A clinical lecture on dementia resulting from poisoning by carbon monoxide : delivered at the Glasgow Royal Infirmary on June 20th, 1895 / by Alexander Scott.

A CLINICAL LECTURE

ON

DEMENTIA

RESULTING FROM POISONING BY CARBON MONOXIDE.

Delivered at the Glasgow Royal Infirmary on June 20th, 1895.

BY

ALEXANDER SCOTT, M.D. GLASG.,

ASSISTANT PHYSICIAN TO THE INFIRMARY; CERTIFYING FACTORY SURGEON, TOLLCROSS, ETC.

Reprinted from THE LANCET, January 25, 1896.

C

DEMENTIA

RESULTING FROM POISONING BY CARBON MONOXIDE.

GENTLEMEN,—This morning I have to lecture to you on the case of a patient aged forty-one years who has been under our care for the last thirteen weeks. He suffers from dementia, from a deficiency rather than an aberration of the intellect, resulting from blood poisoning by the inhalation of carbon monoxide. Whether we study this case from a pathological or a physiological point of view it is intensely interesting. Looking at him as he now sits before you, you cannot detect any lack of intelligence, any paralysis, or, indeed, even the most remote sign of idiocy or imbecility. By careful observation you may notice that he sometimes stares at an object, but this, I think, is due to some defect in his range of accommodation, and does not indicate want of thought. About 2 o'clock on the morning of March 20th last I was called to the Clyde Ironworks to attend to this patient, who was said to be dead or dying from suffocation with gas from the ammonia works which are connected with the blast furnaces. This unfortunate man had been found lying in front of one of the flues apparently dead, and had been immediately hauled out, after having been exposed to the noxious vapours for ten minutes. I found him sitting on a chair supported by two men and quite insensible. His face was ghastly pale, his eyes were staring and glassy, his pupils dilated and fixed, the breathing was shallow and quiet, and the pulse moderately strong, but remarkably slow. His whole muscular system was relaxed, and apparently life was quietly ebbing away. Any attempt to rouse him was without effect. Having set him in a good current of fresh air, I alternately douched him with cold water and applied to his mouth and nostrils carbonate of ammonia, and at the end of an hour he began to bestir himself and to talk incoherently At the same time his pulse reached 58 per minute and the respiration became deeper. This seeming improvement

did not last long, for soon the patient was attacked with violent clonic convulsions which lasted for about two hours. The mouth was open and drawn to the left side, and the muscles of that side generally were mostly affected. The only premonitory sign of the onset of these convulsions was a slowing of the pulse down to about 50, and, being still of opinion that they were syncopal in character, I continued the resuscitating efforts till the convulsions disappeared and the patient had been safely removed to his home. At this stage I tried to get him to swallow a teaspoonful of brandy, but failed. About 6 A.M., when the condition of the patient appeared to be more hopeful, I left him in charge of my assistant, Dr. James Lang. So far, however, from the effects of the poison disappearing, they returned with alarming severity and with a somewhat different character, for suddenly the patient was affected with tetanic contractions of the muscles, which were so violent that Dr. Lang had to get the assistance of several men to prevent him from doing himself bodily injury. At 10 A.M. I visited the patient and found that, with very short intervals, the extensor muscles of the trunk and the flexors of the limbs—chiefly the arms—were contracted and rigid the eyes open, the pupils dilated, the bloodvessels of the forehead prominent, the skin bedewed with perspiration, and the pulse rising and falling with the intensity of the spasms. Nothing gave any relief except chloroform, and as soon as its effects had passed off the spasms returned. The patient was once more removed to the open air and oxygen by inhalation administered, but not with any appreciable amount of success. Free action of the bowels by a drop of croton oil was next tried, but with no better result, for the spasms even increased in severity for the next forty-eight hours. At the end of this period it was observed that the intervals of rest were of longer duration, and that during these intervals the patient was in a state of coma. The tetanic contractions gradually became less violent until, on the fourteenth day after the accident, only faint tremors of the flexor muscles were perceptible. Only on rare occasions would the patient allow himself to be fed. Up to this stage the symptoms pointed throughout to asphyxia as the cause, and, according to Dr. Lauder Brunton, the opisthotonic character of the spasms is due to the fact "that, all the muscles being stimulated at once by the action of the

venous blood in the motor centres, the stronger overpower the weaker, and the extensor muscles of the back, being more powerful than the flexors, bend the spine backwards."[1] In this connexion it is extremely interesting to note that in every stage of this man's illness there was an entire absence of cyanosis, the pathological significance of which will be explained further on.

