

Accidental fatal intoxication with Carbon Monoxide

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Abstract

Despite repeated warnings, newspaper reports of fatalities and public health and safety campaigns; accidental deaths from carbon monoxide poisoning continue to occur. They can be from accident, ignorance, criminal negligence or foolhardiness; what ever the reason such deaths are tragic and often avoidable. The case presented here was some of these. The physiology and biochemistry is discussed as well as other unusual causes of death by suffocation. This includes the use and abuse of helium from party balloons and nitrous oxide from the misuse of whipped cream dispensers provoking near suffocation and the occasional deaths, though fortunately rare.

The request to attend a “sudden death”, although the death may often be many days, if not weeks old, is never pleasant. However, it is always instructive and often the most interesting, challenging and satisfying of all the work that a forensic medical examiner (FME) does. The approach should be methodical and with care and attention to detail. An awareness of the causes of injuries, forms and types of self-harm, presence of knives, drugs or weapons, and the changes after death are all part of the consideration that the experienced FME can bring to bear in assisting the police. Initial assessment if this is a natural death, a death by misadventure, a death by suicide or perhaps murder is all part of the work of the FME.

Paramedics are now increasingly allowed to pronounce life extinct without any of the experience or forensic training of the FME and, in the case presented here, it is doubtful if the former would have spotted what had actually caused this death.

Case History

On a Thursday in December 2001 at 12:55 hours I attended the body of R. L. M, a man in his 70's, at Streatham SW16, South London at the request of the Police to establish the absence of life and, if confirmed, to pronounce life extinct. According to the police controller, it was reported as a “sudden death” with no other information at that time.

On arrival the police told me that R.L.M had been living there for the last six years and had recently been given notice to quit his tenancy. He was the last tenant of the large Victorian house to still be living there. There was no electricity, either because he had fallen into arrears and been cut off or had not had further credits put on his electricity key, although an allegation had been made that the landlord had disconnected the supply for other reasons.

The body, that of an elderly Afro-Caribbean man, showed marked evidence of post mortem decay and gas bloating. There was no heating in the room, it was mid-December and very cold, though I did not take a temperature reading for the room. A new double glazed window had recently been installed and this was tightly closed.

The body was lying supine on the bed. Due to his being Afro-Caribbean and the state of decay of the body, there was no indication of the classic cherry-red colouring of carbon monoxide poisoning, due to the formation of carboxyhaemoglobin that might be seen in a Caucasian. Livido or any cherry pink hypostasis was impossible to determine, but there was no indication of the body having been moved. The body was quite cold and with no great smell noted; possibly because of the low temperature. Rigor mortis was wearing off and the limbs easily flexible and allowing for ambient temperature and the fact that I

felt that he had been a fit healthy man with a normal basal temperature, the death was more than 48 hours old [1].

The room was clean and tidy; his clothes were neat and hung up. I noted a number of candles in holders by the head of the bed which he had clearly been using for illumination, having no electricity supply. No pills, tablets or liquid medicines were found; nor any letters from the health services or hospitals. There was soap, shampoo toothbrush and toothpaste; so it was again clear that he had been able to take care of himself and took care of his appearance and general hygiene. There was no evidence of any mental problems or senility. The picture was of a man who lived on his own, but managed well. I then noted a metal dustbin raised on bricks and resting on a solid iron plate on the far side of the room. Inside were the remains of a fire which he had used, with fatal consequences, to keep warm and it was clear that this was a potential source of carbon monoxide. There was no ventilation of the room at all and the door to the room was well fitting and original. I took a number of digital photographs of the scene, which, as digital photographs, would not have been legally admissible evidence until 2004 [2].

I pronounced life extinct at 13:01 hours due to suspected carbon monoxide poisoning. As, in my opinion, he had died from carbon monoxide poisoning, I asked that the case be referred urgently to the coroner for further advice and instruction before the body was moved or the scene disturbed [3].

