Pathological Explanation

OF

THE DIMINISHED ABSORPTION BY THE LUNGS DURING THE STAGE OF CHOLERAIC COLLAPSE.

BY

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IN a previous communication (BRITISH MEDICAL JOURNAL, Jan. 20th, p. 61), I have endeavoured to explain the phenomenon of diminished absorption, which occurs during the collapse stage of cholera, by showing that, in accordance with well established and familiar physiological facts, this diminution of the process of absorption is a necessary consequence of the scanty and slowly moving stream of blood. All other conditions remaining the same, absorption is rapid and active in proportion to the velocity of the blood-current, and *vice versa*. In the present communication, I purpose to illustrate the same subject by referring to the phenomena of absorption by the lungs.

It is a well known fact that many gases and vapours, when inhaled by the lungs, rapidly enter the blood, and are thus speedily conveyed through the whole system. It is well known, too, that such substances as are capable of exerting an injurious influence, act with extraordinary rapidity and power when they are thus introduced into the system in a gaseous form. In illustration of this, I need only refer to such familiar examples as those of the vapours of chloroform and of ether when employed as anæsthetics, and to the poisonous effects of arseniuretted hydrogen and sulphuretted hydrogen gases when inhaled even in minute quantities. These gaseous bodies enter the blood by a process of endosmose; in other words, they are absorbed or sucked up by the blood. In the same manner—by the same physical process—the atmospheric gases are absorbed by the blood in the pulmonary capillaries during the process of respiration. In the phenomena of respiration, too, we have a simple and beautiful illustration of the processes of absorption and exhalation going on simultaneously through the same sets of vessels. There is absorption of oxygen from the air into the blood, and at the same time an exhalation of carbonic acid and aqueous vapour from the blood into the air.

Then, again, we know how intimate is the relation between the blood-current through the lungs and the demand for air to combine with the blood in its passage through the pulmonary capillaries. When the heart's action is quickened by exercise, so that the blood is sent more rapidly through the lungs, simultaneously the respiratory movements are increased in force and frequency, in order to meet the increased demand for air to be taken up by the rapid blood-stream. On the contrary, when the heart's action is slow, as during rest in the recumbent position,

and more especially during sleep, the breathing is in a corresponding degree slow; there is less demand for air to be absorbed by the diminished and retarded current of blood. Here, in the phenomena of absorption of gases and vapours by the lungs, we have a very simple and intelligible illustration of the general principle, that, other conditions remaining the same, absorption is active in proportion to the rapidity of the blood-current through the vessels.

Let us now pass on to consider in what way the process of absorption by the lungs is modified during the stage of choleraic collapse. And, first, we know that absorption by the lungs is not absolutely suspended during collapse. This is shown by the undoubted fact, that the inhalation of the vapour of chloroform by a patient in collapse is attended by the usual anæsthetic effects of that drug. The chloroform vapour is absorbed through the pulmonary vessels, enters the circulation, and acts upon the brain.

That absorption by the lungs is much diminished during the stage of collapse, is proved by certain chemical phenomena which I now proceed to mention. Several observers agree in stating that, during the stage of collapse, the expired air contains less than the usual proportion of carbonic acid. (See Dr. Budd's article, "Cholera," in the *Library of Practical Medicine*, vol. iv, p. 111; Lehmann, *Lehrbuch der Physiologischen Chemie*, 1853, vol. iii, p. 332; Twining's *Clinical Illustrations of the more important Diseases of Bengal*, 2nd ed., vol. ii, p. 15.) The most careful and complete observations that I have met with are those recorded by Twining. He states that, during the cold stage of cholera, he has several times found the quantity of carbonic acid in the expired air as low as 1.5 per cent., and seldom as high as 2 per cent. It is estimated that the normal amount of carbonic acid exhaled with the expired air is 4.35 per cent. (See Carpenter's *Human Physiology*, 6th ed., p. 287.) A comparison of these numbers, however, affords insufficient data for determining the actual decrease in the amount of carbonic acid exhaled during collapse. We must also take into consideration the total amount of air expired. This has been found to be considerably diminished. Twining (*op. cit.*) appears to have experimented with great care; and he states that "it is often very difficult to procure even ten cubic inches of air in a satisfactory manner from the lungs of a patient in the stage of lowness and collapse, when restlessness and extreme anxiety prevail." The normal amount of air taken in and given out by each act of respiration is estimated at from thirty to forty cubic inches. (Carpenter, *op. cit.*, p. 287.) If, therefore, the expired air be reduced to one-third of the normal amount, and if the proportion of carbonic acid in that reduced volume of air be less than half the standard quantity, it is evident that the amount of carbonic acid exhaled during the stage of collapse must be less than one-sixth of the normal average; and this diminished exhalation of carbonic acid, as we shall presently see, involves a correspondingly diminished absorption of oxygen. Here I would remark, that the results of Twining's experiments on the amount of respired air are in strict agreement with other facts which have been repeatedly observed—namely, the incompleteness of the respiratory movements during collapse; the imperfect expansion of the chest; the feebleness and sometimes even the complete absence of the vesicular respiratory murmur; and the peculiar feebleness of the voice, the most probable explanation of which is, that it is due to the smallness and feebleness of the expiratory current of air. All these phenomena point to the conclusion, that, during the stage of col-

lapse, much less than the usual amount of air is respired.

The explanation of the diminished respiration during collapse is this. Owing to the arrest of blood in the minute branches of the pulmonary artery, and the greatly reduced volume of blood which, in consequence, passes through the capillaries of the lungs, there is less demand for air to be absorbed into the blood. We have here, again, an illustration of the principle, that absorption is checked when the current of blood moving through the vessels is retarded and greatly reduced in volume.

