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THE DANGER OF ACCIDENTAL CARBON MONOXIDE POISONING

A REVIEW OF 100 CASES

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Every year in England and Wales some 400–500 cases of accidental poisoning by domestic coal-gas occur—a disquieting toll of life that has for many years been accepted as a natural risk of urban existence (Table I).

TABLE I.—Registrar-General's Figures

	1947	1948	1949	1950	1951
Males	170	166	195	158	215
Females	250	195	226	248	300
Total	420	361	421	406	515

Of the 1951 figure of 515 deaths, only 15 occurred at work; no fewer than 459 occurred at home, and some two-thirds of these involved elderly people—over 60 years of age—exposed to risk through forgetfulness or infirmity. Some means of reducing this carnage of accidental death must be sought, and this review of 100 successive cases from my records is designed to draw

attention to: (a) common dangers inherent in present-day domestic gas usage; (b) other commonly unsuspected sources of CO pollution of air; and (c) the urgent need for adequate warning of danger, and for safety mechanisms in domestic apparatus.

Recognition of CO Poisoning

Although nothing new has come to light in recent years with regard to the treatment of CO poisoning, the importance of recognizing the condition and giving the appropriate treatment for it at the earliest possible moment cannot be emphasized too strongly. A low concentration of CO is easily overlooked, both in a stale atmosphere and in the body. The following review illustrates the ease with which the doctor may fail to recognize CO poisoning, though exercising reasonable care and maintaining an average vigilance for such matters in carrying out his everyday duties. Two examples will suffice.

In 1946 a family of three were found unconscious in the kitchen of a house at Watford; suspicion of foul play had arisen. A police constable left on guard for two and a half hours had become so obviously ill himself while waiting in the room—complaining of the stuffy atmosphere, of headache and nausea—that the possibility of CO poisoning from a vitiated atmosphere was at once suspected. The flue to a kitchen stove burning coke was found to be blocked by two sanitary pads which had been dropped through the top of the stove to burn but had been drawn into the vent. Samples of blood from the victims confirmed the absorption of carbon monoxide. A child already dead showed a figure of 44%: vomit inhalation had precipitated death at this low saturation.

In 1954 six persons—four children and two women—were found unconscious in a single bedroom at the rear of a flat at Waltham Cross. Poisoning with nicotine was suspected, as an empty tin had been found in an adjacent passage; but the atmosphere was thick with the stale fumes of gas, the window curtains were drawn, the window and door were closed, and a gas mantle and gas fire were found still burning. The fire had been lifted on to the mantelpiece to put it out of the way of the children, and it had thereby been deprived of the ventilation approved by the gas authority. All bodies were characteristically pink, and samples of blood revealed HbCO readings of between 20 and 42%. It was an astonishing fact that the persons first called to make entry—a police constable, C.I.D. officers, and a police surgeon—had not thought of CO as a cause for the catastrophe in spite of these pointers. Two of the victims recovered.

Such instances could be multiplied, and do, in fact, form a substantial proportion of the 100 successive cases reviewed here. A doctor called to an elderly person found dead under circumstances which raise no suspicion of violence may—and, it seems likely, commonly does—overlook the real substance of the case: CO poisoning may not be apparent in the first instance and may not be detected until the absence of disease and suspicion of poisoning from the colour of the blood have caused the pathologist to undertake a CO reading.

Age Incidence

In the sample series of 100 successive deaths from accidental exposure to CO taken for the purpose of this study the age incidence in decades was:

Age	No.	Age	No.	Age	No.
0–	6	30–	7	60–	17
10–	5	40–	5	70–	33
20–	3	50–	8	80–	16

The frequency of fatal exposure remains more or less the same until somewhere approaching the age of 60, after which a sharp rise to a level some four times that of any other period in life is reached. Of the 100 persons involved, 66 were over 60, and analysis of the circumstances showed that most of these cases—the figures are too small for more detailed breakdown in this respect—seemed likely to be attributable to increasing age and forgetfulness, senile decrepitude, or frank collapse.

The main causes were, in order of decreasing frequency: (a) trivial accidents with taps or burners, partly turned stop-cocks, etc.; (b) ignorance of the importance of adequate

ventilation; blocked flues or vent pipes, especially from the bathroom; (c) fortuitous incidents reflecting defects in the supply, such as leaky apparatus, fractured mains, etc.; (d) exposure in consequence of collapse from natural disease, drunkenness, etc.

Many cases are presented to the doctor as unexpected sudden deaths, some of which he might feel tempted to certify, or to the pathologist as requiring necropsy to establish the cause of death, when, in fact, they revealed both natural disease and evidence of CO absorption. The ease with which the latter may be overlooked has already been referred to.