It is essential, indeed vital, to take photographs at the scene regardless of whatever suggestions or initial thoughts one might have regarding the nature of the death that one has been called to. The official photographs should be taken by an authorised police photographer and the scene of crime officer (SOCO) will request the ones that he or she needs. The scene should be recorded as an overview and in individual detail. The body should be photographed from different angles showing any injuries, abnormalities and relevant objects. The official photographs form part of the investigation and are used as

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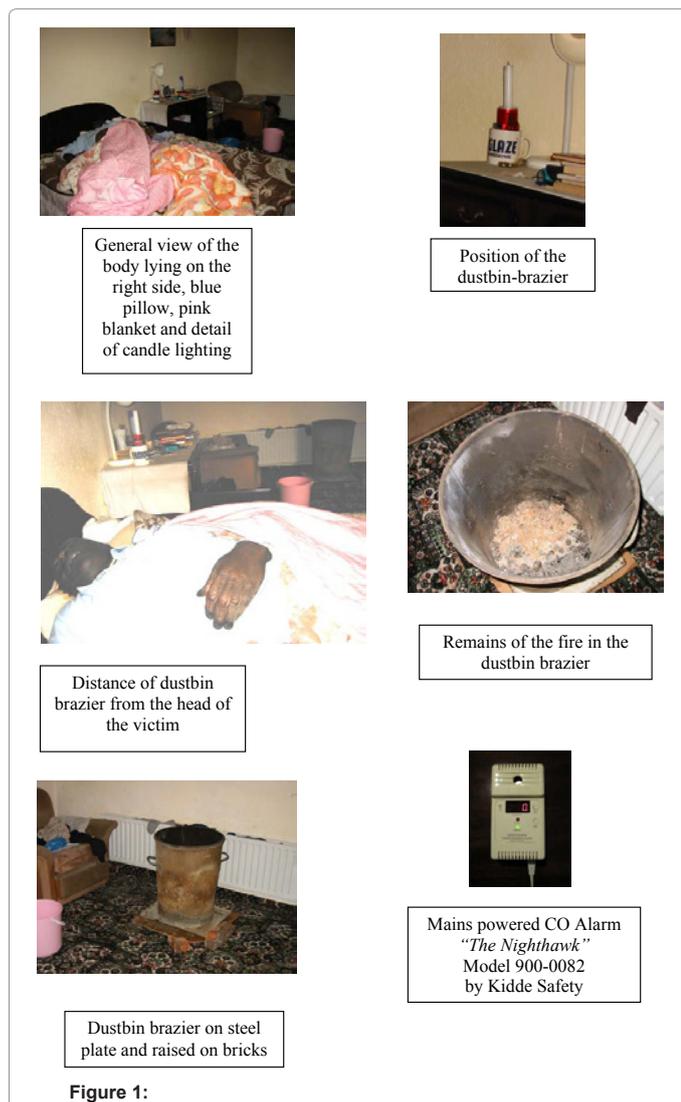
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references after the body has been moved to the coroner’s morgue. Further photographs may well be taken during the autopsy and all the photographs must be properly labelled and are then subject to the rules of the disclosure of evidence. I asked that a police photographer and the SOCO should be called to record the scene in case there were any concerns about an investigation and questioning of the landlord and the possibility of a future criminal prosecution.

I left the scene at 13:16 hours drove to the nearest police station and there completed an entry in Book 83, reference number: 631863 with a brief summary of my findings. From the amount of ash in the dustbin brazier it was interesting to wonder if he had died the first time he used it, or had managed to get away with it a couple of times merely wondering why he had woken with a splitting headache the following morning before going off to his work as a kitchen porter, as we found out later. He may, of course, have not remembered anything as retrograde amnesia is a well-recognised neurological sequela of non-fatal CO poisoning [4,5].

Post-mortem examination

This was performed on 7/12/01 by Dr Peter Jerreat at Greenwich



public mortuary and I have summarised some of the autopsy findings with: “Not relevant to cause of death”, italicising those that I consider were relevant to a cause of death of Carbon Monoxide poisoning.

External examination

The body was that of a well-built black Afro-caribbean male. DoB 19/06/1929. Aged 72. Height 1.27m. The upper body only was clothed.

Internal examination

Skull: Scalp and skull normal. Brain & Meninges, Brain stem and cerebellum: “Not relevant to cause of death”.

Cardiovascular system: “Not relevant to cause of death”.

