REMARKS

ON

THE PHYSIOLOGY OF ANÆSTHESIA.

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THE late Dr. Snow, after a careful inquiry into the mode of action of anæsthetic vapours, arrived at the conclusion that "chloroform, ether, and similar substances, when present in the blood in certain quantities, have the effect of limiting those combinations between the oxygen of the arterial blood and the tissues of the body which are essential to sensation, volition, and, in short, all the animal functions. These substances modify, and in larger quantities arrest, the animal functions, in the same way and by the same power that they modify and arrest combustion, the slow oxidation of phosphorus, and other kinds of oxidation unconnected with the living body, when they are mixed in certain quantities with the atmospheric air." (*Medical Gazette*, vol. xlvii, p. 626.) He goes on to say that "this explanation is probably applicable to the action of all narcotics." He refers to the observation of Dr. Prout, "who discovered that fermented and spirituous liquors diminish the amount of carbonic acid given off from the lungs." He also refers to Beneke's observation, that not only does alcohol lessen the amount of carbonic acid exhaled by the lungs, but also the amount of all the urinary constituents. And Dr. Snow proved, by experiments upon animals and upon himself, that the inhalation of the vapour of chloroform and of ether lowers the temperature of the body, and lessens the amount of carbonic acid exhaled by the lungs. In short, Dr. Snow collected a large amount of evidence in support of the proposition that the action of narcotics is due to the power which they possess of lessening the oxidation of the tissues. A taper burning with a dim and smoky flame, and being finally extinguished by the action of chloroform-vapour, affords a simple yet striking illustration of the manner in which the same vapour lessens and extinguishes "the flame of life". Dr. Snow further proved that the diminished oxidation is not explained by the combination of the narcotic substance with the oxygen of the arterial blood; for, as he says, the vapours of chloroform and ether escape for the most part unchanged in the expired air. Then, in the case of chloroform, the amount of material capable of combining with the oxygen is quite insufficient to rob the blood of its oxygen; and, lastly, "to increase the amount of oxygen in the respired air does not prevent the action of the narcotics."

In confirmation of the same view, I may refer to the result of Dr. George Harley's experiments, by which he has shown that a mixture of chloroform, alcohol, morphia or other narcotic substances, with the blood out of the body, lessens the amount of oxygen absorbed, and of carbonic acid given off, when the blood is shaken up with the atmospheric air.

If now we take a more extended survey of the subject of anæsthesia, so as to include all cases in which unconsciousness results from disease, or accident, or well-designed experiment, we shall find a number of facts all pointing to the conclusion that, however diverse may be the remote causes of anæsthesia, the immediate cause in every instance is a suspended or diminished oxidation of the nervous tissue.

In order that the nervous tissue may receive the supply of oxygen which is required for the discharge of its functions, there must be a free circulation of oxygenised blood. The blood, in moving through the capillaries, undergoes a rapid change of composition. In the pulmonary capillaries, it gives out carbonic acid, and takes in oxygen; and, in so doing, it changes from black to red. On the contrary, in the systemic capillaries, it exchanges oxygen for carbonic acid, and again becomes dark in colour. Each particle of blood, as it passes through the systemic capillaries, gives up its oxygen in a moment, and thus, of course,

loses its power of imparting oxygen to the tissues. Therefore an arrest of the capillary circulation through an organ immediately suspends the oxidation of its tissue; and, if that organ be the brain, loss of consciousness is an inevitable result. Stagnant blood in the capillaries can no more maintain the functions of the brain, than stagnant air in the lungs can maintain the process of respiration. In this way, then, we explain the loss of consciousness in *syncope* and in *epilepsy*. In *syncope*, the heart's action fails, and the circulation ceases more or less completely; and in the same proportion there is a more or less complete loss of consciousness. In *epilepsy*, as is now generally admitted, the arrest of the cerebral circulation is due to a sudden and extreme contraction of the minute arteries of the brain; and the phenomena of the disease may be exactly imitated by a rapid and copious hæmorrhage, or by ligaturing the arteries which supply the brain with blood.

We have another example of anæsthesia from an arrest of the circulation in the insensibility of the skin produced by extreme cold, and in the unconsciousness which Dr. Richardson produces in birds by freezing their brains. The cold stops the circulation, and with it, of course, the oxidation of the tissues. The application of cold, even before it actually freezes the tissues, lessens sensibility, probably, by checking the chemical action of oxygen. And Dr. Snow explains the drowsiness which results from exposure of the whole body to extreme cold by the diminished consumption of oxygen which is thus induced.*

In cases of *apnœa*, the anæsthetic condition is a result of two concurring causes. When the respiration is suspended from any cause, there is a rapidly increasing deoxidation of the blood, and a rapidly increasing impediment to the flow of blood through the lungs. Thus the oxidation of the brain; and with that its functions are suspended, partly from anæmia, but mainly in consequence of the blood being unærated.

What is the explanation of the anæsthesia which often results from *cerebral hæmorrhage*? It may sometimes be explained by the interrupted circulation through the brain-tissue caused by the pressure of a large clot, or by arterial contraction excited through a reflex nervous influence. Far more frequently, I believe, it is a consequence of the apnœal condition which results from the influence of the brain-mischief upon the respiratory movements.

The most unequivocal examples of anæsthesia resulting from the circulation of unoxxygenised blood are afforded by the inhalation of *protoxide of nitrogen*, and of uncombined nitrogen, as lately practised by Drs. Sanderson and Murray. It can scarcely be doubted that both these gases act as anæsthetics simply by taking the place of the normal oxygen in the blood; and thus they suspend the oxidation of the brain-tissue. There is no reason to suppose that the inhalation of these gases is associated with an accumulation of carbonic acid in the blood.

Lastly, we come again to the anæsthetic action of chloroform, ether, alcohol, opium, etc., the explanation of which has already been given, in accordance with the observations of Dr. Snow. In general terms, then, it may be said that unconsciousness or anæsthesia is a result of defective oxidation of the nervous tissues. This defective oxidation may have for its cause—1, an interrupted circulation of blood, the circulating blood being the vehicle by which the oxygen is carried from the lungs to the tissues;† 2, a circulation of unoxxygenised blood; or 3, a mixture with the circulating blood of certain narcotics which prevent the union of its oxygen with the tissues. In confirmation of the view that narcotics lessen oxidation, I would refer to the well-known fact that opium checks the secretion of bile; so that, as a result of its administration, we often get clay-coloured stools. This is intelligible, if we bear in mind that bile is a product of oxidation, and that opium lessens oxidation. The clay-coloured stools which result from a dose of opium are analogous to the rice-water stools of cholera-collapse, in so far as the scanty secretion of bile is a consequence of defective oxidation, although the cause of the defective oxidation is very dissimilar in the two classes of cases: in the one, a scanty blood-stream through the lungs, and a consequent partial apnœa; in the other, the mixture of a narcotic with the blood.

* "The flame of mammalian life, like the flame of inorganic combustion of CH₄, can only be sustained at a high temperature; a certain reduction is as fatal to the one as it is to the other in the Davy lamp, and the vitality of the more exposed peripheral is more easily depressed than that of the more protected central nervous system."—Professor Rolleston's *Address in Physiology*.

† Since this paper was read at the meeting of the Association at Oxford, Mr. Moore of the Middlesex Hospital tells me that he has lately treated a popliteal aneurism by pressure on the femoral; and that the interrupted circulation thus occasioned caused, for a time, complete loss of sensation in the leg below the knee.