HPAwebAutoListName/Page/1158945066055

## Leaflets and further information

1. Carbon Monoxide – Are you at risk? Patient information leaflet (Available in 12 languages) http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_090124

2. Department of Health: http://www.dh.gov.uk/en/Aboutus/Campaigns/DH_121156

3. NHS Choices – Video and further information on CO: www.nhs.uk/carbonmonoxide

4. The Health Protection Agency – Further information on CO: http://www.hpa.org.uk/CarbonMonoxide/

5. Gas Appliances – Get Them Checked, Keep Them Safe. From the Health and Safety Executive (HSE). HSE information line 0845 3450055

6. Health and Safety Executive have also prepared a series of short videos on gas safety, which help to highlight typical scenarios and symptoms of CO poisoning. See the Gas Safety section at: http://www.hse.gov.uk/campaigns/worksmart/videos/

7. An in-depth review of the health effects of domestic CO exposure is contained in *Indoor Air Quality in the Home (2): Carbon Monoxide, Assessment A5.* Institute for Environment and Health, Leicester, 1998. http://www.cranfield.ac.uk/health/researchareas/environmenthealth/ieh/ieh%20publications/a5.pdf

# Appendix

## Mechanisms of action of carbon monoxide

Carbon monoxide gas enters the blood via the lung. Inhaled CO combines with hemoglobin to form carboxyhemoglobin (COHb). Once this reaction occurs, the capacity of hemoglobin to carry oxygen is much reduced. 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 reduce oxygen delivery to the tissues.

In addition, carbon monoxide 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 carbon monoxide may function as a local transmitter substance in the body playing a role in controlling permeability of the micro-vasculature and may increase adhesion of inflammatory cells and platelets to the capillary endothelium. Carbon monoxide poisoning leads to leakage of fluid across cerebral capillaries and thus to cerebral oedema. In 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 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 carbon monoxide to cytochrome A3 reduces the capacity of cells to deal with free radicals.

Carbon monoxide 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: this 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 carbon monoxide bound to mitochondrial cytochromes may well be much longer than that of carboxyhaemoglobin and hyperbaric oxygen has been suggested as being important in attacking this binding site. Carbon monoxide binds to fetal haemoglobin and shifts the already left-shifted fetal oxyhaemoglobin dissociation curve further to the left. The half life of CO in the fetus is longer than that in the mother.

Carbon monoxide 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.

# *Diagnosing Poisoning:*
# Carbon Monoxide (CO)

Health Protection Agency

**Patient presenting with:**
Headache, nausea/vomiting, drowsiness, dizziness, dyspnoea, chest pain
**COULD THIS BE A CASE OF CO POISONING?** 1

**Ask the patient:**
- Do you feel better away from your house or place of work?
- Is anybody else in your family or house experiencing the same symptoms as you?
- Have you recently had a heating or cooking appliance installed?
- Have all gas, coke/coal, wood or oil fired appliances, eg, cookers, fires, boilers at your home been serviced within the last year?
- Do you ever use your oven or gas stove for heating purposes as well as for cooking?
- Has there been any change in ventilation in your home recently, eg, fitting double glazing?
- Have you noticed any sooty stains around appliances or an increase in condensation?
- Does your work involve possible exposure to smoke, fumes or motor vehicle exhaust?
- Is your home detached, semi-detached, terraced, flat, bedsit or hostel? 2

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

**You are confident:** This is **NOT** a case of CO poisoning

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

1 **Test for CO**
*GP - breath test for exhaled CO if device is available. (Note: Only indicates recent exposure; interpretation difficult in smokers. For interpretation of results see TOXBASE).*
ED - heparinized venous blood sample for COHb estimation. For interpretation of results see TOXBASE and contact the National Poisons Information Service (NPIS).

2 **Management - Commence oxygen therapy**
*GP - follow advice on TOXBASE; refer to ED if required.*
ED - follow advice on TOXBASE. Contact NPIS for severe poisoning. (See CMO/CNO letter November 2008: www.dh.gov.uk/cmo).

3 **Protect your patient and others** - Contact your local Health Protection Unit (HPU). They will co-ordinate services for your patient and provide further CO guidance. Telephone gas, oil or solid fuel helpline (see Notes).

4 **DO NOT** allow patient home without a warning NOT to use the suspect appliances.

5 **Follow up**
*GP - note that symptoms may persist or develop later.*
ED - advise patient to see GP for follow-up. Note this advice in discharge letter. 3

**If patient does not improve**
- Contact NPIS for advice.
- Contact local HPU for advice.
- Reconsider diagnosis. 4

**See over for Notes on Boxes 1 - 4**

## Notes

**Box 1** Carbon monoxide is a mimic

Carbon monoxide poisoning is notorious for simulating other more common conditions, including flu-like illnesses, migraine, food-poisoning, tension headaches and depression.

Headache is the commonest symptom - think CO!

**Box 2** Carbon monoxide sources are multiple

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, coke and wood heating appliances are the commonest sources in the home. Malfunctioning heating appliances may be indicated by there being yellow rather than blue flames (if it is not a 'decorative flame' fire) and by the deposition of soot on radiants or on the wall adjacent to the fire. There may be more than one source of carbon monoxide.

Poisoning is not limited to those from lower income groups. Carbon monoxide can leak into a semidetached or terraced house/flat from neighbouring premises. It is unlikely that a patient will know about servicing of appliances at his/her workplace, but it is worth asking about the sort of heating devices in use.

It is also worth asking: "Have you recently started to re-use heating appliances/boilers after the summer break/during an unexpected cold spell?"

**Box 3** Stopping further exposure is essential

Preventing further exposure is the most important thing you can do. Breath tests and blood samples may prove inconclusive some hours after exposure has ended: CO levels in the blood decline with a half-life of about 6 hours. Note that a normal concentration of carboxyhaemoglobin (COHb) does not disprove CO poisoning unless the sample has been taken soon after exposure ended. A heparinized venous blood sample should however, always be taken and sent to the local Clinical Chemistry Laboratory for analysis. *For interpretation of results and detailed advice on CO poisoning see TOXBASE and call NPIS.*

If you strongly suspect CO poisoning do not wait for the result of the analysis before taking the other steps listed in Box 3. Contacting the gas (**0800 111999**), oil (**0845 6585080**) or solid fuel (**0845 6014406**) safety services is essential. Contacting your local HPU is essential as they will co-ordinate Environmental Health, Safety, Social and other services to protect your patient and others. 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 an audible carbon monoxide alarm for installation in the home.

**Box 4** Links and contact details for information on carbon monoxide

- TOXBASE: www.toxbase.org.
- National Poisons Information Service (NPIS) 24 h hotline: **0844 892 0111**
- Health Protection Agency: www.hpa.org.uk/chemicals/compendium/carbon_monoxide/default.htm
- NHS Direct: www.nhsdirect.nhs.uk
- Department of Health: www.direct.gov.uk/keepwarmkeepwell
- Carbon monoxide – Are you at risk?: www.dh.gov.uk
- Information in joint CMO/CNO letter of November 2008: www.dh.gov.uk/cmo
- Local HPU contacts: www.hpa.org.uk/hpucontactdetails. 24 h Chemicals hotline: **0844 892 0555**

Copies can be downloaded from the HPA website at www.hpa.org.uk/carbonmonoxide.

Further hard copies can be obtained from
Department of Health Publications Orderline, PO Box 777, London SE1 6XH
www.orderline.dh.gov.uk Tel: 0300 123 1022 email: dh@prolog.uk.com

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