CARBON MONOXIDE POISONING IN SINGAPORE

By Seah Han Cheow and Chao Tzee Cheng

SYNOPSIS

During the ten-year period from 1965 to 1974, 47 cases of carbon monoxide poisoning were autopsied at the Government Department of Pathology, Singapore. The largest number, 26 deaths, occurred in ships and shipyards. This incidence is on the increase.

In this series, 91% of the deaths were due to accidental causes; only 9% were due to suicidal attempts. Of special importance were the 7 deaths due to the misuse of gas water-heaters in attached bathrooms of air-conditioned bedrooms. In all these cases, there was inadequate ventilation in the rooms.

Hitherto death due to carbon monoxide poisoning appears not common in Singapore. In a survey of deaths from poisons in Singapore over a ten-year period 1960-1969, one of us (Chao, 1971) could only find 7 cases. It was thought that this low incidence was due to the absence of domestic heating problems in the tropics. In temperate countries, carbon monoxide poisoning continues to be a common cause of poisoning (Polson and Tattersall, 1969; Baker *et al*, 1972).

Sources of carbon monoxide (CO)

Domestic gas is the most common source of carbon monoxide. The content varies from 7 to 15% with an average of 11%. In Singapore the CO content in city gas is 18·5%. CO is also produced when there is incomplete combustion. Thus fire occurring in a confined space or burning of fuel in a badly ventilated room would produce large amount of CO. Exhaust fumes from automobiles contain CO in the range of 5-10% (Dutra, 1957). This has caused many fatal cases by suicide or accident every year in the West (Baker *et al*, 1972). When there are defects in the exhaust system, these fumes may find their way to the inside of the car and cause carbon monoxide poisoning. The danger is greater in air-conditioned cars, and although no fatal cases had yet occurred, clinical cases have been reported. Deaths have been recorded from a tailwind blowing exhaust gas fumes back into the open boot.

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Other sources of CO such as occur in mines (fire-damp), water gas, etc. are of no importance locally.

Present study

During the ten-year period from 1965 to 1974, there were 11,445 cases of Coroner's autopsies performed at the Government Department of Pathology, Singapore. Among these, 47 deaths were due to Carbon Monoxide Poisoning. Although this amounted to only 0·41% of the coroner's cases, it signifies a steep increase in the incidence of such poisoning (Fig. 1).

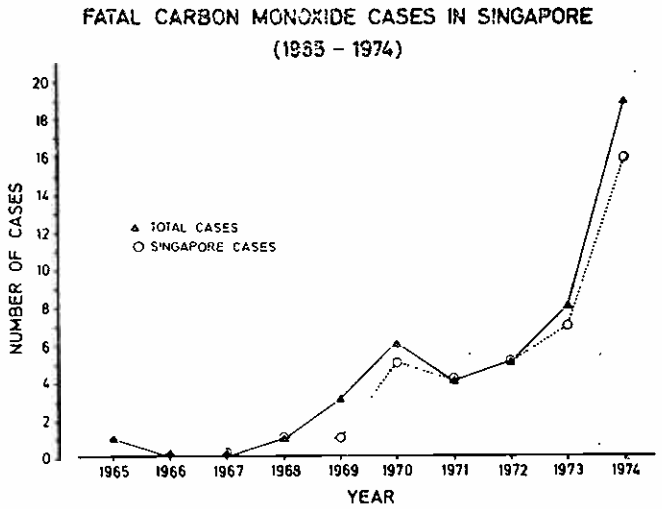

Fig. 1.

Among these 47 cases, 7 deaths occurred in international waters on ships, the remainder occurring in Singapore itself.

The circumstances of deaths and CO saturation in the blood are shown in Table I.

It can be seen that 91% of deaths were accidental deaths and only 9% were suicides (Table II).

TABLE I

Circumstances	No. of Cases	HbCO
Explosion or fire hazard on ships	26	20% to 80%
Fire in Building	8	15% to 80%
Suicides with domestic gas	4	55% to 80%
Accidental deaths due to bathroom water heaters	7	18% to 80%
Burning of a small lamp inside a cabin	1	24%
Exhaust from diesel engine from a ship	1	50%

TABLE II

CLASSIFICATION OF DEATH

Industrial accidents	26 cases = 55%	
Domestic accidents	7 cases = 15%	91%
Other accidents	10 cases = 21%	
Suicide	4 cases = 9%	
TOTAL	47	100%

The 26 deaths due to explosions or fire on board ships occurred in 10 different incidents, five of which in international waters. Nineteen deaths occurred in harbours or shipyards in Singapore. The worst accident happened in December 1974 when 13 lives were lost in the 'Iron Parkgate' Disaster. The 'Iron Parkgate' was a cargo bulk carrier which arrived in Singapore for drydocking survey and repair. Welding work was being carried out in the engine room when an electrode was dropped in the bilge below which contained a significant amount of flammable oil. Fire broke out and as the ventilation was inadequate there was a quick build-up of CO and 13 of the workers died of CO poisoning with no evidence of burning. This was the largest group of victims in our small series.

