Notes

ON

THE PATHOLOGY AND TREATMENT
OF CHOLERA.

BY

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THE SYMPTOMS AND PATHOLOGY OF COLLAPSE.

The symptoms of choleraic collapse are so well known as to need no minute description. The most important and characteristic of them are the following. Coldness and blueness of the skin; great diminution of the volume and force of the pulse; shrinking of the features, with a corpse-like sinking of the eye-balls; more or less hurry and difficulty of breathing, with a short dry cough; a peculiar feebleness of the voice; coldness of the tongue and breath; a sensation of burning heat in the epigastric region; great thirst; more or less complete suppression of bile and urine; vomiting and purging of a rice-water fluid; torpor and drowsiness in a variable degree, but without delirium; and, lastly, cramps in the muscles. Most of these symptoms are present in every case of collapse; some, however, may be absent.

What is the pathological explanation of this remarkable train of symptoms? The one great central fact is this, that, during the stage of collapse, the passage of blood through the lungs from the right to the left side of the heart is, in a greater or less degree, impeded. Let us now consider the evidence of there being this impediment to the pulmonary circulation; and let us endeavour to ascertain the probable cause and consequences of this obstruction to the flow of blood. Very conclusive evidence as to the existence of impeded pulmonary circulation during life is afforded by the appearances observed in the heart, blood-vessels, and lungs after death. The *post mortem* appearances within the chest have been described, with more or less minuteness, by several authors; but by no one, I believe, with so much care and accuracy as by Dr. Parkes. (*Researches on the Pathology and Treatment of the Asiatic or Algide Cholera.*)

In the great majority of cases in which death has occurred during the stage of collapse, the right side of the heart and the pulmonary arteries are filled, and sometimes distended, with blood; while the left cavities of the heart are generally empty, or contain only a small quantity of blood; the auricle being partially and the ventricle completely and firmly contracted. The tissue of the lungs is, in most cases, of pale colour, dense in texture, and contains less than the usual amount of blood and air. With respect to the extremely anæmic condition of the lung, when death has occurred during the stage of collapse, there is an entire agreement amongst those authors who have most accurately described the *post mortem* appearances. There is something surprising, as Briquet and Mignet observe (*Traité Critique et Analytique du Cholera Morbus*), in the contrast between the almost constant occurrence of this extremely anæmic condition of the lung, from which scarcely even a few drops of blood flow when the

tissue is cut, and the hyperæmia of most of the other viscera.

There is a remarkable contrast, too, between this anæmia of the lung when death has occurred during collapse, and the great engorgement of the lungs which is almost invariably found when death occurs in the febrile stage which often follows reaction.

Now, it is evident, from the appearances here described that, during the stage of collapse, there is an arrest of blood in the branches of the pulmonary artery before it has reached the pulmonary capillaries. The arrest at this point explains the remarkable anæmia of the texture of the lungs, while the hyperæmia of the lungs after reaction is due to engorgement of the pulmonary capillaries. Before I attempt to explain this remarkable arrest of blood, it may be well to allude briefly to certain phenomena in the living but collapsed patient which afford confirmatory evidence that the pulmonary circulation is greatly impeded. The impeded flow of blood through the lungs resulting, as it must, in a very scanty supply of blood to the arteries, accounts for the character of the pulse in cholera. It accounts, too, for the fact that the pulse has often been observed to increase in power and volume under the influence of venesection, which, by relieving the over-distension of the right cavities of the heart, increases their contractile power. (See Dr. Reid's essay, *On the Effects of Venesection in Renewing and Increasing the Heart's Action under Certain Circumstances.*)

Another appearance which receives explanation from the small stream of blood in the arteries, is that of the shrinking of the integuments, and especially the collapse of the features and the sinking of the eye-balls. The eyes of a patient in deep collapse are often as much sunk as those of a corpse; and the chief cause of this, in the case of both the cholera-patient and the corpse, is the more or less complete emptiness of the branches of the ophthalmic artery.