The sources of exposure from which the accidents arose are detailed in Table II.

TABLE II.—*Sources of Exposure*

Domestic supply not at fault	58
Age and infirmity: resulting in unlit or partly lit gas, and taps partly turned on or off	34
Explosions after gas escapes from similar causes	2
Natural causes not immediately fatal	11
Drunkenness	6
with explosion after gas escape	1
Accidental kicking-on, elbowing on, dousing (e.g., by fluids boiling over) of gas	4
Domestic supply at fault	22
Defective piping or tubing, dirty or inefficient burning	12
Fractured mains outside premises	8
War operations causing fractured mains	2
The "common meter" danger	3
Defective ventilation (domestic rooms, 3; bathroom vents (geysers), 6; coke-burning stoves, 3; fireworks, 1; running car, 2; amateur heating apparatus, 2)	17
Industrial conditions	2

The best way to illustrate the common dangers of a domestic gas supply which is "in a satisfactory state" on inspection is to select certain more common circumstances in fatal poisoning as a basis for comment.

Domestic Supply Not at Fault

Of the 58 cases coming within this category, 51 occurred as a consequence of aged, tottery, trembling hands half turning on or half turning off taps, turning on one jet and endeavouring to light the burner supplied by another, through fluid boiling over, through leaning on wall taps or kicking or pushing on floor taps (as by moving furniture)—a surprisingly large number (16) having, it was said at the inquests, no sense of smell. Blindness and deafness also contributed to fatalities.

Drunkenness has always added substantially to the risk of living; and, of course, to blunder drunkenly amid taps, fire-pokers, gas-rings, and other apparatus capable of turning on a highly lethal gas like carbon monoxide is to invite disaster.

The 11 subjects suffering from natural disease, the 36 merely old and infirm, the 7 who were drunk, and the 4 who leaned against taps or pushed furniture against them would not have died if there had been some spring return to the "off" requiring a ratchet or pin lock both to open the tap and to keep it open—rather as one does to lock a nut. One cannot pretend that all risk would be eliminated.

A man with pronounced coronary occlusion was found dead on the floor clutching a gas-bracket torn from the wall. The HbCO saturation had reached 38% only, death being due partly to this and partly to coronary occlusion.

An old recluse of 74 was found dead on the floor of her kitchen; one tap of the stove (supplying the oven) was on, but her food was still cooking, charred and by then dry, on a low ring flame. She was said to have had no sense of smell whatever. The saturation by HbCO was 63%.

A man of 60, under treatment for Hodgkin's disease, was found dead sitting in his chair by a gas-fire: it was unlit, and, some ventilation being present, no smell of coal-gas was reported. At necropsy the colour of the blood was thought to be surprisingly pink. Analysis showed a saturation of 40% HbCO, and a visit to the chair in which deceased sat made it clear that one only had to stretch one's feet to kick on a tap by the fireside: It was not of the drop type. The doctor in this case was prepared to certify death as due to Hodgkin's disease, but had not seen the patient for "about a month."

Faulty Domestic Supply

Where the domestic supply is at fault the consumer is, it must be admitted, as likely to be to blame as the supplier. The use of ancient, dilapidated, dirty apparatus, rotted rubber tubing, inefficient combustion systems, and the like is tantamount to risking death every day. In New York a big toll of life occurs each year from the use in small apartments of refrigerators which have been allowed to get into disrepair; the same carelessness plays a substantial part in the English figures.

A man of 53 (said to be without a sense of smell) was found dead on a lavatory seat. A gas copper lay in the room, supplied by a leaky rubber tubing which was fitted with the control tap at the distal end. The flow-meter showed a consumption of 21.7 cubic ft. (0.61 cubic metre) per hour instead of 5 to 7 cubic ft. (0.14–0.2 cubic metre) which would have been normal. The blood HbCO was 70%.

An old-fashioned geyser responsible for the death from CO fumes of a girl of 17 in her bath in London was found to be quite unable to burn efficiently the gas flow set for it. The room when closed accumulated 0.297% of CO. The girl had accumulated 52% HbCO by the time of her death, which may have been aided by coexistent oxygen shortage.

Mills and Smith (1950) have drawn attention to the necessity for adequate ventilation for instantaneous water-heaters in bathrooms of small capacity. Chilling and condensation add to the risk of incomplete combustion. Vitiating of the atmosphere is hardly avoidable in bathrooms (see below).