In this semi-comatose condition the patient remained for ten days, and we were hopeful that he would speedily recover. But here the drama did not end, for on the fifteenth day after the accident, without any warning, he was attacked with acute mania, and had again to be put under restraint. At this time, you will remember, I was asked to take charge of Dr. Anderson's wards, and for the purpose of obtaining a more careful observation of the case he was admitted to Ward 7 on April 3rd. So violent was he after admission that the services of male attendants had to be procured for twenty-four hours, when he once more relapsed into his former comatose state. For the next eight days he remained *in statu quo*. The following notes were taken :—

"April 13th.—Listlessness disappearing. Patient, on being asked this morning to put out his tongue, complied. Continues to talk incoherently, but the articulation is more distinct. Faint tremors occasionally present.

"17th.—Patient does not look so ghastly or so stupid. He sits up in bed ; his eye and body generally very restless, and he seems to take no intelligent notice of his surroundings. When roused and asked if he knows me he appears to be *dreaming* or *trying to think*. I mention my name, and for an instant he brightens up and says, 'Yes, yes,' and then lapses into unconsciousness. Nurse informs me that for the last twenty-four hours his bed has been perfectly dry and clean, his necessities having been anticipated, though the only indication was restlessness.

"24th.—To-day he took a biscuit in his hand and ate it.

"May 22nd.—The lucid intervals are occurring more frequently and they last longer. To-day he repeated the names of the months of the year in one sustained effort.

"June 5th.—Up till this date he was fed by the nurse. He now sits at table and attends to his own wants.

---

[1] Pharmacology, Therapeutics, and Materia Medica, third edition, p. 189.

"8th.—While at dinner and during a lucid interval he rose from the table and said he must go home, but when reasoned with and advised to put on his boots he quietly resumed his seat. This interval occupied about three minutes.

"19th.—One lucid interval lasted fully forty minutes, during which patient talked rationally and coherently."

Temperature.—The temperature has all along been normal except on one occasion, when it reached 104° F., and was due to constipation.

Pulse.—Owing to the tremors a careful examination of the pulse could not be made, but about three weeks after admission, when the agitated state of the muscles had partially subsided, sphygmographic tracings were obtained by our resident physician, Dr. Crawford Robertson.

The tracings exhibited the slowness of the heart's action, the small volume of the pulse, and the moderately high arterial tension.

Reflexes.—As might be expected, the reflexes were at times pronounced and exaggerated, while at others they were entirely absent.

Urine.—For the first two or three weeks it was quite impossible to make a careful examination of the urine. At first it was scanty. It contained neither albumin nor sugar, but the quantity of urea varied from nearly eleven grains down to two and a half grains per ounce. At the present time it is quite normal in every way.

We come now to consider the antecedent brain disorder on which this dementia depends, and, as I have already indicated, the chief agent is poisoning by carbon monoxide; but in case I may be accused of squaring my proofs to my conclusions instead of confining my conclusions to my proofs I proceed to examine the analysis of the gas that was inhaled by this patient. It is known as "clear gas" from ammonia works and consists of—