That the arterial stream during collapse is reduced to a minimum, is proved by the fact that arteries of considerable size have been opened during life without the escape of blood. Magendie states (*Leçons sur le Cholera Morbus*, p. 21) that, on one occasion, he cut across the temporal artery of a patient in collapse and no blood escaped. ("Il ne s'écoula pas une goutte de liquide.") Scot says (*op. cit.*, p. 30) that the temporal artery has often been opened without the escape of blood. He also states that a surgeon, "despairing of other means, cut down upon the brachial artery; but so completely had the circulation failed, that no blood flowed."

While, therefore, the small and feeble pulse, the collapse of the features, and the occasional absence of hæmorrhage from a wounded artery, are explicable on the supposition that the arteries receive a very scanty supply of blood, these phenomena afford evidence confirmatory of that derived from *post mortem* appearances, that during the stage of collapse the passage of blood through the lungs is much impeded.

It appears, therefore, that, during the stage of collapse, 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. What is the cause of this arrest of blood? Some writers have suggested that the blood has been rendered so thick by the loss of serum, that it cannot pass through the minute vessels. This theory is scarcely deserving of a moment's consideration. It is entirely at variance with the fact before referred to, that there is no direct relation between collapse and loss of fluid by the bowels; and, again, with the fact that the state of collapse passes off, while loss of fluid by purging continues, and while,

therefore, the thickening of the blood which, according to this theory, has stopped its passage through the lungs, should be continually increasing. The suddenness with which collapse often occurs, is quite inexplicable by the theory that thickening of the blood through loss of its water is the cause of that condition. In illustration of the sudden occurrence of collapse, I may refer to the following passages in Sir William Burnett's Report on Cholera in the Black Sea Fleet in 1854. "The first to be attacked were men already on the list for diarrhoea, several of whom fell into a state of collapse one after the other; but, about the same time, robust healthy men, who had fallen suddenly down in a state of collapse, began to be brought in from various parts of the ship (the *Bri-tannia*), even from the yards, where they were seized while reefing sails." And the surgeon on board the *Albion* reported that "the attacks in many instances were so sudden, that many men fell as if they had drunk the concentrated poison of the upas-tree." The supporters of this theory of blood-thickening as the cause of collapse would have us believe that, in the course of a few minutes, the blood of these robust men had become so thickened by loss of water as to be incapable of transmission through the minute vessels of the lungs. I shall hereafter show that the thickening of the blood is a *consequence* and not a *cause* of the arrest of blood in the pulmonary arteries.

I believe the true explanation of the arrest of blood in the lungs to be this. The blood contains a poison whose irritant action upon the muscular tissue is shown by the painful cramps which it occasions; the blood thus poisoned excites contraction of the muscular walls of the minute pulmonary arteries, the effect of which is to diminish, and in fatal cases entirely to arrest, the flow of blood through the lungs.

We have seen that the condition of the lungs after death during collapse affords conclusive evidence that the arrest of the blood occurs, not in the capillaries, but in the branches of the pulmonary artery, before the capillaries are reached by the blood. We know that the walls of the arteries are muscular, and that they have the power of contracting upon their contents under the influence of a stimulus, such as cold, electricity, or mechanical irritation. I suppose that no physiologist at the present day would deny that spasm of the arteries is as real a fact as spasm of the muscles.

Many experiments and observations prove that contraction of the muscular walls of the arteries has great influence on the passage of their contents. For instance, it is a well known fact, that the tissues of an animal immediately after death cannot, without a force which endangers the integrity of the vessels, be injected with any of the fluids which are commonly used for that purpose. The coats of the arteries, so long as their vital tonicity remains, contract upon their strange contents, and impede the passage of the injection into the capillaries.