Fractured mains outside premises constitute a particularly lethal agent. Much of London's 4-in. (10-cm.) main piping was laid 50 to 60 years ago, and from cast rather than drawn pipes. Although of good-quality iron, they do not bend, and fractures are caused by violent ground movements such as occurred from war operations, or the slower subsidences of peacetime, especially in extremes of cold. Gas leaks from these may travel some distance between soil layers or around supply pipes and percolate into dwelling-houses, some of which have no domestic supply.

A night watchman of 63 was found dead in office premises at 6 a.m. He had had influenza three weeks previously and had not recovered fully. His death was assumed to be due to natural causes, but was reported for lack of recent medical attention. Necropsy revealed a faintly suspicious CO colour in the blood, and a sample revealed 29% HbCO. There was no fire or gas on the premises. Investigation revealed a 4-in. (10-cm.) main fracture 60 ft. (18 metres) away under the opposite side of the road. The myocardium showed some post-influenzal changes, explaining the low CO saturation, and it was subsequently said of the dead man that his recent illness had disturbed his sense of smell.

A woman of 73 and her daughter were found dead in bed on the ground floor of a house 110 ft. (33.5 metres) away from a fractured gas-pipe under the pavement. A hole had been burned in the 4-in. (10-cm.) main by fusion of an electric cable. Both had died in their sleep.

War operations and, in a recent catastrophe, flooding of the basement and lower floors of a house which put out a lighted gas-heater have resulted in the same fortuitous escape of gas with fatal results.

The Common Meter

Where several apartments, or a number of rooms in a single house, obtain a supply of gas through a common meter there is always a danger that someone, finding the supply exhausted, will insert a coin and thus start a flow of gas to rooms occupied by other persons unaware of the possibility.

A man of 68 returned drunk at midnight to his lodgings, shared by him with two other men having separate rooms—all supplied by a common penny-in-the-slot meter placed on the landing. He was found dead in bed next morning; the room was "filled with gas," and a gas-ring tap was found "full on." Two spent matches and a box lay near by. The two other lodgers had both inserted a coin to obtain a supply of gas for cooking between 7 and 8 o'clock that morning, and had left for work without ascertaining the whereabouts of the third man.

He, it was said, usually made himself a hot drink on retiring; but it appeared that he had found no supply of gas and had abandoned the idea *without shutting off the tap*.

A child of 10, left playing in a room lit by a gas-mantle whilst the parents went to the cinema, was found dead in bed at 6.30 o'clock next morning: gas was escaping from the gas-mantle bracket. It would seem that the gas had gone out during the night, and at 6 a.m. the mother had put a shilling in the slot of a downstairs meter on finding the supply exhausted. The saturation of the child's blood had reached 74% HbCO. No suspicion of foul play arose.

While there must always be a risk to joint users of a single meter who sleep with a mantle or fire burning, there can be no excuse for risking the lives of those living in a block of flats by a system which allows one householder to supply gas to others of whose movements and habits he may be ignorant. The "common meter" constitutes an obvious danger, and should be scrapped out of hand.

Defective Ventilation

Defective ventilation is, like defective apparatus, as likely to be fatal because of indifference to earlier warnings or danger, or to procrastination over repairs, as to lack of care in arranging for ventilation when the apparatus is installed. Gas radiators, stoves, refrigerators, and geysers should all have vents, for all are, in consequence of the risk of choking by dirt, of variations in the pressure of supply, of chilling and condensation, capable of imperfect combustion or of back-draughting CO into the atmosphere.

A man of 32 was found dead in his bath one Sunday morning. A geyser was on and hot water was running away from the overflow. He had drowned, but the colour of the livid stains and the saturation by CO of the blood (HbCO 37%) gave a clear indication of the cause. A starling's nest was found blocking the vent (which had no cowl or guard). A year previously his wife had been found unconscious in the same room—and a bird's nest had been removed from the same place, but nothing had been done to prevent a recurrence.

A man of 66 was found dead in the bunk he had fitted up in an air-raid shelter (dimensions 6 ft. 6 in. by 4 ft. 6 in. by 6 ft.—2 by 1.4 by 1.8 metres), the door of which had been closed by a heavy curtain. In order to provide heat he had arranged to burn a gas-mantle beneath a builder's brick propped across two other bricks. Condensation was marked, for the distance between the mantle and the transverse brick under which it burned was a bare $\frac{1}{2}$ in. (1.3 cm.). The blood HbCO was 65%.