	Per cent.
CO_2	6·55
CO	25·57
H	4·80
CH_4	5·57
O	0·52
N	56·99
	100·00

When examining the flue from which this gas passed out in large volume it appeared to me to possess no particular

odour, and this explains why no exertion is made to escape by the person exposed where it would require but slight efforts on his part to do so. It gave no warning of its presence, and, therefore, it destroys life in a most insidious manner. Looking, again, at the analysis of this gas, it is obviously difficult to differentiate between the effects of its various constituents; but if we exempt marsh gas (CH_4), which may be respired to a great extent without apparent injury, and nitrogen, which exhibits no positive poisonous properties, there remain only carbonic acid (CO_2) and carbon monoxide (CO) to be reckoned with. In disposing of carbonic acid we have to bear in mind that even in a diluted state it penetrates into the lungs, is absorbed and circulated with the blood, and thereby interferes with the "internal respiration," and, according to Dr. Lauder Brunton,[2] "the processes of oxidation are interfered with and their functions lessened or destroyed." But 6·55 per cent. of carbonic acid is not a fatal proportion; it requires 10 per cent., and that, too, in still air, to destroy life. Berzelius[3] even recommended a 5 per cent. solution in the treatment of phthisis pulmonalis. To carbon monoxide, then, we must attribute the main danger, and this danger is largely increased by its combination with carbonic acid. The one gas acts as a powerful adjuvant to the other. Bernard,[4] when writing on the poisonous effects of charcoal vapour, clearly proved that so small a volume as ½ per cent. of carbon monoxide is fatal to life when mixed with even less than 5 per cent. of carbonic acid; and Guerard[5] declared that a mixture was fatal when the same quantity of these gases respired alone was perfectly innocuous. Not only so, but the symptoms in this case agree, in the main, with those produced by carbon monoxide and are due to the action of that gas upon the hæmoglobin of the blood, the union of which forms a compound of interesting and characteristic attributes. Now, you will remember that hæmoglobin is known as the oxygen carrier, its most important property being its affinity for that gas; but, while it readily combines with oxygen, it just as readily parts with it to the tissues—indeed, so unstable is the com-

[2] Ibid., p. 584.

[3] Traité de Chimie, tome ii, p. 83.

[4] Les Substances Toxiques, 1857, p. 135.

[5] Annales d'Hygiène, 1843, 2. 55.

bination that it has been roughly compared to a mere solution of the gas in a fluid. On the other hand, the combination of hæmoglobin with carbon-monoxide is most stable, forming carboxyhæmoglobin, which compound offers such strong resistance to displacement by oxygen that it was at one time considered absolutely incapable of dissolution; and, therefore, we need not be surprised at our lack of success in the treatment of our patient either by artificial respiration or the inhalation of oxygen. As having a distinct pathological bearing on this case let me also remind you that hæmoglobin readily crystallises in elongated prisms, but that it affords a most remarkable exception to the law of diffusion inasmuch as it will not diffuse through membrane *as such* without decomposition. The most reliable test for presence of carboxyhæmoglobin in the blood is that afforded by the spectroscope as expounded by Professor Lehman.[6] In the spectroscope, carboxyhæmoglobin exhibits two absorption bands which are very similar to those of ordinary oxyhæmoglobin, but the results may be differentiated in the following manner. If to a solution of oxyhæmoglobin we add two drops of yellow ammonium sulphide or of Stokes's solution (ferrous ammonium tartrate) the two bands will disappear and in their place will be produced a broad band of reduced hæmoglobin; whereas if we apply the same reagent to a solution of carboxyhæmoglobin both bands will remain, because this compound resists reduction. For the verification of this test I am indebted to my friend, Professor Oliver of Newcastle, who has all along taken a very great interest in the progress of our case.

The literature on the subject and the reports of cases, so far as I have been able to discover, are extremely scanty. Dr. Siegfried Stockes[7] of Lucerne published a case in which a patient, after exposure to carbon monoxide, remained in a seemingly hopeless state for forty-eight hours and only revived when transfusion was resorted to. About three days thereafter a very gradual improvement set in; but extreme prostration and mental weakness ensued, and the patient only fully recovered two months later. Mr. James Hamilton, manager of Coltness Ironworks, at which sulphate of ammonia is manufactured on the same principle, has

[6] Method of Practical Hygiene, p. 238.