Deaths due to faulty bathroom geysers had been recorded frequently in temperate countries, where in order to conserve heat, bathroom doors and windows were tightly closed. If the air vent was blocked CO would accumulate to lethal levels in a short time. In Singapore, CO poisoning could occur in air-conditioned bedrooms with bathrooms attached if gas geysers are used in these bathrooms without adequate ventilation. Indeed the 7 cases in this series died under these circumstances.

A couple was found dead in a hotel room with bathroom attached. Autopsy revealed CO poisoning. Each of them had a HbCO saturation of 80%. According to the police, when they broke in, the room was full of gaseous fumes and steam. The bedroom was air-conditioned with the ventilation in 'closed' position. In the bathroom the geyser was on and hot water was still running. The louvre windows in the bathroom were tightly closed. It was found that the geyser was defective and when it was put on for 1½ hours, the concentration of CO in the air of bedroom due to seepage reached a level of 0·1%. In this atmosphere, blood HbCO could reach the fatal level of 55%-60% in 2½ to 3 hours.

The other cases who were either hotel guests or tenants of lodging houses died under similar circumstances and the same brand of geyser was used. The facts were publicised at coroner's inquiries, and the public was warned to ensure adequate ventilation in their bathrooms when gas geysers were in use.

The four cases of suicide died in the kitchen with the gas stove on. Among these was a 13 year-old boy from a well-to-do family who was unhappy about the way he was treated by his parents. A novel was in front of him, turned to a page describing a scene in suicide by gas. He left a note which was presumably written while the gas tap was on and the pattern of writing turned irregular as poisoning progressed. A blood HbCO saturation of 55% was found at autopsy.

A small flame burning within a small enclosed space could be lethal. This was illustrated by the death of an elderly boatman found in a small cabin on an old barge. A small kerosene lamp was still burning inside the cabin when he was found. The HbCO concentration was only 24% but he had severe coronary arteriosclerosis.

DISCUSSION

Carbon monoxide is a colourless and odourless gas. The odour we associate with city gas is specially introduced for easy detection in case of leakage. The main action of CO is oxygen deprivation as its affinity to haemoglobin is almost 300 times more than that of oxygen (Haldane, 1931) and it forms a stable compound carboxyhaemoglobin (HbCO) with haemoglobin.

In suicides by domestic gas, death could occur in two to five minutes when blood HbCO concentration of 55% or more is attained.

Death could still occur with lower concentrations of HbCO if there is pre-existing disease such as chronic obstructive lung disease, myocardial ischaemia, anaemia and other conditions that predispose to tissue anoxia. This is seen in two cases who had low blood concentrations of HbCO but severe coronary atherosclerosis.

In victims of fire, blood HbCO levels of between 15% to 20% could cause confusion, headaches, dizziness and muscular weakness which could come on so suddenly that escape becomes impossible. Several victims of fire in buildings and ships so incapacitated died from falls, drowning or severe burns.

CO poisoning is an occupational hazard to crew members and those who work in the closed confined space of the ship's hold. As the incidence is on the increase, there is an urgent need for further improvement of safety measures such as ventilation, control of hot works on board, fire prevention and fire-fighting. This was stressed by the Commission of Inquiry to the 'Iron Parkgate' Disaster.

Addendum

Since the paper was prepared another case of fatal CO poisoning was reported in February 1975. A tenant was found dead in an air-conditioned bedroom with bathroom attached. The gas geyser in the bathroom was on with only the pilot light burning. It was ascertained that the geyser, thought not in proper working order, showed no leakage. Tests carried out by the Government Chemist and PUB engineer showed that after the bathroom was shut for 40 minutes the CO build-up was 500 parts per million. The bedroom atmosphere contained 900 p.p.m. after being kept shut for 21 hours. The influx of CO was traced to the faulty (hence dry) gully trap of the bathroom drain. Further examination revealed that the growth of a strong tree root had fractured the gas main outside the house. CO had seeped into the dry gully trap finding its way into the bathroom and bedroom. The air-conditioner was not in proper working order and the absence of ventilation caused a heavy build-up of CO in the room.

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