Nearly a century ago, Hales (*Statistical Essays*, 1769) performed some ingenious experiments to demonstrate the power which arteries possess to control the flow of various liquids through them. His experiments were performed on animals recently killed; and he found that, while warm water passed very readily through the arteries, cold water, decoction of bark, and brandy, passed much more slowly.

Some experiments performed by Blake (*Edinburgh Medical and Surgical Journal*, vols. liii, liv, and lv) on living animals bear upon this question. He found that a concentrated solution of a salt of soda, when injected into the jugular vein of a dog, killed the animal in less than a minute. On examination after death, the right side of the heart was found greatly distended, while the left contained only a little black

blood. A few grains of nitrate of silver in solution destroyed life in precisely the same way. The passage of blood through the lungs is arrested, and the animal dies with the right cavities of the heart distended while the left cavities are nearly empty.

The sudden arrest of the flow of blood through the lungs in consequence of the accidental admission of air through a wounded vein in the neck or axilla has some relation to this subject. The entrance of air has usually been indicated by a peculiar gurgling sound in the wound, and the symptoms which rapidly follow are thus described. (Dr. John Reid's *Physiological, Anatomical, and Pathological Researches*, p. 553.) "Speedy occurrence of syncope, which is either preceded by a cry, with the expression, 'I die,' 'I am dead,' 'I suffocate,' or by anxiety and tremblings. Or, without any such precursors, the syncope rapidly reaches such a degree that all consciousness is lost, and the patient falls down; cold sweat breaks out on the forehead; and, in a quarter of an hour, sometimes sooner, sometimes later, he is dead." After death, both in the human subject and in animals that have been the subjects of experiments, the right side of the heart is found to be much distended with frothy blood; and the same mixture of air and blood is usually found in the pulmonary arteries. The left side of the heart is usually empty; but a small quantity of frothy blood is occasionally found in the left cavities and in the aorta. The cause of death in these cases is the distension of the right side of the heart, which results from the impeded transit of frothy blood through the vessels of the lungs. Mr. Erichsen found, by experiments on a dog recently killed, that beaten bullock's blood, mixed with air, required nearly twice the pressure to drive it through the pulmonary vessels, that would suffice to drive unmixed blood through the lungs. (*Edinburgh Medical and Surgical Journal*, vol. lxi.)

I have referred to these experiments in illustration of the general principle: 1, that the movement of blood through the lungs may be quickly arrested by the addition of some foreign ingredient to the blood; and 2, that this arrest is probably due to the power which the arteries possess to contract upon their contents.

The proof that the blood is arrested during the stage of collapse in cholera is, as before stated, partly the anatomical condition of the lungs after death, partly the symptoms observed during life.

About two years since, I had under my care in the hospital a woman (S. B.) who was suffering from dropsy, the result of heart-disease of long standing. On going through the ward one afternoon, I saw her sitting up in bed as well as usual. In less than five minutes after I left her to go into another ward, I was sent for in consequence of her having become suddenly worse. I found her gasping for breath, cold, and pulseless, with a blue and shrunken appearance of the features, exactly resembling the collapse of cholera. I at first thought that she would die in a few minutes; but she rallied in some degree, and lived forty-eight hours, during which time her dropsical legs became rapidly gangrenous. We found, as I had predicted, that, besides old standing disease of the mitral valve, there were firm fibrinous coagula in the branches of the pulmonary artery. The sudden obstruction of the pulmonary arteries by fibrine caused a state of collapse exactly resembling that of cholera. (*Hospital Case-Book*, vol. xix, p. 59.)

The most interesting and conclusive evidence that arrest of blood in the lungs is the true key to the pathology of choleraic collapse, is to be found in the simple yet complete explanation which it affords of all the most striking chemical phenomena of the disease—the imperfect aëration of the blood, the fall of

temperature, the dark and thickened appearance of the blood, and the suppression of bile and urine.

