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Carbon monoxide poisoning in a group of restaurant workers: lessons learnt and how to prevent future occurrences

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INTRODUCTION

Carbon monoxide (CO) is dubbed the silent killer as it is colourless, odourless and tasteless. Clinical symptoms are non-specific and many patients are unaware that they have been exposed until a CO detector alarms or when the patient presents to the hospital and is found to have an elevated carboxyhaemoglobin (CoHb) level. CO is produced from the incomplete combustion of hydrocarbons and malfunctioning heating systems, improperly ventilated vehicles, generators, grills, stoves and residential fires are common sources of CO poisoning.[(1)] Anybody is at risk of CO poisoning and vulnerable groups like infants, elderly and those with chronic medical issues are especially at risk. More than 400 Americans die from unintentional CO poisoning not linked to fire annually, more than 20000 end up in the emergency department and more than 4000 are hospitalised.[(2)] An American study found that majority (72.8%) of CO exposure occurred in homes; only 13.4% of CO poisoning were work related.[(3)] Locally, the most common cause of accidental CO poisoning was smoke inhalation from faulty vehicles (33%), followed by house fire (25%).[(4)]

The incident described here occurred in a restaurant in Singapore in 2016, where some workers suffered CO poisoning due to a malfunctioning ventilation system in the kitchen. Thirty patients were sent to our Emergency Department (ED) which was closest to the incident site and which also houses the only Burns Unit in Singapore. Box 1 summarises the learning points from this incident.

NARRATIVE OF INCIDENT

The first 4 patients were brought in from 2129 hours to 2135 hours via separate ambulances. Whilst they were being triaged, there was a standby call for a case of smoke inhalation. At 2138 hours, this case arrived in our Resuscitation area. History was obtained from the paramedics as the patient was agitated and hyperventilating. He was a chef in a restaurant kitchen preparing for a banquet when the exhaust fan malfunctioned. His carboxyhaemoglobin level was 18.9% and lactate was 10.5 mmol/L which confirmed the diagnosis of CO poisoning. Given that there was a sudden influx of patients from the same restaurant, the attending emergency physicians deduced that they were all exposed to CO. Due to uncertainty of events and possibility of further influx of patients, 2 toxicologists who were off duty were recalled and the Emergency Medical Services (EMS) despatch centre was then informed of this incident. The hospitals' senior management, preparedness and response department and communications department were also notified in anticipation of a mass casualty incident (MCI) plan activation. All patients who were brought in from the same restaurant were initiated on 100% oxygen while waiting to be assessed by a doctor. Investigations included venous blood gas (including CoHb level), lactate, full blood count, renal panel, troponin T, ECG and chest X-ray.

A total of 30 patients, aged 22 to 63 years old, from the restaurant were reviewed in the ED. There were 2 distinct waves of patient arrival – 20 cases from 2129 hours to 2242 hours and 10 cases from 0011 hours to 0109 hours. The initial wave comprised 7 casualties brought in via ambulances while the rest were self-conveyed. All but two of the first group of patients presented with non-specific symptoms which can be classified into neurological (headache, dizziness, numbness or tingling sensation, confusion, syncope), cardiorespiratory (breathlessness, chest discomfort) and irritative symptoms (eye or throat irritation, cough, nausea). The second group of patients were advised by the management of the restaurant to have a medical check-up even though most were asymptomatic. 3 had transient symptoms which had resolved in the ED.

Among the 30 patients, 11 were female (36.7%) and 19 were male (63.3%). None of them had any pre-existing cardiorespiratory diseases. All were restaurant staff – 10 chefs, 7 kitchen staff, 1 cashier, and the rest were wait staff. No restaurant patrons attended. Figure 1 shows the layout of the restaurant. All chefs, kitchen staff and the cashier, near or in the affected kitchen were seen in the first wave. 19 out of the 20 patients who attended during the first wave were admitted to hospital with 2 to the Burns High Dependency Unit for closer monitoring as they were symptomatic and 17 to the ED observation ward. The latter group received oxygen and had down-trending CoHb levels. Figure 2 shows the CoHb trend of all patients. All were asymptomatic when discharged at the end of the 8-hour protocol. The 2 inpatients were also discharged uneventfully. None had airway burns or inhalational injuries but 3 patients had elevated troponin with transient chest discomfort initially which spontaneously resolved. They were given outpatient cardiology appointments. None received hyperbaric treatment and there were no fatalities. Findings from the regulatory authorities and workplace hygiene monitoring team at the incident site revealed that the CO levels were above the permissible exposure limit. Other toxic gases like methane were not detected.

