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THE THEORY OF CHOLERA COLLAPSE.

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To Dr. Johnson we are undoubtedly indebted for much painstaking and skilful research into the disease now so prevalent amongst us, though, if we mistake not, there are many medical men to whose minds the arguments he has advanced on the subject of cholera will fail to carry conviction. While confessing ourselves amongst this number, we cannot too highly express, though attempting a somewhat diverse elucidation of the subject, our respect for the authority and position of Dr. Johnson, whose candid reasoning and gentlemanly discussion of this topic are of themselves almost sufficient to disarm criticism. At any rate, they encourage the belief that he is prepared to deal fairly with any opponent of his views who may meet him in the liberal spirit he has himself displayed in this matter.

According to Dr. Johnson, whose published treatises on cholera may be regarded as embodying the most recent knowledge of the disease, the central pathological phenomenon of cholera collapse consists in the fact that, after death, the tissue of the lungs contains "less than the usual amount of blood and air"; indicating a most decided stasis of blood behind the pulmonary capillaries. Respecting the cause of this, he says, "The blood which is sent into the pulmonary artery is in great part arrested in the minute branches of the artery before it reaches the capillaries of the lungs"; and, again, "the blood thus poisoned (by the *materies morbi* of cholera) excites contraction of the muscular walls of the minute pulmonary artery, the effect of which is to diminish, and in fatal cases entirely to arrest the flow of blood through the lungs." In support of these views, Dr. Johnson brings forward arguments from pathology and physiology, and opposed to what he seems to consider the only other alternative—viz., that of simple mechanical obstruction to the onward passage of the blood in consequence of the separation of its solid and fluid constituents. While regarding this latter theory as altogether beside the mark, we contend that these two views are not the only ones open for the acceptance or rejection of pathologists.

Dr. Johnson proceeds to argue that this spasm of the minute pulmonary arteries is akin to that constituting cramps in the limbs, both being due to the same cause. "The blood", he says, "contains a poison whose irritant action upon the muscular tissue is shown by the painful cramps which it occasions." Quite a legitimate inference this from the standpoint to which we are alluding; though, before accepting it, we are met by this difficulty. Presuming that the poison has produced the same contracted effect on the small arteries supplying the muscles, and that therefore the capillary system of the muscles are as empty of blood as those of the lung are stated to be, it is difficult to understand in what way the poison in question is brought into such intimate contact with the muscular fibres (now that the capillary system is in abeyance) as to produce in them the violent contractions known as cramp. Why, also, should there not be spasms of other muscular fibres equally exposed to the influence of the poison; as, e.g., those of the finer bronchial tubes, or of the epiglottis? And if it be answered, that the arteries conveying blood to these organs are in the same state of tonic spasm as are the pulmonary arteries,

how is it that the heart itself should escape the effects of spasm? which, if there be any relation between the amount of a cause and the degree of resulting effect, should, one would think, be most violently convulsed, inasmuch as the whole poison contained in the blood passes through it, as long as the circulation continues.

But the theory of spasm of the smaller pulmonary arteries being the main pathological condition of cholera, involves another difficulty. Dr. Johnson says he is prepared to show that "the thickening of the blood is a consequence and not a cause of the arrest of blood in the pulmonary arteries." If so, then every case of cholera collapse should be sudden and complete, coinciding with the setting in of spasm of the pulmonary arteries; and so, no doubt, the collapse is sometimes thus suddenly fatal, though rarely. And, again, the collapse should invariably precede the access of rice-water evacuations; these latter being the direct consequence of the separation of the solid from the fluid constituents of the blood, which separation ("or thickening") is a consequence of the "arrest of blood in the pulmonary arteries." But the instances in which rice-water evacuations precede the symptoms of collapse are so numerous as to constitute the rule; so that we are bound to look for some other solution of a phenomenon which obtains in the majority of cases, than that which can only explain the peculiarities of the exceptional ones. Here, too, though we question Dr. Johnson's conclusion, that the "thickening of the blood is a consequence of its arrest in the pulmonary arteries," we by no means accept his alternative; viz., that it is the cause of its thickening. In fact, we think it is neither the one nor the other. Perhaps, the weakest point in Dr. Johnson's argument is, that it appears to explain the exceptional cases better than it does the general ones.

Before passing from Dr. Johnson's views, we cannot do better, for the sake of clearly understanding them, than to quote his own summary of the chain of events in cholera collapse and their mutual relationship; viz.,

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

Now, it appears to us that the links of the chain, as here given, are not only misplaced, but that the dependence stated to exist between them is also erroneous.

