INTRAVENOUS INJECTION OF OXYGEN

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Intravenous injection of oxygen is still in the experimental stage. It had attracted attention about 20 years ago, to counteract anoxaemia in pulmonary pneumonia, in case where oxygen by the pulmonary route was of no avail due to extensive consolidation and oedema of the lungs. The advent of sulpha drugs, however, drove pneumonia out, so that the subject did not receive much attention. The apparatus used in experiments on the subject was a pressure chamber for compression and decompression. This is a familiar apparatus used by aero-physiologists.

Intravenous injection of Oxygen may be useful for victims of modern warfare. For example, one of the ways in which poison gas kills is to produce acute oedema of the lungs. Under such conditions the only way to oxygenate the blood is by injecting oxygen intravenously. There is no other method. In Hydrogen war, the atomic radiations might affect the lungs, and produce oedema thereof. In that case also intravenous oxygen might be useful.

Oxygen Therapy

Oxygen therapy is a life saving device under certain conditions. To be successful, it is essential that the lungs should be able to function properly. The oxygen should diffuse from the lungs alveoli to the blood in the capillaries and carbon dioxide should be able to move in the opposite direction. If the lungs are water-logged, as happens when there is oedema of the lungs, the passage of gas in either direction will be hampered. Owing to the greater diffusibility of carbon dioxide than oxygen, the diffusion of oxygen is impaired before that of carbon dioxide, and results of anoxaemia become manifest. It is obvious that under such conditions the lung will become useless as regards the oxygenation of blood, and oxygen therapy by the usual methods will be of no avail. If under such conditions a method was found to oxygenate the blood, life might be saved.

There are other possible routes by which oxygen might be introduced into the blood. Oxygen might be injected subcutaneously, intra-peritonially, and into the alimentary canal.

Rate Absorption of Oxygen

Some years ago I determined the rate of absorption of oxygen from these regions. I found that the rate of absorption of oxygen from these regions was very slow 1,2.

The method used to determine the rate of absorption of oxygen from these areas was as follows:— Oxygen consumption from the lungs was determined before and after the

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injection of oxygen. The difference in the two values gave the rate of absorption of oxygen which was injected. For these experiments to be successful, the oxygen consumption through the lungs must remain constant. The ordinary routine methods of determining the oxygen consumption show too much variation, so the method had to be modified.

Subcutaneous Route

Decapitated cats were used to eliminate the variations produced by the central nervous system. The whole cat was immersed in saline at a constant temperature of 37°C. The oxygen consumption was then measured by a sensitive method.

It was then found that if 500 c.c. of oxygen were injected subcutaneously, then the absorption rate varied only from 0.6 to 1.2 c.c. per minute. The efficiency of the lungs to saturate blood with oxygen was found to be 15 to 20 times that of the whole subcutaneous region. Further, the absorption of oxygen so injected became nil in an hour and half after injection. This is due to the lowering of oxygen tension owing to the diffusion of carbon dioxide and nitrogen out from the tissues. Similarly, the lungs were found 20 times more efficient than the peritonial cavity and about 50 times more efficient than the alimentary canal.

Intravenous Route

Intravenous oxygen had long been used previously, but not much could be injected owing to the formation of pulmonary embolism. The maximum that could be injected in a human being was 15-20 c.c. per minute. This small quantity was sometimes of benefit, but the risk of embolism is too great for the method to be of any practical use. These experiments were carried out by me at the K.E.M. Hospital Bombay. Oxygen used must be 100 per cent pure. It was prepared electrolytically. Ordinary cylinder oxygen contains a little nitrogen.

It was, therefore, deemed proper to find some method to eliminate pulmonary embolism. The method used was to place the whole animal, including the experimenter in a steel chamber, in which the atmospheric pressure could be raised. This increase in pressure would diminish the size of the bubbles and hasten absorption. Experiments were performed on cats and dogs.

Experiments under Normal Atmospheric Pressure

Preliminary experiments were made on cats during which blood pressure tracings were taken to get some idea as to the requisite dosage. 5 c.c. injected over 10 minutes generally caused no change, 10. c.c. usually caused a rise in blood pressure, sometimes preceded by a fall, while 15 c.c. in 10 minutes generally caused death. The measurement of oxygen consumption through the lungs showed that 5 c.c. were just absorbed and 10 c.c. caused pulmonary embolism. This was also shown by continuous injection of oxygen. In 5 cats, the following amount of oxygen was injected at the rate of 5 c.c in 10 minutes without any untoward effect:— 45, 36, 45, 20, 20, c.c.

There is hardly any doubt about the success of the injection as 15 c.c in 10 minutes caused death.

Rabbits could not stand 0.2 c.c of oxygen per minute. Cats could absorb 0.5 c.c. of oxygen per minute, whilst dogs required about 8 c.c of oxygen per minute to produce embolism. It appears that larger the animal more oxygen is absorbed intravenously per kilogram.

Discussion

The factors determining the absorption of bubbles of a given size are the distance between the point of injection and the heart and lungs, and the calibre of veins. In narrow veins, more of the bubble is in contact with the wall of the blood vessel presenting very little surface to the blood for absorption. As the calibre of the vein increases, more of the gas injected comes in contact with the blood, while in a large vein the bubble is practically surrounded with blood. Difference in the calibre of the veins probably accounts for the difference in dose of oxygen absorbed per kilogram of the animal. The individuals of a particular species of animal, for example cats, may differ largely in weight, but may not differ much as regards calibre of the veins. The dose of oxygen may be increased by injecting the gas into several veins.

Experiments under Increased Atmospheric Pressure

The tension of oxygen in a bubble under one atmospheric pressure is about 713 m.m. Hg. if the tension of water vapour is taken to be 47 m.m. If the pressure is doubled the tension of oxygen would be more than doubled since the tension of water vapour remains the same. Theoretically, at a certain pressure it should be possible to inject intravenously all the oxygen required by the animal.

It was determined that at one atmospheric pressure, only 5 c.c of oxygen could be injected in cats in 10 minutes. What is the difference if the atmospheric pressure in the experimental room is increased. In the first series of experiments the atmospheric pressure was increased to 2 atmospheres. In the first two cats, it was possible to inject oxygen at the rate of 20 c.c. per minute, i.e. 4 times the value at 1 atmospheric pressure. In the 3rd cat the oxygen content of the inspired air was lowered to 14 p.c. of oxygen at ordinary atmospheric pressure, so that anoxaemia was produced. This cat received oxygen at the rate of 40 c.c per minute without any untoward effect. In the last cat 40 c.c of oxygen was injected in 5 minutes.

In the 3rd series of experiments a dog was used under 3 atmospheres. It was given oxygen intravenously as shown in Table I.

Duration of Injection	Amount Injected	Rate per Minute
10 min	600 c.c.	60 c.c.
5 ,,	465 ,,	93 ,,
5 ,,	465 ,,	99 ,,
5 ,,	465 ,,	93 ,,

Table I.

The Oxygen consumption of the dog was 145 c.c. per minute. Its basal metabolism about 100 c.c. per minute.

In the last crucial experiment the atmospheric pressure was increased to 4 atmospheres, and the trachea was closed. The dog was kept alive for 16 minutes. The rate of injection was 120 c.c. per minute. Its B.M.R. was about 110 c.c. per minute, though the actual oxygen consumption was 100 c.c. per minute. Throughout the respiration was normal.

Summary.

It has been shown both theoretically and practically that it is possible to dispense with one of the most important vital functions. In fact, this was done for the first time. Later, other vital functions have been dispensed with, such as the use of the artificial kidney, artificial heart, artificial digestion.

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