[7] Correspondenzblatt für Schweizer Aerzte, No. 8, 1888, p. 258.

kindly furnished me with notes of a strikingly similar case which was carefully observed by Dr. John Millar. The patient, a young man aged twenty, was engaged in repairing an exhauster at the ammonia works when he was overcome by the gas and fell unconscious to the bottom of the exhauster. An interval of fifty-two minutes elapsed before he could be rescued. Energetic resuscitating efforts were continued by Dr. Millar for fully one hour, and ether was injected twice before the heart's action was perceptible. The patient was maniacal for three days and quite insensible for eight days. His vision was imperfect for seventeen days ; and, indeed, he could not recognise the time of day for many months, during which period he was quite unable in any way to attend to his own necessities. After a lapse of two years his health has now become fairly good, but he still remains facile, with a weakly smile, and cannot be trusted with any responsible work. Altogether the analogy between Dr. Millar's case and the one we are now considering is very interesting and instructive.

Treatment. — During the early stage when collapse is imminent a free current of fresh air, the inhalation of oxygen, together with stimulation by the inhalation of carbonate of ammonia or the injection of ether, are naturally indicated. Bearing in mind, however, that carboxyhæmoglobin owing to its stability simply circulates in the blood without performing the function of respiration, and also that, as yet, no agent has been discovered which will dissolve this compound, it follows that the only rational line of treatment points to venesection and transfusion.

Deaths due to this noxious vapour are becoming frequent (in a neighbouring works there have been no fewer than six), while even in the mildest cases early and complete recovery is extremely rare. For prevention I would suggest (1) that there should be a free current of air around the flues, and (2) that every attendant should wear a respirator.

I will now recapitulate some of the outstanding features of the case. 1. The accumulative action of this gas. The effects continued to increase for fourteen days after the patient had ceased to breathe the poison. First we had complete relaxation of the muscular system with shallow breathing and slow pulse for an hour, after which we had violent convulsions for three hours, which were again succeeded by rigid tetanic spasms with mania until the

fifteenth day. 2. The asphyxial nature of the symptoms with persistent absence of cyanosis. This condition is explained by the fact that the carboxyhæmoglobin does not part with its oxygen, and consequently the bright cherry colour of the blood, circulating but not oxygenating, accounts for the pallor, aided doubtless by contracted arteries. Bernard also explains this as due to carbon monoxide paralysing the blood cells and thus rendering them incapable of taking up oxygen, and hence the bright arterial blood is prevented from becoming venous. 3. The length of time during which the brain retains, and is affected by, the poison after the other organs of the body have seemingly eliminated it. 4. The periodicity of the recurrence of the more prominent symptoms. This was noticed in the behaviour of the muscles from the appearance of the convulsions down to that of the indistinct tremors; in the temporary presence and absence of the reflexes; and especially in his lucid intervals, during which the brain is supplied with pure blood. If I were to ask the patient a question and if one of these waves of consciousness were present he would reply intelligently, but immediately the lucid interval passed off his mind would be quite blank. In the history of the case I pointed out that the first ray of consciousness was observed when he was asked to put out his tongue and he readily complied, but no persuasion could make him repeat the act. The next was when he endeavoured—weakly, indeed—to attend to his own necessities. Then he could hold a biscuit in his hand and eat it. Shortly afterwards he at times would recognise me and could tell where I lived. Then he could repeat the names of the months of the year, and now he recognises that this is not his home. When first observed the lucid intervals were only momentary, and the nurse now informs us that yesterday, June 19th, he talked quite intelligently for nearly forty minutes. Hitherto the improvement in the condition of our patient has been very slow, but when you reflect on the pathological condition of the blood you will readily understand why it should be so, for carboxyhæmoglobin will not diffuse through membrane without decomposition, and as yet no solvent of this compound has been discovered. It follows that its elimination from the system by the ordinary processes of excretion must be remarkably slow. Not only so, but, as malnutrition seems to be the *fons et origo* of

insanity generally, I should not be surprised if our patient had yet to be removed to an asylum or home for the treatment of mental diseases. If venesection and transfusion had been resorted to, or, indeed, were they to be resorted to now, the symptoms of dementia in all probability would disappear more rapidly; but in the present state of his health we can only trust to the *vis medicatrix naturæ*.

PRINTED AT THE LANCET OFFICE, 423, STRAND, W.C.