Box 1. Learning points:

1. Emergency medical services including the despatch centre, needs to be vigilant of the possibility of a mass casualty event if there are requests for multiple ambulances from the same location.
2. Consider equipping paramedics with a handheld portable pulse CO oximetry for rapid diagnosis and treatment of patients with CO poisoning.
3. Increase awareness of CO poisoning at work sites and consider installation of CO detector in high risk confined areas involving machinery that can generate CO.
4. Co-ordinated and prompt notification and alerts to relevant regulatory and response agencies will help prevent escalation of the incident.

DISCUSSION

This is the first local case-series of mass CO poisoning from occupational exposure. This was only recognised after obtaining the history of smoke inhalation from the index case and multiple casualties from the same locality who presented simultaneously with multiple, non-specific symptoms. CO poisoning is readily treatable, simply by removing patients away from the source and provide supplemental oxygen via a non-rebreather mask which reduces the CoHb half-life from 4-5 hours to 40-80 min. However, the difficulty lies in diagnosing CO poisoning promptly.

Despite receiving requests for multiple ambulances at the same location, the EMS did not send a standby call to the hospital to inform this potential MCI. One should consider a potential chemical exposure when there are multiple casualties within the same locality with irritative and cardiorespiratory symptoms, failing which paramedics and hospital staff may not be appropriately protected and there may be increased morbidity and mortality as they become unwell and this surge in victims may overwhelm the local healthcare system. The lack of decontamination at the scene of the Tokyo subway Sarine attack and the lack of personal protective equipment (PPE) usage resulted in 9.9% of fire department personnel (135 out of 1364) being exposed secondarily while transporting victims.[(5)] It is thus imperative to seal off the incident site and decontaminate victims to avoid medical facilities from being contaminated, especially if the chemical agent is unknown.[(6)] The HAZMAT team will usually be activated in these circumstances and their advanced detector will detect the presence of any toxic and combustible gases. Once the agent is known e.g. CO, the level of PPE can be adjusted, and the appropriate treatment or antidote may also be administered immediately.

Our paramedics were also not equipped with a portable CO detector nor a pulse CO-oximeter despite their unpredictable and occasional risky job nature. This resulted in the delay in the diagnosis of mass CO poisoning, and more importantly this could also have endangered them should they perform a prolonged resuscitation in the closed confines of the restaurant kitchen. An analysis of smoke inhalation cases from house fires can possibly shed some light on the caseload and justify the provision of this useful device for our frontline paramedics.

Amongst the first wave of patients who presented to the ED, some were aware that the kitchen exhaust fan was malfunctioning. However, they continued working as they were asymptomatic initially. Moreover, there was no CO detector as there is no legal requirement to install it in industrial kitchens or residential homes locally. In America, 27 states as well as the District of Columbia have enacted statutes requiring CO detectors in residences. Data from the National Poison Data System has shown that the odds of CO poisoning were 3.2 times higher (95% CI 1.5, 6.9) among those without CO detectors compared to those who had CO detectors that alarmed, and at a higher degree of poisoning severity.[(7)] Following 3 incidents of CO poisoning in UK residences arising from activities in neighbouring restaurants, CO alarms are now mandated in residences with solid fuel appliances.[(8)]

Smoke detectors, which are known to reduce the risk of injury or death from home fires by 88%,[(9)] were mandated in all new local residences since June 2018.[(10)] However, a study on awareness, perception and knowledge of CO poisoning has revealed that more than 1/3 of interviewees believe that CO can be identified by its odour, smoke or the smoke alarm signal.[(11)] As such, this may convey a false sense of security and the public should be educated on the differences between a smoke and CO detector.

The cost of a CO detector is low (USD15-60) and has a 5-10 years lifespan with no maintenance cost.[(12)] However, CO detectors are not as popular as smoke alarms. In a survey, 97.6% of respondents have at least 1 smoke alarm in their home, but only 51.4% have a CO alarm.[(13)] Given that combination smoke and CO detectors are available, these should be considered for residential use instead since the price difference between these and smoke alarms is marginal.

Local studies should also be performed to look at the risk of CO exposure in Singapore e.g. vessels for recreational or industrial purposes, where there is an inherent risk due to the use of fossil fuels in confined spaces. By identifying areas of high risk of CO poisoning, there can be a tiered strategy by legislating CO detectors in high risk areas and encouraging other places with lower risk to consider installation due to low cost and maintenance.

As emergency departments are sentinel outposts in the frontline, it would be prudent to have contingency plans built in for a co-ordinated and prompt alert system that is triggered early to prevent escalation of the incident. In this case, although the hospital authorities were notified early, communication among the different agencies involved in emergency response to disasters could improve to better integrate and coordinate the response at the national level. This incident can also be used to teach EMS in identification of potential hazardous materials incidents.

CONCLUSION

CO poisoning is difficult to detect due to non-specific symptoms and one should have a high index of suspicion. The HAZMAT team should be activated in suspected MCI in order to identify any causative agents, with management of casualties following a predetermined workflow. As most CO exposures are accidental, increased public awareness and CO detectors will help prevent and reduce the incidence.[11] Local studies should also be performed to look at the risk of CO exposure in Singapore to assist authorities in considering the mandate of CO detectors in high risk areas to reduce the risk of accidental CO poisoning.

