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To: Directors of Public Health
Medical Directors of NHS Trusts
General Practitioners
Accident and Emergency Teams
NHS Trusts (England) Medical Directors
NHS Foundation Trusts (England) Medical Directors
Directors of Nursing

cc: Regional Directors of Public Health
NHS Trusts (England) – Chief Executives
NHS Foundation Trusts (England) - Chief Executives
Clinical Commissioning Groups
Territorial CMOs in Ireland Scotland & Wales
NHS England Area Teams

Gateway Reference No 00764

Dear Colleague

CARBON MONOXIDE POISONING: RECOGNISE THE SYMPTOMS AND TACKLE THE CAUSE

We are writing to highlight to you the importance of recognising the signs and symptoms of carbon monoxide poisoning. The onset of colder weather and the use of domestic heating systems at this time of year can lead to an increase in cases of accidental carbon monoxide poisoning.

Accidental (and therefore preventable) carbon monoxide poisoning still result in recorded cases of around 40 deaths and 200 hospitalisations each year in England & Wales. Recent figures from the Department of Health indicate that there are 4,000 attendances at accident and emergency departments for treatment for CO poisoning each year in England. Whilst a considerable number of people die from accidental acute carbon monoxide poisoning, it is now confirmed many more are injured by sub-lethal exposure. It is likely that the true number exposed in this way is even greater than reported.

Taking a clinical history by asking your patient appropriate questions is an essential part of making a diagnosis. This is particularly important when diagnosing carbon monoxide poisoning: your index of suspicion may be raised by the answers you receive. Carbon monoxide poisoning, especially when there has

been long-term exposure to low concentrations, is notoriously difficult to diagnose because the symptoms often mimic other more common illnesses such as flu and food poisoning. The most common symptom of carbon monoxide poisoning is headache. Misdiagnosis leading to treatment of only the symptoms of poisoning may lead to the patient being sent home where exposure might continue, leading to serious, perhaps fatal consequences. Sub-lethal levels of carbon monoxide poisoning can lead to chronic health problems.

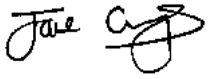
Enquiring about possible sources of exposure to carbon monoxide is important. Carbon monoxide poisonings have occurred due to the inappropriate use of cooking equipment: gas ovens being used for heating purposes, BBQs being used inside homes, caravans and tents for cooking and heating. Increased exposure to CO has been identified in homes where oversized pots are placed on gas cooker rings. In addition, smoking shisha pipes in poorly ventilated rooms and failing to maintain fossil fuel or wood burning appliances, chimneys or flues, or reducing ventilation of rooms to conserve warmth have all created situations that have resulted in exposure to carbon monoxide. Exposure may occur not only close to the source but also in adjoining premises.

There are four key questions that should be asked to raise or lower the level of suspicion of all healthcare professionals when considering a diagnosis of CO poisoning. These questions can be remembered using the acronym 'C.O.M.A' (C- Co-habitees /co-occupants, O – Outside, M – Maintenance, A – Alarm). Public Health England (PHE) have updated their flowchart 'Diagnosing poisoning: Carbon Monoxide (CO) ', which also provides advice on actions to take and details of whom to contact for further assistance, with these key questions. We have attached a copy of this flowchart which is supported by the Department of Health, Royal College of General Practitioners and College of Emergency Medicine, to assist you in diagnosing CO poisoning. Flowcharts have also been produced by PHE for particular scenarios such as home visits, smoking cessation clinics and during antenatal checks. They can be used to take advantage of every opportunity to recognise carbon monoxide poisoning.

There have been success stories where environmental exposure to carbon monoxide has been suspected and confirmed from a diagnosis made by healthcare professionals in each of the scenarios mentioned above. But unfortunately, in the past, some patients have been advised to stay at home and keep warm when the symptoms they presented with were in fact those of CO poisoning. Such errors have led to fatalities.

We would be grateful if Nurse Executive Directors could arrange for this letter to be circulated to community nurses and health visitors working within their Trust and midwives via Heads of Midwifery. We are sure that this letter, its appendices and the associated tools will be appreciated by your teams.