While admitting the frequent, though by no means constant, occurrence in collapse of an anæmic state of the lungs, we cannot dissociate this from the corresponding indications of the arrest of the capillary circulation in other parts of the system; as, e.g., in the skin, indicated by the pale hue and clammy feel, as well as by the shrinking of the features; and in the brain by the drowsy torpor so often present (a condition similar to that of sleep shown by Durham to depend on brain anæmia). We have then to deal with the cause of this general abnegation of the capillary circulation in the circumstances now under consideration. Here it will be advantageous to recall the conditions under which the capillary circulation takes place in the normal state of the system.

These depend, as every tyro in physiology knows, on the mutual affinities existing between the blood on the one hand, and the particular tissue through which it has to pass, and whose nutrition it mediates, on the other. "The conditions necessary for the energetic flow of blood through the capillaries, are nothing else than the active performance of those

nutritive and other operations to which they are subservient." (Dr. Carpenter's *Physiology*.) The force of the heart's action, therefore, does little else in the case of the capillary vessels than to keep up the supply of blood; being altogether inadequate to propel the blood through them. There must be, then, the quality to give and take mutually present in the blood contained in the capillaries and the parts it has to supply, or this portion of the circulation will not go on. But we are now treating of a disease in which perhaps the most marked feature is the change that takes place in the constitution of the blood itself. A change distinctly recognisable during life, and of such a nature as completely to destroy the physical conditions of that fluid, so that the mechanical conditions under which it remains in its proper channels, and mediates the nutrition of the various parts of the system, are destroyed. This effect is in its extreme degree, coincident with the collapse, and is due, as we believe, to the immediate action of the cholera-poison upon the blood. Not so, says Dr. Johnson, but rather the poison in the blood induces spasm of the pulmonary capillaries which, by preventing aëration of the blood, is the cause of its degeneration. Now, as neither of these views can be actually put to the proof, their rejection or acceptance will rest on the greater degree of consistency which either offers in explaining the phenomena of the disease.

The first link in the chain of morbid phenomena, as we view it, is the disintegration of the blood, in such a way that it fails to fulfil the conditions necessary for maintaining the circulation.

The known hygroscopic affinities of the cholera germ suggest the idea that the form in which the poison is introduced into the blood is that of a cell, which being brought into immediate contact with the blood-corpuscles, a fresh osmotic relationship is established between the two sets of cells, by means of which the dialytic powers of the blood discs are for the time lost, and with them the ability to mediate the nutrition of the system. Nor will the possibility of such a state of things be questioned by any one who has watched the extraordinary effect which organic cells produce on one another when brought within the range of each other's attraction. This theory which assumes that the effect of the cholera-poison on the blood is physical rather than chemical, renders intelligible the rapid restoration of the blood when the influence of the cholera-poison is withdrawn from it through the evacuations—for, with the exception of the removal from the blood of its watery and saline constituents, its organic chemistry, though disturbed, is not destroyed.

It is only necessary, therefore, that the depreciated corpuscles should regain their wonted constitution in order that the processes of nutrition thus kept in abeyance during collapse may be re-established. But whether this view of the *modus operandi* of the cholera-poison be or be not correct in no wise affects the main argument; viz., that the primary influence it produces on the blood is to negative the physical adaptability for nourishing the frame inherent to a healthy state of this fluid.

The succeeding stage of the process comprises the much debated one of the capillary circulation. Neither the pulmonary nor the systemic capillary circulation is in active operation. With Dr. Carpenter's words just quoted before us, we need surely seek for no other explanation of the fact. The blood, being rendered incapable of conveying nutrition to the tissues, is excluded from the capillaries through which this nutrition is conveyed. The condition requisite for maintaining the capillary circulation being destroyed, it is not unnatural that the circulation itself should cease. Thus it will be seen

that, though we insist on the morbid state of the blood as the first step in the series, we do not make the second step (the cessation of the capillary circulation) to depend simply upon the thickened state of the morbid blood, but to the temporary destruction in it of the ability to furnish nutriment to the tissues, and the consequent loss of those affinities between the blood and the tissues which are the essential condition of the capillary circulation.

But the term nutrition has a very extensive application, and must be considered to include such an interchange of elements as in health suffices not only to supply pabulum to the part, but to remove from it the *débris* arising from the wear of the tissues. Consequently there is, on the suspension of this interchange, another set of phenomena, the tissues become charged with effete matter. This would constitute another stage in the disease. Thus, the muscles retain those elements in their anteputentimate condition of decay, which, if the change were complete, would pass off as the constituents of urine and bile by their respective excretories. In consequence of this, there is stored up in the substance of the muscle many highly irritating matters, which, by their presence, give rise to the cramps of cholera.