Respiratory system: Decomposition fluid in chest cavity. No significant adhesions. *Deep red discolouration (due to carboxyhaemoglobin and carboxymyoglobin) of trachea and bronchial tree linings*, which were largely empty. *Distinct reddish (idem) pattern of the sectioned surface of the lungs*, which showed increased antracotic pigment and mild thickening of the bronchial tree. Pulmonary arteries patent, no Thrombo-embolism.

Oesophagus and stomach: The stomach contained a little fluid food only. *The mucosa was decomposed & reddened.*

Pancreas: *Gold-brown in colour (CO)* and decomposed. Intestines, Liver, Spleen, Reticulo-endothelial system, Kidneys & Ureters Prostate, G/U organs

Endocrine organs: “Not relevant to cause of death”.

Organs weights in grams:

- Brain:1270g RightLung: 510g LeftLung:405g
- Heart: 330g Liver: 1234g Spleen: 115g
- Right Kidney: 115g Left Kidney:135g

Conclusions

Death was not due to natural causes. Blood and liver samples have been retained for toxicological analysis, but the blood looked: “in very poor condition”.

Cause of death

1a. Carbon monoxide poisoning: Toxicology. The subsequent toxicology report on 04.01.2002, showed:

- 1) Blood ethanol = 131mg/100mL (*UK legal driving limit = 80mg/100mL*) ≈ 64% over
- 2) Carboxyhaemoglobin (blood) = 51% (Lethal level usually 50% +)

The Coroner’s inquest was held on 19.06.2002 at London’s Southwark Coroners Court with Dr Lynch sitting as the coroner. The verdict was that of: **Accidental Death**; the cause of death being recorded as: Carbon monoxide poisoning.

Legislation in the UK: Despite CO-free North Sea gas, accidental carbon monoxide poisoning still occurs in the UK despite strict government regulations for annual inspections of boilers, CORGI registration of central heating engineers and severe penalties, including custodial sentences in the event of a manslaughter verdict on a landlord who has failed to maintain the installation and have an annual Landlord’s Safety Certificate issued.

The Health and Safety Executive strongly recommends the use of CO alarms as one useful precaution to give occupants advance warning of CO in any property. These can be either battery powered, mains supplied or best of all, both. Such alarms should not be regarded by owners or occupiers as a replacement for regular maintenance and safety checks by a CORGI-registered installer [7]. These CO alarms cost between £20-£30 and can be purchased in most hardware shops, but must comply with British Standard EN 50291 and carry a British or European approval mark, such as a Kitemark. Such CO alarms should be installed and maintained in line with the manufacturer's instructions.

On March 7 2007, the Department for Work and Pensions Minister, Lord McKenzie, announced a further scheme to improve domestic gas safety, following the 2006 Review of the domestic gas safety regime to reduce the risks of CO poisoning.

The Health and Safety Offences Act 2008, increased the penalties and provided the UK courts with greater sentencing powers for those in breach of health and safety legislation. The Act came into force on 16 January 2009, with the new sanctions applying to health and safety offences committed after that date.

The Act amended section 33 of the Health and Safety at Work etc Act 1974 by raising the maximum fine in the lower courts to £20,000, making imprisonment an option in both the lower and higher courts and making certain offences, which are currently triable only in the lower courts, triable in both lower or higher courts. The new Act makes imprisonment available for most health and safety offences; up to 12 months in the Magistrate's Court and up to 2 years in the Crown Court [8].

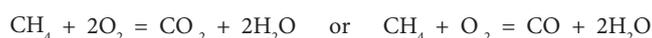
The fitting of platinum-palladium catalytic converters to all petrol cars, registered in the UK after 1993, removes 95% of pollutants from the exhaust as compared with a similar 1976 standard model. The catalyst helps convert CO into CO₂, converts the hydrocarbons into carbon dioxide and water and converts the nitrogen oxides back into nitrogen and oxygen. Since one of the three pollutants was CO, the use of catalysed car exhaust gases for self-poisoning by suicides has been reduced [9]. As a direct result of course, we now pollute the global atmosphere with increased level of CO₂, a greenhouse gas, a sequela rarely if ever mentioned by the press or those that wish to save the Earth!

The UK Government has very recently decided to allow dairy farmers to resume badger culls by gassing, to help control bovine tuberculosis (TB). Gassing of on-farm badger sets can be done, as before, using a detuned, rich-burn, part de-oxygenated, small petrol engine with an old-style muffler deliberately producing highly toxic carbon monoxide gas. Trapping and shooting has proved too slow and too expensive, so shooting without trapping is also being permitted.