A man of 49 used a tin biscuit-box heated by a gas-tube burner for the same purpose in an Anderson-type shelter. He was found dead with a blood HbCO of 68%. A gas expert found that with a full supply of gas the flame became appreciably dulled from oxygen lack in 24 minutes.

On two occasions deaths in the bathroom were said by the gas experts to have been due not so much to the fact that the geyser had failed to effect a full combustion as to the tendency for a strong wind from the "wrong quarter" to impede the easy escape of fumes or even to blow them back into the room. Instantaneous water-heaters whose consumption of "cold gas" is imperfect at the start should always have an efficient vent fixed.

The car in the garage and coke or other slow fuel-burning stove systems are better-known dangers, though again it is remarkable how commonly the need for free ventilation is overlooked.

A man of 53, recovering from a cold in the head, was found dead on the bed which he occupied as caretaker at school premises. A doctor who was called found no indication of the cause of death, but a police officer reported that the atmosphere was very close, since all the windows were shut and a stove burning coal and coke was still warm and appeared to be emitting fumes. The damper was closed and the draught door half open. The saturation of the blood was 58% HbCO. He had last been seen late in the previous evening, and had spent some 12 hours in a 35 by 15 by 7 ft. (10.7 by 4.6 by 2.1 metres) room in which there was no ventilation.

A single man of 34 was found, some 15 hours after being last seen putting his car away, lying prone with facial injuries on the floor of the garage close to the sliding door—which was latched closed. The bonnet of the car was open and a tool-kit lay on

the floor with tools, loose, close to the dead man's feet. The ignition was on, but though petrol was available the engine was not running. He was not found until search was made for him after failing to appear for work next day, by which time the atmosphere had cleared. The blood saturation of HbCO was 65%.

Industrial Sources of CO Poisoning

Industrial sources of CO are well recognized, and the possibilities of accidental exposure are so effectively controlled that, except for the sharp rise that wartime emergencies bring (see Registrar-General's annual figures for 1939-45), they contribute no significant part to the general incidence of accidental poisoning by CO. Events which are beyond ordinary calculations of risk are bound to occur, but they are comparatively rare.

A man of 58 went to inspect the lid of a water-gas production tank, the felt washers of which were giving trouble. He did not reappear, and search revealed him lying dead on the ground by the side of the tank, with minor bruising and abrasions of the face. There was a 42% saturation of the blood by HbCO, and it became clear that in making the lid of an 18 by 12-ft. (5.5 by 3.7-metre) tank secure he had become exposed to an escape of water-gas. The composition of this was CO₂, 4.7; CO, 32.3; CNH₃N, 9.2; O₂, 0.1; H₂, 33.0; CH₄, 7.9; N₂, 12.2. It would follow that to be caught in an escape of this, even in ventilated premises, would be extremely dangerous—if not from CO, then from extreme oxygen lack. Sudden oxygen lack may in itself prove surprisingly quickly fatal.

Explosions and fire provide sources of accidental CO poisoning that do not come within the limits of this review, designed as it is to illustrate the disturbingly high annual death rate from the everyday use of domestic heating and lighting appliances. The apparent unconcern with which the gas authorities take this alarming annual toll of life is astonishing: the bovine calm with which the average householder accepts 400 to 500 deaths from accidental coal-gas poisoning each year reflects a remarkable lethargy of spirit.

A gas inspector gave evidence that "there was no defect in the installation" but, under examination, agreed that he had himself "inadvertently turned on" a rather loose gas-tap with his sleeve cuff in making an examination of the premises. This was precisely how an old lady had met her death—and how nearly a third of such deaths arise.

An energetic application to this simple mechanical problem is long overdue from those whose vast machinery and staff are concerned with the safe supply of coal-gas for domestic purposes: warning of the dangers of unlit gas, and of decrepit, dirty, unserviced, or inadequately ventilated apparatus should appear on every piece supplied, and the menace of the "party meter" must go without parley or delay. Accidents will always happen, but of the 100 cases reviewed here it would seem that some 70-75% could reasonably have been prevented. It is high time the problem was tackled and disposed of: it is not insuperable.

Summary

An analysis of 100 successive accidental deaths from carbon monoxide is given. Common dangers of domestic illuminating and heating apparatus, especially to the elderly and infirm, ill or drunk, are outlined.

The ease with which the general practitioner or the pathologist may overlook CO poisoning when the circumstances are not obvious or some adjuvant factor is operating indicates the need for vigilance. Low-saturation CO deaths are not uncommonly mistaken for natural deaths.

The very urgent need for tackling the problem of accidental domestic coal-gas deaths instead of accepting them as a misfortune is made clear by the large proportion of preventable deaths.

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