It is important here to recall the circumstance that there is a comparative absence of carbonic acid in the blood of cholera patients; nor is any carbonic acid found in the respired air during the stage of collapse. These facts are intelligible when it is recognised that none of the carbon-yielding elements resulting from the decay of the muscles are returned to the blood, owing to the suspension of the capillary circulation. We simply call attention to these circumstances in passing, as we shall return to them shortly in referring to the state of the respiration in collapse. Now, it will be easy to understand why there should be a suspension of urine and bile in cholera; for the elements from which the solid constituents of these excretions are elaborated do not, as just shown, leave the tissues in which they are generated to enter the blood; much less can they be eliminated through the kidney or liver, which, in fact, they do not reach.

A correspondent states, in the JOURNAL (p. 647) that he attributes the absence of bile and urine "to a constricted condition of the biliary and renal ducts attributable to the action of the poison on their musculo-contractile structures." And it appears to us that he is as much warranted in maintaining this view of the case, as is Dr. Johnson in his; but it has this fatal objection. If the bile, for example, were retained by closure of the ducts, we have a condition similar to what actually occurs in some forms of liver disease, where, however, the obstruction is mechanical, rather than of the nature of spasm, and the immediate issue of which is jaundice. The bile being formed by the liver, but unable, from the obstructed state of the ducts, to find its natural vent, enters the blood and gives rise to jaundice. The same would also occur in cholera if spasm of the ducts were the real cause of absence of bile from the excretions in cholera. But in collapse there is no bile found in the blood, neither is any expelled from the bowels; hence none is formed by the liver. The same line of argument applies to the kidney; for if urine were formed and not excreted, it would pass into the blood and give rise to the train of symptoms known as uræmia; but neither does this condition obtain in cholera collapse. We are left, then, to the conclusion, that neither bile nor urine is formed by their respective organs, owing to the suspension of the capillary circulation and the consequent non-return of the effete matters of the system to the blood, out of which these excretions are elaborated.

The absence of the capillary circulation to a more or less degree, then, loads the tissues, not the blood, with the *débris* of their own normal existence; a fact this of the highest importance in a therapeutic point of view.

Bringing this theory to bear on the *pulmonary phenomena of collapse*, we shall obtain, we think, a more complete explanation of these by it, than by any other hypothesis. We have stated that the chief condition for carrying on the capillary circulation consists in the reciprocal affinities existing between the blood and the organ or tissue through which the blood ramifies. Now, it is known that, in the lungs, oxygen from the air is exchanged for carbonic acid gas from the blood: not, as is sometimes supposed, that oxygen from the air unites with carbon from the blood to form carbonic acid, which is then expired; but, as Dr. Carpenter has well expressed it, "the blood comes to the lungs *charged with carbonic acid*; and that it gives out this ready formed, and receives oxygen in its stead." Now, carbonic acid is one of those materials derived from the decay of the tissues which we have already shown does not get into the blood during collapse; and as, in the progress of the disease, all the carbonic acid contained in the blood previous to the attack is carried off, and the new supply from the tissues is withheld, we at once perceive in what consists the reciprocity between the blood and the lungs, and how it comes to be lost. *As the vital fluid is unable to fulfil its part of the operations for the performance of which the pulmonary capillaries are provided, these latter refuse to convey the blood through them—an explanation of the anæmic condition of the lungs in collapse which we may be excused for preferring to that of spasm of the pulmonary arteries.* This, moreover, is a condition which the supply of no amount of pure air will remedy. Until the blood has carbonic acid furnished to it to give up in exchange for the oxygen of the air, none of the latter gas will enter the blood; and the processes dependent upon its presence there will in the meantime remain in abeyance. Dr. Sutton of the London Hospital has informed the writer that nitrous oxide has been inhaled by patients in collapse without producing any effect whatever on the system: a circumstance which is intelligible only on the supposition that this gas does not enter the circulation at all, but is expired exactly as it is inspired. This fact serves to confirm the theory now broached; the reason why the nitrous oxide is excluded being the same as that which prohibits the entrance of oxygen through the lungs—viz., the absence of carbonic acid in the blood to exchange for it, entailing a cessation of the circulation through the pulmonary capillaries. The water also, which usually finds an evaporating surface in the air-cells of the lungs, being carried off by the bowels, these organs are reduced to the same state of inactivity as are the liver and kidneys, and so but little air and less blood are found in them after death.