Physiology and biochemistry

Carbon monoxide has an affinity for haemoglobin 200-300 times that of oxygen and has a mainly hypoxic action as well as an enzymatic effect on vital cellular function. In healthy adults a level over 50% normally associated with death, though variations between 40% for death to 60% for survival have been recorded [10]. The classic cherry-pink colouration is usually evident if the saturation with CO is above 30%, below 20% no colouration is visible, though at these low levels it is seldom fatal, though a splitting headache is almost guaranteed. Heavy smokers can have a habitual concentration of as much as 10% [11].

Anaemia may mask the visible degree of the saturation as there is then insufficient haemoglobin to convert to display the colour. In black skin, as here, or less pigmented skin, the colour is obviously masked, though it will be seen on the buccal mucosa, nail beds, tongue, inside the eyelids and on the palms of the hands and soles of the feet, where there is far less melanin. Carbon monoxide is produced when fossil fuels are incompletely burned or oxidized to carbon dioxide, as occurs when there is insufficient oxygen available. Using as an example: for Methane, CH₄, the simplest carbon of the paraffin series, also known as *fredamp* in coal mines, and one of the chief constituents of coal gas, the two balanced chemical equations are as follows:



This lack of combustible oxygen can either be due to imbalance of the flue of a boiler or, as here, where a primitive form of heating was used with inadequate ventilation (as all the windows and doors were shut to try to keep all the heat in the room due to the December weather outside). It should also be remembered that inhaled CO₂ is not without its toxic properties resulting in the hypercapnia and acidosis of 'CO₂ narcosis' [12] leading to anoxial CO₂ death. A concentration of 3% will cause headaches, drowsiness, Vertigo and muscle weakness. The minimal fatal CO₂ concentration is 25-30 %, whilst a high CO₂ concentration of 60-80 %, found in grain silos, produced by the germinating seeds, results in instant collapse and death from suffocation due to the reduction of oxygen in the inspired air. Nitrogen in ship's tanks may cause instant collapse and death, often serially of several people as they try to rescue each other. Last year three seamen died sequentially on a North Sea emergency rescue vessel when they entered the anchor chain locker to secure rattling links of heavy chain. A classic example of ignorance of a very well documented risk and criminal negligence in the training and supervision of those involved. The atmosphere of nearly pure nitrogen in ship's tanks is due to the normal ~21% atmospheric oxygen being used up by the formation, on damp steel bulkheads, of ferric oxide, Fe₂O₃, rusts [13,14].

The inhalation of pure helium at parties from helium balloons to amuse others with a "Donald Duck" voice can be highly hazardous. Several deaths have occurred from suffocation and it has been cited as a way to commit suicide or assist suicide by right-to-die advocates. If the lungs are fully emptied of air in order to get a full lung volume of helium to prolong the speaking time this can produce the symptoms of suffocation; repeated attempts with smaller volumes can produce an oxygen "wash-out" effect with similar symptoms due to the rapid diffusion gradient.

This latter property is why it is used in HeliOx mixture (79% He, 21% O₂) to displace nitrogen from deep-sea divers when saturation diving to avoid the risk of the "bends". HeliOx has been used since the 1930's for the treatment of obstructive airways disease as it reduces resistance to turbulent flow and increases the tendency to laminar flow, due to the lightness of helium, resulting in lower airways resistance.

Asthma, chronic obstructive pulmonary disease (COPD) and tumour obstructed airways have all been treated using HeliOx. Nitrous oxide as a propellant for whipped cream dispensers has also been implicated in suffocation after inhalation from balloons or a supply canister when abused as an euphoric. The fatal pulmonary physiology is similar.

One could argue that these were all deaths by misadventure, an innate ignorance of basic organic and inorganic chemistry, basic lung

physiology and diffusion gradients or just plain accidental, but at the end of the day they are always a tragedy.

Such deaths remain a continuing “lesson in collective forgetfulness”, to quote the late Geoffrey Pyke; destined to be repeated again and again, despite all the clearly documented risks, legislation and custodial sentences where ignorance is no defence.

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