Professor Dame Sally Davies
Chief Medical Officer,
England



Doctor Jane Cummings
Chief Nursing Officer,
England

Professor Viv Bennett, Director of Nursing
Department of Health and Public Health England

Appendix 1

Summary

This letter and appendices bring together the most up-to-date information on CO poisoning and updates the CMO/CNO letter of November 2010. It describes the signs and symptoms which should be looked for, the investigations to establish whether CO poisoning has occurred, how cases should be managed, the main sources of CO in the home and other indoor environments and gives sources of further advice and information.

Background

Carbon monoxide is a colourless, odourless gas that causes the accidental death of around 40 people each year. Around 200 people each year in England and Wales are seriously injured by CO and new data suggests that 4,000 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 currently being exposed and suffering the ill effects of exposure, unknowingly. Older people, children, pregnant women and their unborn children 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 health adviser. 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.

What look like 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

Key questions

There are four key questions that should be asked to help diagnose domestic carbon monoxide poisoning. These questions can be remembered using the acronym **COMA:**

C for Co-habitees & co-occupants - is anyone else in the house affected (including pets)?
O for Outdoors - do your symptoms improve when out of the house?
M for Maintenance - are heating and cooking appliances properly maintained?
A for Alarm – do you have a carbon monoxide alarm?

The answers given for each question should raise or lower suspicion of poisoning by carbon monoxide.

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

A neurological examination, including tests of coordination and balance (finger-nose movement, Romberg's test, normal gait and heel-toe walking), a mini-mental state examination, testing of short-term memory and of mental function, e.g. the ability to subtract 7, serially, from 100, is helpful in the diagnosis of chronic CO poisoning.

The cherry red skin colour often said to occur in cases of exposure to carbon monoxide is not a common sign of poisoning: it is produced when COHb concentrations exceed about 20% and is rarely seen in live patients.

Investigations

Carbon monoxide can be measured in expired air. Breath analyzers are used in smoking cessation clinics, by midwives during antenatal checks and should, when available, be used in doctors' surgeries. These devices convert CO concentration into COHb concentration from the standard carbon monoxide-haemoglobin equilibration curve. There is no point in taking a measurement if the patient has spent hours away from the source of CO, as CO levels will have declined. Therefore, these devices must be used as soon as poisoning is suspected.

Lactose intolerant patients have raised H_2 in their expired breath which can interfere with the CO reading taken from a breath analyzer.

COHb levels can be measured in blood. 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 falsely high oxygen saturations are likely to be recorded due to the similar light absorbance of carboxyhaemoglobin and oxyhaemoglobin. Pulse CO-oximetry devices are available and are useful in ambulance settings.

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

Note: carbon monoxide is also 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.

Management

- Remove patient and co-occupants 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 or symptoms other than headache;
- Myocardial ischaemia/arrhythmia diagnosed by ECG;
- Pregnancy.

Sources of carbon monoxide

Carbon monoxide is not just produced 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 with portable devices using these fuels are also potential sites of exposure. Exhaust gasses from vehicle engines, diesel and petrol powered electricity generators and BBQs can also contain or emit 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 lead to the accumulation of dangerous concentrations of CO.

Inadequate installation or poor maintenance of fossil fuel and wood-burning appliances leading to incomplete combustion of fuel, inadequate removal of waste products because of blocked and partially blocked or cracked 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.

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.

Smoking Shisha pipes indoors in rooms without adequate ventilation has also resulted in groups of individuals being poisoned by carbon monoxide. Shisha pipes slowly burn charcoal and tobacco which both release CO into the environment where the pipes are smoked.

Cigarette smoke, through active smoking or passive smoking, is also a source of exposure to carbon monoxide.

Avoiding exposure to CO is of particular importance to pregnant women as fetal blood has a much higher affinity for CO than an adult's. This means that not only is CO more readily taken up by the fetus, but it also releases CO much more slowly, therefore prolonging exposure of the fetus even after the pregnant woman is herself no longer being exposed. Exposure to CO reduces the amount of oxygen available for the growing fetus and has been linked to birth defects and other poor pregnancy outcomes including fetal and infant mortality.