Dr. Johnson states, that "there is no direct relation between collapse and loss of fluid by the bowels;" and, except that both phenomena acknowledge the same cause—viz., the deranged physical state of the blood—we entirely agree with him. At the same time, we do not remember to have met with any satisfactory explanation of this symptom. In some aspects, it appears to resemble the anasarca produced by kidney or heart disease; and we can conceive of no reason why anasarca should not occur in cholera, except that the blood does not enter the capillaries of the integument. This arrest of the circulation, as it pertains to the pulmonary and hepatic capillaries especially, retains the blood in the veins of the intestinal track. The visceral veins thus become

increasingly gorged with blood, of which the fluid portions are of a much less degree of density than usual. This serous fluid then passes outwards through the veins, obeying the same laws of osmosis as, under the opposite condition of health, cause the fluids to pass out of the stomach, through the veins of that organ, into the portal circulation.

Instead, therefore, of the rice-water evacuations being the result simply of an eliminative effort of Nature—though they may indirectly serve to carry off the poison—they are, on our theory, the direct necessity of the loss of the statical relations between the blood and its channels, induced in the former by the poison of cholera. Any attempt, therefore, to interfere with this purely physical condition by the administration of drugs, in the ordinary acceptance of the term, will be useless.

If the views now advocated be correct, cholera will be seen to be a disease in which the *dynamical conditions* of health are subverted; and, if the life of the body is lost, it is because the *physical conditions* on which vitality depends are too far deranged to allow of its continuance.

The order of events, as seen from our stand-point, is as follows.

Deranged physical condition of blood, its consequent inability to mediate the nutrition of textures, or to remain within its channels,	causes	Suspension of capillary circulation, both pulmonary and systemic. Watery evacuations.
Suspension of capillary circulation	causes	Retention of effete elements in the textures.
Retention of effete elements in the textures	causes	Cramps. Suspension of bile, urine, and respiration. Collapse.

Furthermore, in support of this view, we claim that it has an equal application to the ordinary and to the exceptional cases: *e. g.*, the suddenness and completeness of the collapse in some cases is due either to the concentration with which the poison attacks the patient, or his incapacity of resisting its disturbing influence upon the blood, or both of these together, inducing the physical change previously alluded to in the entire fluid, and the consequent abrupt and universal check of all the dynamical changes which are necessary for the continuance of vitality, the complete analogy of which, as regards the rapidly fatal issue, we see in typhus and scarlet fevers. Moreover, taking the altered physical state of the blood to be the starting-point in the disease, it shows how the watery evacuations may precede any indication of collapse, and may exist independently of any change in the respiration. Lastly, it explains what proportion of the morbid phenomena is due directly to the cholera poison, and what symptoms are simply indirectly referable to it. Thus we limit the action of the *materies morbi* to the disturbing effect upon the blood, its further capability for evil being exhausted when this is accomplished; the supposititious cell breaking up into countless nuclei, which pass out with the evacuations, to become in their turn the centres of fresh disease, should they by any mischance alight upon a suitable nidus for their development. Cholera, as a specific disease, may be said to end with the establishment of this altered state of the blood, and its severity to depend entirely upon the extent to which this has proceeded.

We shall close these remarks by one or two suggestions for treating the disease, deducible from the foregoing theory.

Believing that the evacuations, if not curative, are

simply the effects of other and therefore of more important lesions; and that the attempts to restrain them, if not harmful, are absolutely nugatory—we shall bestow no further attention upon them than to secure that they be immediately removed, and rendered innocuous by disinfectants. Manifestly, then, the primary indication is to restore to the blood those elements of decay which the temporary cessation of the capillary circulation has caused to accumulate in the tissues. This we take to be the salient point in the disease, and the one which more than any other tends, by its persistence, to prevent the recovery of the patient. For it is highly probable that the effect of the poison on the blood is, as far as it goes, immediate; and that no attempt to eliminate it can be nearly so efficacious or rapid as its own tendency to exhaust itself. Death, according to this theory, takes place, not in consequence of the altered state of the blood persisting throughout the disease, but in consequence of those stases which have occurred during the immediate operation of the poison, and the persistence of which, by withholding the essential conditions for continuing the circulation of the blood, prevents the possibility of its re-establishment. The wheels of life are clogged by refuse matter, though the machine itself remains unimpaired. How is this indication to be accomplished?