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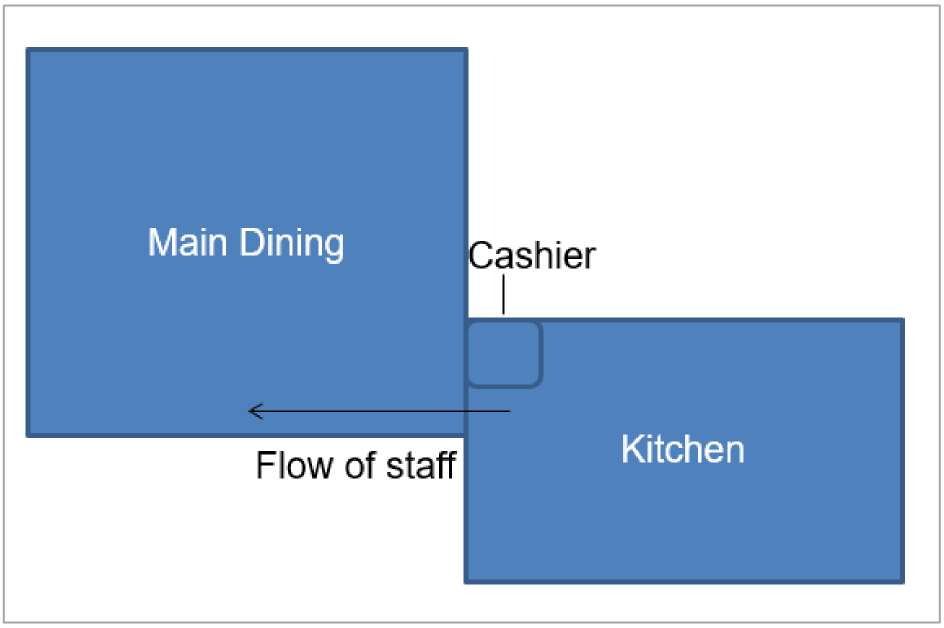

Fig 1. Restaurant's kitchen and dining area with separate air conditioning and ventilation systems.

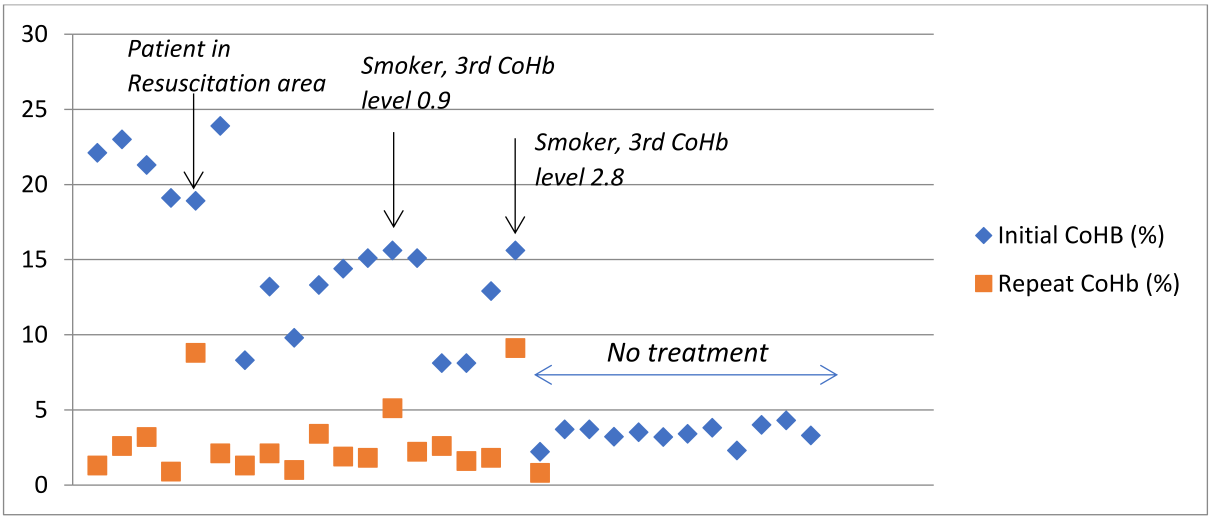

Fig 2. CoHb trend of all 30 patients. 3 had elevated levels on repeat testing – the first being the patient in Resuscitation whose CoHb was repeated after 1 hour. The other 2 were smokers, with reduced CoHb levels during the 3rd CoHb testing. It was noted that the last patient removed his nonbreather mask during sleep hence the elevated CoHb level of 9.1 during the 2nd test. *(X-axis: trend of patient arrival, Y-axis: CoHb level)*