It is manifest that the diminished exhalation of carbonic acid during collapse must be associated with a corresponding diminution in the amount of oxygen absorbed. This is evident, from certain physiological considerations. For instance, if we compare and contrast the phenomena of cholera with those of ordinary asphyxia, it appears certain that if, with the same degree of impediment to the passage through the lungs as exists during collapse, oxygen were absorbed and carbonic acid generated within the blood as rapidly as in ordinary circumstances, the patient would be killed by the narcotic influence of the carbonic acid within a few minutes. The passage of blood through the lungs in cases of extreme collapse is so much obstructed, that the arteries are comparatively empty, and the pulse is often imperceptible. This obstruction, occurring in the minute branches of the pulmonary artery, lessens the volume of blood passing through the pulmonary capillaries, and, in the same degree, it lessens the absorption of oxygen and the consequent formation of carbonic acid. In the case of asphyxia, on the contrary, whether it occur slowly during the progress of disease, or suddenly from drowning or other modes of suffocation, the obstruction to the flow of blood through the lungs exists, not in the pulmonary artery (which, being accustomed to receive and to transmit black blood offers no impediment to its passage), but in the pulmonary capillaries, and it is a direct consequence of the excess of carbonic acid in the blood. But the animal, whether human or brute, is rendered insensible by the action of the carbonic acid on the brain long before the stream of blood through the lungs can be diminished to the degree in which it is during the collapse of cholera; indeed, before it is perceptibly diminished in any degree. This statement admits of the most conclusive proof from observations made on the lower animals as well as on man. Thus, it was observed by Dr. Reid (*On the Order of Succession in which the Vital Phenomena cease in Asphyxia*), that, for a period of about two minutes after a dog had been rendered insensible, and had ceased to struggle, in consequence of air having been shut off from the lungs, the arteries continued to be unusually distended with black unærated blood.

Again, in the human subject, when a patient is gradually dying from the slow asphyxia resulting from emphysema of the lungs, with bronchitis and effusion into the air-tubes, we often find the pulse fall in consequence of the impeded flow of black blood through the minute systemic arteries. And long before the volume of the pulse can be lessened by the limited passage of unoxygenated blood through the lungs, the patient has usually passed from a state of increasing drowsiness to one of profound and fatal coma.

Now a patient in collapse from cholera, with so scanty a stream of blood through the lungs that the arterial pulse is quite imperceptible, is often as free from drowsiness and as fully in possession of his mental faculties as a person in perfect health. It is obvious, therefore, that in these cases there can be no great accumulation of carbonic acid in the blood.

This relative deficiency of carbonic acid in the blood is explained by the fact that the small current of blood through the pulmonary capillaries involves, as a necessary consequence, a correspondingly diminished absorption of oxygen and an equally diminished formation of carbonic acid. We see, then, that the reduced supply of oxygen to the blood during the stage of collapse, is a result of that diminished activity of the process of absorption which is necessarily associated with the slow and scanty current of blood.

The one great central fact in the pathology of collapse, is the arrest of blood in the minute branches of the pulmonary artery. This is a demonstrated anatomical fact. The other leading physical and chemical phenomena of collapse are connected with that one, as necessary consequences. I maintain, then, that the question as to the pathology of cholera—the relation of the symptoms to each other and to their primary cause—is, of all the great pathological problems that have ever been presented to us, the one which admits of the most complete and simple and intelligible solution.

MILITARY SURGERY IN AMERICA. The Surgeon-General of the United States has published a report, which shows that over 87,000 cases of wounds and 17,000 surgical operations were recorded up to September 1865. In comparing the numbers of cases of gunshot fractures of the femur, it is found that in the French Crimean army there were 459 such injuries, and in the English army 194, while over 5,000 such cases were reported in America. Of excision of the head of the humerus, the Crimean returns give 16 in the British and 38 in the French army, but the American registers contain the detailed histories of 575 such operations.

CLINICAL HOSPITAL AT NAPLES. The foundation-stone of the new part of the building, which formerly belonged to a monastery, was laid two years ago by Victor Emmanuel. Last summer it was inaugurated, and but for the visitation of the cholera would have been opened earlier. Professor Tommasi, in an admirable speech, addressed a crowded audience. The hospital makes up three hundred and fifty beds. The baths and other necessary institutions are all constructed on an excellent system, and standing as the building does on a considerable eminence, the best guarantees are given for the health of the convalescent. The hospital of "Gesù e Maria", a suppressed monastery, is, in fact, to be the school of the medical students of the University; and the many eminent men who now fill the chairs connected with the profession give promise that a medical school which once was celebrated will be equal to the demands of modern civilisation. At present, there are seventeen chairs in the University connected with medicine and surgery, filled, many of them, by very distinguished men. That of pathological anatomy and microscopical anatomy is filled by a German, M. Schrön; and it is to the honour of the Italians that there are four Germans occupying chairs in as many Universities—M. Moleschott, Professor of Physiology in Turin; M. Schiff, Professor of Physiology in Florence; M. Schrön, Professor of Pathological Anatomy in Naples; and M. Lieben, Professor of Organic Chemistry in Palermo. Since the new order of things, a great impulse has been given to education. As there are no registrations in the University of Naples, the lectures being gratuitous, it is difficult to ascertain the precise number of the students; but, as a correct approximation, it may be stated that they amount to 10,000, of whom it is calculated 4,000 are medical students.