Pathological Explanation

OF

THE CHIEF PHYSICAL CHANGES IN THE BLOOD OF CHOLERA PATIENTS.

BY

GEORGE JOHNSON, M.D., F.R.C.P.,

PHYSICIAN TO KING'S COLLEGE HOSPITAL; PROFESSOR OF MEDICINE IN KING'S COLLEGE; ETC.

THE blood of patients during the stage of choleraic collapse is found to have undergone very remarkable physical changes. It coagulates imperfectly or not at all; it is of dark colour, and apparently thicker than natural; its specific gravity is considerably increased. According to Becquerel and Rodier, the maximum specific gravity of blood in the healthy male is 1062, and in the female 1060. In cholera cases, Dr. Garrod found the specific gravity in adult males to be, in round numbers, 1076 and 1081; and in females, 1068, 1074, and 1076. (*London Journal of Medicine*, vol. i, p. 409.) Can we explain these physical changes in the blood? To a considerable extent we can.

It is manifest that in cholera-blood there is an excess of solids in proportion to water; and the explanation which is generally given of this condition is that, the water having been drained away by the intestinal discharges, a concentrated blood is left behind in the vessels. Now, it is to be observed, that this great increase in the density of the blood is found to occur only during the stage of collapse. So long as the symptoms are those only of epidemic diarrhoea with bilious stools, no matter how copious may be the drain of liquid from the stomach and bowels, the blood does not undergo those striking physical changes which are so constantly present during the stage of collapse. If loss of water be the sole or the chief cause of the blood-thickening, why is it that this change in the blood occurs only during the stage of collapse, when, as a rule, there is a less copious drain of liquid from the blood than during the stage of bilious diarrhoea? And, if loss of water be the main cause of blood-thickening, what is the explanation of the fact that, during the stage of reaction from collapse, the blood becomes rapidly thinner, notwithstanding a continuous drain of water from the blood by vomiting and purging? The answer which is usually given to these questions is this. During collapse, the process of absorption is almost or altogether suspended, so that the drain from the blood is not counteracted by the absorption of liquid from without—a process which is in active operation before the onset of collapse, and during reaction after collapse. There is some truth in this argument; but it is not the whole truth, as we shall presently see.

I have, in a previous communication (*BRITISH MEDICAL JOURNAL*, Jan. 20, p. 61) given what appears to be the rational explanation of the diminished ab-

sorption during the stage of collapse. It is a necessary result of the diminished blood-current—first through the pulmonary vessels, and consequently through the systemic vessels. Absorption during collapse will be checked in proportion to the diminution and retardation of the blood-stream. In many, probably in most cases of collapse, the amount of liquid excretion from the blood is also lessened during this stage, in consequence of the diminished supply of blood to the systemic arteries; and, in cases of extreme collapse, the flow of blood through the lungs is so nearly arrested, that the process of intestinal excretion is almost suspended. As a rule, however, it is probable that absorption is lessened in a greater degree than the excretion of liquid; and hence one cause of the increased density of the blood—namely, a draining away of liquid, not counterbalanced by an equivalent amount of absorption.

But there is another cause for the excess of solids in the blood during the stage of collapse, and that is *defective aëration of the blood*; and, as a consequence of this, an accumulation of solid constituents, which, in combination with oxygen, are normally excreted in the form of carbonic acid, bile, and urine. I have before shown (*BRITISH MEDICAL JOURNAL*, Jan. 27, p. 87) that the scanty stream of blood through the lungs during collapse involves, as a necessary consequence, a proportionate diminution of the amount of atmospheric air introduced into the system, and an equally scanty formation of carbonic acid, bile, and urine. The chief change in the blood-constituents consists in an excess of red corpuscles and albumen in proportion to water, and a deficiency of fibrine; so that the blood coagulates imperfectly, or not at all. Now, that this alteration in the physical condition of the blood is in great part due to defective aëration, is certain. Increased thickness and density of the blood is known to occur as a consequence of defective aëration when there has been no drain of liquid to explain the physical change in the blood. Thus the late Dr. Dundas Thomson states that one specimen of blood from "a patient who laboured under an affection of the mucous membrane of the air-tubes," contained a greater excess of solids in proportion to water than he had found even in cholera-blood. (*Med. Chir. Trans.*, vol. xxxiii, p. 67.) Then Dr. Garrod admits (*loc. cit.*) that, according to his experience of cholera-blood, "the amount of intestinal evacuations in any case is by no means an indication of the extent to which the blood has become altered."

It is an acknowledged fact that, when animals are made to breathe a highly oxygenated atmosphere, the amount of fibrine in their blood is increased, while the albumen and globules are rapidly diminished in amount. Dr. Gairdner proved this by experiments on rabbits. (See his book on *Gout*, 1851, p. 152; also Carpenter's *Human Physiology*, 4th Edit., p. 157.) This result, too, is in accordance with the observations of Dr. Franz Simon (*Animal Chemistry*, Sydenham Society, vol. i, p. 157), who says: "It is a well known fact that the respiratory process not only increases the plasticity of the fibrine in the blood, but also its quantity; and that, on the other hand, the amount of fibrine diminishes in blood which is not efficiently brought in contact with oxygen." The deficiency of fibrine and the imperfect coagulation of the blood in cholera are in strict accordance with this doctrine. Then Simon states, and confirms his statement by the results of analysis, that, with very few exceptions, the amount of fibrine always varies

inversely with the mass of the blood-corpuscles; or, in other words, that the more corpuscles there are, the less in quantity is the fibrine, and *vice versa*. And he explains this result by the statement, that oxygen quickens the metamorphosis of the corpuscles, and that the products of this metamorphosis are fibrine, urea, uric acid, and biline. The dark colour of the blood during collapse, is obviously a result of defective aëration.