Chemical Consequences of the Obstructed Flow of Blood through the Pulmonary Arteries. It is obvious that the stream of blood from the pulmonary capillaries to the left side of the heart is the channel by which the supply of oxygen is introduced into the system. One necessary consequence, then, of a great diminution in the volume of blood transmitted to the left side of the heart, must be that the supply of oxygen is lessened in a corresponding degree. This position probably will not be disputed by any one who will give the subject a moment's consideration. Nor, again, can it be denied or doubted that certain results must of necessity follow this limited supply of oxygen.

The combustion of those constituents of the blood which are normally subjected to the action of oxygen will be diminished in proportion to the deficiency of that gas; and thence follows simultaneously and of necessity a reduction of temperature, and so scanty a formation of urinary and biliary constituents, that, while the state of collapse continues, the functions of the kidneys and liver are virtually suspended. The blood at the same time has that black, thick, treacly appearance which is not peculiar to the collapse of cholera, but which is common to it with all diseases which are attended with a defective aëration of the blood. The blood has this character during the cold stage of a severe ague fit. Dr. Mackintosh and others, who have bled patients during the cold stage of ague, describe the blood as flowing from the arm at first in a slowly trickling stream, being of a dark colour, and not coagulable. (See Mackintosh's *Practice of Physic*, vol. i, p. 86 *et seq.*) Dr. Dundas Thomson, who published an elaborate paper on the Chemistry of the Blood in Cholera (*Med.-Chir. Trans.*, vol. xxxii, p. 67), 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.

The blood in cholera is black and thick only during the stage of collapse; in other words, during the stage of pulmonary obstruction and defective aëration. This state of the blood bears no relation to the loss of water; it comes on when the loss of water has been very trifling; it passes off rapidly, while loss of water by purging continues unchecked. It is simply a result of defective aëration, just as the thick and smoky flame of a lamp is a result of defective aëration.

The constituents of bile and urine and carbonic acid are all results of oxidation; none of them can be formed without a large supply of oxygen. Suppression of bile and urine during the stage of collapse is a necessary consequence of the limited supply of oxygen which results from the obstruction in the lungs. The amount of carbonic acid expired during collapse is also much diminished. (See, on this point particularly, Twining's *Clinical Illustrations*, etc., 2nd ed., p. 15.) One fact confirmatory of the view that the very scanty formation of bile, urine, and carbonic acid during collapse is a result of the diminished supply of oxygen, is, that *the secretion of milk continues apparently undiminished*. I have myself observed this fact, and it has been mentioned by several authors.* Thus Magendie states that, one of his patients having been delivered of a child a few

days before she was seized with cholera, the secretion of milk continued so abundant through a first and a second collapse, which ended fatally, that it was necessary to empty the breasts, in order to relieve the pain which their distension occasioned. Now, if the other secretions are suppressed on account of the deficiency of water in the blood, why does the secretion of milk continue? Magendie says, because the blood reaches the breasts, and supplies the materials for their secretion, on account of those glands being nearer to the heart than the liver and kidneys, which, being at a greater distance, do not receive the supply of blood necessary for the discharge of their functions! My explanation of this remarkable and instructive fact is simply this. The chief constituents of milk—casein, sugar, oil, and water—may be obtained from the blood without the addition of oxygen. The secretion of milk, therefore, continues during the stage of collapse; while the highly oxygenised secretions are suspended, their essential constituents being formed only in very minute quantities during that stage, on account of the defective supply of oxygen.

Explanation of the great temporary Relief resulting from the Injection of a Hot Saline Solution into the Veins. No theory of collapse can be considered complete which does not give a satisfactory explanation of the great temporary benefit which immediately follows the injection of a hot saline solution into the veins. I have before referred to this subject (see *ante*, p. 251); and I deferred my explanation until I had given some account of the phenomena of collapse.