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 Team – they will co-ordinate services for your patient. Contact details can be found on the Public Health England 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 http://www.gov.uk/phe

2. Keep Warm Keep Well (leaflet) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213126/KeepWarmKeepWell.pdf

3. Get Ready For Winter (leaflet) http://www.metoffice.gov.uk/learning/get-ready-for-winter/health-and-wellbeing

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

5. The Public Health England (previously Health Protection Agency) website – Further information on CO can be found at: http://www.hpa.org.uk/CarbonMonoxide/

6. Gas Appliances – Get Them Checked, Keep Them Safe. From the Health and Safety Executive (HSE). www.hse.gov.uk/pubns/indg238.pdf HSE information line 0800 300 363

7. 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/

8. 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

9. Help and support for pregnant women for giving up smoking can be accessed through the Smokefree website: www.smokefree.nhs.uk

References

1. Cross Government Group on Gas Safety and Carbon Monoxide. Annual Report 2011/2012. www.hse.gov.uk/gas/domestic/cross-government-group.htm

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3. McCann et al Indoor carbon monoxide: A case study in England for detection and interventions to reduce population exposure. Journal of Environmental and Public Health 2013.

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4. Kar-Purkayastha, Ishani; Finlay, Sarah; Murray, Virginia. Low- Level Exposure to Carbon Monoxide. British Journal of General Practice, Volume 62, Number 601, August 2012 , pp. 404-404(1)
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Appendix 2

Mechanisms of action of carbon monoxide

Carbon monoxide enters the blood via the lungs. Inhaled CO combines with hemoglobin to form carboxyhemoglobin (COHb). Once this 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. 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.

Public Health England

Diagnosing Poisoning: Carbon Monoxide (CO)

Patient presenting with:
Headache, nausea/vomiting, drowsiness, dizziness, dyspnoea, chest pain
Could this be a case of CO poisoning? 1

Ask the patient YES/NO

C Cohabitees/companions *Is anyone else in the property affected (including pets)?* Y/N
O Outdoors *Do your symptoms improve when out of the building? ('better outdoors')* Y/N
M Maintenance *Are your fuel-burning appliances and vents properly maintained?* Y/N
A Alarm *Do you have a carbon monoxide alarm?* Y/N

If you are suspicious then ask
Have you recently had a heating or cooking appliance installed?
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, hostel or mobile home? 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: this only indicates recent exposure; interpretation difficult in smokers. For interpretation of results see TOXBASE.)
ED: heparinised 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 2013): www.gov.uk/government/publications/carbon-monoxide-poisoning.

3 **Protect your patient and others** – contact your local PHE health protection team (HPT). The HPT will co-ordinate services for your patient and provide further guidance on CO. Provide your patient with the phone number for gas, oil or solid fuel helplines (see notes).

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

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

If the patient does not improve
Contact the NPIS for advice.
Contact your local HPT 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 most common symptom – ***think CO!***

Box 2 There are many sources of carbon monoxide

The source of CO may be in the home, in the car due to a leaking exhaust system, in the workplace or in tents or caravans.

Malfunctioning gas, oil, coal, coke- and wood-fuelled heating and cooking appliances are the most common sources in the home. There may be more than one source of carbon monoxide. BBQs must never be taken indoors or into tents or caravans, even when extinguished and cold to the touch.

Poisoning can occur in all income groups and types of housing. Carbon monoxide can leak into a semi-detached or terraced house/flat from neighbouring premises. 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 during or soon after exposure ended. A heparinised 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 the 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 111 999**), oil (**0845 658 5080**) or solid fuel (**0845 601 4406**) safety services is essential. Contacting your local HPT is essential as the team 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 CO 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-hour hotline – **0844 892 0111**

NHS Direct: www.nhsdirect.nhs.uk – **0845 4647**

CMO/CNO letter (November 2013): www.gov.uk/government/publications/carbon-monoxide-poisoning

Public Health England: Keep Warm Keep Well – www.gov.uk/phe
Carbon monoxide – Are you at risk? – www.gov.uk/phe
Information on carbon monoxide – www.hpa.org.uk/carbonmonoxide
Local HPT contacts – www.hpa.org.uk/hpucontactdetails
24-hour chemicals hotline – **0844 892 0555**

Department of Health

The College of Emergency Medicine

RCGP Royal College of General Practitioners

Gas Safe Register

PHE publications gateway number: 2013323