For our present purpose, it is not necessary to enter into tedious details as to the precise chemical changes which the blood undergoes under the influence of oxygen. It is certain that carbonic acid, bile, and urine, are products of oxidation of blood-constituents. It is equally certain, that defective oxygenation, such as occurs during choleraic collapse, will result in accumulation of unoxidised material in the blood; there will then be a relative excess of solids and an increase of specific gravity. Then it can scarcely be doubted that the rapid fall in the density of the blood during reaction is, in great part, due to the oxidation of solid blood-constituents which have accumulated during collapse, and which are now abundantly excreted in the form of carbonic acid, bile, and urine.

If now we reconsider the probable causes of this increased thickness and density of blood, we find that, whereas the drain of liquid from the blood is in a greater or less degree continuous throughout all the stages of the disease, the remarkable blood-thickening is limited to the stage of collapse. The drain of liquid from the gastro-intestinal canal, then, cannot alone be the cause of the blood-change.

But there are two other conditions which invariably coexist with collapse; these are diminished absorption and defective respiration. It is scarcely possible to determine which of these two concurring influences is the more powerful in increasing the density of the blood. One point, however, is quite certain, and it is this: that *thickening of the blood is a consequence and not the cause of collapse*. The primary link in the chain of phenomena is a more or less complete arrest of blood in the pulmonary artery; next, as a consequence of the diminished bloodstream, there is a defective absorption of air—in other words, defective respiration—and defective absorption of liquids; then, as a conjoint result of defective respiration and absorption, there is an increase in the thickness and density of the blood.

Arrest of blood in the pulmonary artery	} causes	{ Defective respiration and diminished absorption.
Defective respiration and diminished absorption		
	} cause	{ Increased thickness and density of blood.

I need not repeat here the facts and arguments which I adduced in my last communication (BARRISH MEDICAL JOURNAL, Feb. 17, p. 165) to disprove the hypothesis that the arrest of blood in the lungs during collapse is a consequence of a previous blood thickening.

Opium has been largely given for the purpose of preventing the blood thickening in cholera. The effect has been the exact opposite to that which was intended.

The tendency of opium is to check the escape of the morbid poison and to favour its accumulation in the blood. Then there follows the arrest of blood in the lungs, and, consequent on this, the much dreaded blood thickening. I had observed this effect of opium in cholera long before I could explain it. Now I find an entire agreement between therapeutical experience and pathological science.

Illustrations

OF

HOSPITAL PRACTICE:

METROPOLITAN AND PROVINCIAL.

BIRMINGHAM GENERAL HOSPITAL.

A CASE OF POLYSARKA, IN WHICH DEATH RESULTED FROM DEFICIENT ARTERIALISATION OF THE BLOOD.

Under the care of JAMES RUSSELL, M.D.

THE following case indicates a somewhat unusual mode in which an excessive tendency to the production of fat in the general cellular tissue may cause death. So far as I am aware, the tendency to death in cases of this description is usually through the heart. My present case exhibits this tendency taking place through the lungs.

Under ordinary circumstances, death takes place in consequence of the heart participating in the abnormal growth of fat in the tissues. Fat becomes deposited upon the exterior of that organ as a part of the general growth of fat in the system, constituting the fatty growth of Dr. Quain. By degrees the quantity of fat augments; and, in process of time, the fat-globules begin to intrude themselves between the muscular fascicles, and gradually effect their destruction.

It may, however, be noted in passing, that this process of wasting of the muscular fascicles is not a necessary consequence of the growth of fat upon the exterior of the heart. Fat may exist there in preternatural quantity, whilst the fibre retains its healthy condition; but wasting is always liable to occur, and such liability constitutes one of the chief dangers of the state of corpulence. Under the former circumstances, a sharp line of demarcation is seen on section, separating the fat from the muscular tissue; but, in proportion as this line becomes indistinct, and the fat-tissue merges gradually into the muscular, is the destructive tendency, of which we are speaking, being developed.

In the advanced stages of the disease, such scanty remains of muscular fibre are found in the heart, that the observer finds it difficult to explain how the heart could possibly have carried on its work; and thus death takes place emphatically through the heart, sometimes very suddenly, at other times by a more gradual but very painful process of cardiac apnoea.

In the case which I am about to relate, a condition of complete cyanosis was established some time before death, evidently by very gradual stages. Venous blood had been evidently circulating through the vessels for a considerable length of time, and the patient died poisoned by carbonaceous matter. This state of cyanosis seemed attributable to want of pulmonary capacity, sufficient to meet the increased demand for oxygen created by the highly carbonised state of the tissues and of the blood. The disproportion between the size of the lungs and that of the entire body, enlarged as it was by excessive growth of fat, was most striking after death. The lungs were manifestly unequal to the requirements of the case.

The amount of fat upon the heart was comparatively small; and the fascicles of the organ were nearly healthy. But the heart was generally and