I have adduced many facts and arguments in proof of the position that the essential cause of collapse is an arrest of blood in the lungs, occasioned by a spasmodic contraction of the muscular walls of the pulmonary arteries. If this be the actual cause of collapse, we might, *a priori*, expect that for a time it would be removed by the injection of a hot fluid into the veins. The temperature of the fluid injected by Dr. Mackintosh varied from 106° to 120°; but he states that "the good effects of the injection were rapid in proportion to the heat of the solution." (*Op. cit.*, vol. i, p. 365.) The hot fluid, rapidly mixing with the blood in the right side of the heart and in the pulmonary artery, would as it were dilute the poisoned blood and render it less irritating, just as diluents render the urine less irritating to an inflamed bladder or urethra. It is probable, however, that the chief action of the injection would be to relax the spasm of the minute arteries by its high temperature.* Thus, the impediment to the circulation being overcome, the blood rapidly flows on to the left side of the heart and the arteries, and the phenomena of collapse pass away with marvellous rapidity. The benefit, however, is of but short duration; for the primary cause of the impeded circulation—namely, the poisoned condition of the blood—being still in operation, and the originally hot solution being cooled down by its diffusion through the entire mass of the circulating blood, the stream of blood through the lungs will soon again be obstructed; and the patient thus passes into a state of collapse as profound as and more hopeless than before.

* Dr. Parkes, who tried the injection in some cases, states that he did not see even the temporary vivifying effects which others describe. (*Op. cit.*, p. 219.) The probable reason of this is, that the temperature of his injection was too low. In one case, he says it did not exceed 98°; while in another it was "tepid". In the other cases, the temperature is not stated. I think, therefore, that Dr. Parkes's failure to do good by a tepid injection is confirmatory of my view, that the high temperature of the injection employed by Dr. Mackintosh and others had more influence than the mere mixture of water with the blood. I believe that the hottest room of the Turkish bath would quickly relax the spasm of the pulmonary arteries; and so, if it did not cause faintness, it might be a real help to recovery.

* See on this point Magendie, *Leçons sur le Cholera Morbus*, 1839, p. 27; Dr. Hutchinson, *History and Observations on Asiatic Cholera in Brooklyn*, New York, in 1854, p. 10; Dr. Robertson, *Edinburgh Monthly Journal*, 1848, p. 393; and Dr. Gairdner, "On the Pathological Anatomy of Cholera", *Edinburgh Monthly Journal*, July 1849.

It appears, therefore, that the hot saline injection^u into the veins, and the operation of venesection, when it rapidly relieves, as it often has done, the symptoms of collapse, have this effect in common, that they facilitate the passage of the blood through the lungs, and thus lessen that embarrassment of the pulmonary circulation which is the essential cause of choleraic collapse. But, whereas the hot injections act by removing the impediment which results from spasmodic contraction of the arteries, venesection acts by relieving over-distension of the right cavities of the heart, and thus increasing the contractile power of their walls.

In concluding this communication, I would implore those pathologists who have hitherto thought that the temporary benefit following injections into the veins affords conclusive evidence that collapse results from loss of water, to consider whether the explanation here offered is not at least as probable, as complete, and as consistent with all the known facts of the problem, as that which is commonly received.

[To be continued.]

Original Communications.

HOT MUSTARD BATHS IN THE COLLAPSE STAGE OF BRITISH CHOLERA.

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IN the BRITISH MEDICAL JOURNAL for October 21, I observe a paper by Dr. Joseph Bullar of Southampton, on the excellent effects attending the employment of hot mustard baths in the collapse stage of cholera; and it might not be uninteresting to relate the effects of substantially the same treatment in a class of cases, the severity of which was nearly equal to that of the true Asiatic cholera. The only difference between his mode of employing the mustard bath and that followed here was, that instead of the actual mustard and water bath, I preferred the "hot blanket mustard bath," as employed and recommended by Dr. Newington in the *Lancet* for June 10th, 1865, in the treatment of insanity and other diseases.