On this point, the experiments for injecting fluid into the veins, while raising our expectations with the promise of a brilliant success, only to baffle them by a corresponding degree of disappointment, are most instructive. They teach us that the machinery of the circulation remains intact; but they also show that something more than the crude injection of water, rendered sufficiently dense by some salt thrown in almost at haphazard, is requisite to supply the delicately balanced conditions for maintaining the continuous flow of the vital fluid.

If we mistake not, Dr. Richardson furnished the clue to the only successful method of restoring the capillary circulation, in an experiment he performed some years ago on the corpse of a drowned man—when, in order to recognise the body, which was bloated by a lengthened period of submersion, he placed it in a dense solution; and, according to the laws of osmosis, the water passed out of the body, allowing the tissues to return to their normal degree of distension. In the treatment of cholera collapse, we have to deal with an exactly opposite state of things to that which obtained in the above proceeding. The collapsed body being reduced to a state of semi-desiccation, we must place it in such circumstances as will permit of water passing by endosmosis through the skin of the patient. In this way the fluid will saturate the tissues, taking up from them the soluble debris which constitute the elements requisite for the performance of the functions of those organs whose operations are now in abeyance, and for the want of which effete elements, the capillaries remain empty. Passing still onwards by the irresistible osmotic force, the imbibed fluid will now hasten to join the thickened blood in the veins. These vessels will thus become gradually charged with a fluid medium differing vastly from any that can be injected into them from without the body, and rendered sufficiently dense by the very same constituents of the liquor sanguinis for the conveyance of which, in the normal state of things, the serum of the blood is the proper vehicle.

Now, it will be obvious that the attempt to introduce serum or water into the veins by the process of injection must fail in its purpose, because this cannot safely be charged with the elements required to restore the mutual attraction between the tissues and the now diluted and to some extent invigorated

blood; for the former are not thereby relieved of their inobus, and the capillaries are no nearer acting than previously. Carbonic acid gas cannot thereby be added to the blood; and, until this occurs, there will be no opportunity afforded for restoring the pulmonary circulation. It is probable, indeed, that the first result of the successful induction of the endosmotic process we are discussing would be the conducting to the circulation of a solution of this gas, elaborated and dissolved in the natural laboratory of the animal system in a way peculiarly fitted for the important part it has to perform in the economy. This, passing directly to the right side of the heart, will at once enter the pulmonary artery; and, being now furnished with that condition of the blood requisite for the interchange of oxygen in the lungs, the pulmonary capillaries will hesitate no longer to admit it, and so the circulation through the lungs, and the consequent aëration of the blood, will recommence. This being accomplished, we shall not have long to wait for the reappearance of both bile and urine.

One practical point remains to be considered; viz., how is the end in view to be accomplished? By imitating, *ceteris paribus*, as closely as may be, the experiment of Dr. Richardson. We suggest the following plan, subject to any modification that experience may dictate.

The patient should be supported in the recumbent posture, upon a stage or shelf rendered sufficiently soft for him to lie upon for a considerable length of time. A bath sufficiently large and deep should be nearly filled with water at a temperature of 70°, in which about one pound of mustard is to be stirred. Into this tepid mustard bath, the entire body, with the exception of the head, is to be immersed, and, when the patient is to remain, passing his evacuations into the bath, until faintness, or the necessity of renewing the water, renders it necessary to remove him. He may then, by means of the framework on which he is lying, be raised above the water, without disturbing his prone position. During the process of replenishing and disinfecting the bath, the patient should be covered with warm blankets, and gentle friction applied to the limbs in the course of the venous circulation. As soon as possible the bath is to be repeated, the previous temperature being maintained throughout; the patient remaining in it until such time as indications of the subsidence of the collapse become manifest. The object of the mustard is simply to act as a stimulus to the absorbent powers of the skin, and also to prevent faintness.

During this proceeding, the patient is to drink freely of soda water, in order that, should it be retained by the stomach, carbonic acid may be conveyed to the blood through the veins of that organ.

Of the complications resulting from the reaction from collapse, involving as they do nothing peculiar to the theory of cholera now under consideration, they need no special discussion here.

This theory will afford an explanation of the utility of all mere drugs in a confirmed case of the disease; for, with the arrest of the capillary circulation, the operations of all the organs must cease also. The inutility of administering calomel—*e.g.*, to promote the secretion of bile—will be obvious from our point of view, unless it be contended that this drug is itself capable of being converted into bile.

If the theory now advanced be correct, we shall be reduced to the conclusion that any treatment of cholera, which may have proved successful, has been so in proportion as it has embodied more or less of the plan now advocated; though, as far as we are aware, its partial adoption has had no reference to the principles attempted to be set forth in this thesis.