In and around Banff for the past three months—August, September, and October—we have had a very severe epidemic of what is commonly demonstrated British cholera. On reference to our case-book, I find that we have entries of no fewer than 116 cases, of all degrees of severity, during that time. Of the whole number, 32 were children of and under two years of age; 14 were above four and under fifteen years, and the rest were from sixteen to sixty.

First, as regards the infants attacked. The epidemic commenced on August 5th, during which month there were 8 cases; then during September there were 16 cases, and during October up to the 20th, there were 8 cases. The whole of these were quite different from the ordinary forms of infantile diarrhoea; the child seemed to be seized suddenly, or as some of the mothers observed, "just in a second." Purging of dirty water was first noticed, followed immediately by paleness and coldness of the whole surface, the lips being especially pale; the eyes very much sunk, and half open; a marked blue circle around the eyelids; the tongue shrunk, dry, glazed, and of a pale colour, but not furred; breathing almost imperceptible, and the pulse very weak; in some

cases intermittent, and in the very bad ones almost imperceptible. In a few there was vomiting; but in the children this was not such a marked symptom as in the adults, nor one which there was much difficulty in combating. The skin was cold, moist, and clammy, in some more, and in others less so. In the milder cases, the little patients seemed to suffer some pain, or, at all events, uneasiness, though none of them seemed to suffer severe pain in any part; but in the severe cases, the child lay as if in a dead faint, neither crying, moaning, nor betraying any sign of uneasiness whatever.

In one, a child of seven months, all the above symptoms were seen in their aggravated form. The case occurred in the middle of September when there was the greatest number of adult cases. The infant seemed deprived of all consciousness; indeed, I imagined it to be moribund. When applied to the breast, it made no attempt to seize the nipple, and when nourishment was put into its mouth, it made no attempt to swallow. The pulse was imperceptible at the wrist; and I could barely perceive the chest heave in breathing, noticing only a periodic tremulous movement of the intercostal muscles. I ordered enemata of strong beef-tea with milk, brandy, and a minim of tincture of opium immediately, and to be repeated every two hours, leaving out the laudanum afterwards; the infant to be put in a mustard blanket bath from neck to heels, with hot bottles to each side when laid in its crib; also whenever it made an attempt to swallow, to put it to the breast. Next day the report was that heat and colour were restored to the surface by the bath, that the enemata had been retained, but that the child would neither suck nor swallow what was put into its mouth. The collapse was still very great, and unconsciousness not much less, but yet there was some improvement. I ordered the bath to be repeated, and the enemata to be persisted in without the laudanum, unless they should be passed off as soon as given. On the fourth day, the child had so far recovered as to look up and seize the nipple; no more enemata were required, and the subsequent recovery was rapid.

In a second case, almost exactly parallel, the same means were ordered, but unfortunately none of them were available till after several hours had elapsed, and though the child seemed to rally somewhat after the bath and first enema, it gradually sank and died convulsed. Another unfavourable circumstance connected with this case, was that the child had been some twelve or fourteen hours ill before assistance was sought for.

A third bad case, of which that of the first is nearly as exact a description, was likewise lost on account of the ignorance of the nurse (not the mother) of the child, who preferred, as she said, "to allow the child to die in peace without tormenting it." The second and third cases did not look a bit worse than did the first, and had the means employed in the first been as early begun and as energetically persisted in in them, I think both might have been saved.

The other twenty-nine cases of children were milder than the above, and all recovered with only a partial application of the bath, to the legs in some, and as far as the belly and chest in others. Grey powder, with Dover's powder and chalk, seemed the best remedies where there was no vomiting, and the following mixture where that symptom was present:—

℞ Pilulæ hydrargyri gr. xvi; tincturæ opii ℥ iv-vj-viij-xvj; syrapi zingiberis ʒv; mucilaginis acaciæ ad ʒii. Misce: signaque—A teaspoonful every four hours.

Of the remaining 84 cases, 14 were above four and under 15 years of age, and of these 14 cases, that of a girl ten years of age was probably the most severe.