BLOOD CHEMISTRY AND THE GASTROINTESTINAL TRACT

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Much of the progress that has been made in medicine during recent years has been due to the development and clinical application of microchemical methods for the examination of the blood. Through chemical studies of the blood our viewpoint concerning the nature of some of the most serious disturbances of the gastrointestinal tract has been entirely changed and the treatment of such disorders has been revolutionized, with great advantage to the patient. The clinical conditions in the case of which blood chemistry studies are most important are those conditions which are associated with disturbances in motility accompanied usually by an abnormal loss of the gastrointestinal secretions, such as: (1) obstruction of the (a) small intestine, (b) pylorus, and (c) esophagus; (2) vomiting without obstruction; (3) fistula of the upper intestinal tract; (4) prolonged diarrhea from any cause; (5) paralytic ileus; and (6) acute peritonitis.

In all of these various clinical conditions a rather characteristic toxemia is present and in all of them, also, the chemical changes which take place in the blood and urine are of a somewhat similar nature. Intestinal obstruction is a condition which is found frequently and has been intensively studied for many years. Long before it was known that characteristic chemical changes take place in the blood, the toxemia of intestinal obstruction was considered to be due to the absorption of putrifying organic material from the lumen of the obstructed gut. Hartwell and Houget in 1910[1] concluded that dehydration was the most important factor in the toxemia of intestinal obstruction because the life of a dog in the case of which the small intestine had been obstructed experimentally could be prolonged by the administration of fluid in the form of a physiologic saline solution. In 1914 Tileston and Comfort[2] observed a marked increase in the nonprotein nitrogen of the blood in patients suffering from intestinal obstruction. This observation was verified by Whipple and his coworkers[3] in an experimental study of intestinal obstruction. Whipple[4] also found an increased destruction of protein as evidenced by the increase in excretion of nonprotein nitrogen, and concluded that the existing toxemia was due to the absorption of a toxic protein derivative from the wall of the obstructed gut. The other constituents of the blood showed no significant variation from normal.

Further clinical and experimental studies by Haden and Orr[5] showed, in addition to changes in the nitrogenous bodies, very striking variations in the blood chloride and bicarbonate. After experimental obstruction had been brought about in which the changes could be followed from the onset, there was found to be a progressive fall in the blood chlorides. As the chlorides are lost there is usually a rise in the carbon dioxide capacity of the plasma since the sodium which is left behind as a result of the loss of chloride combines with the carbon dioxide which is constantly present, thus increasing the circulating sodium bicarbonate. The level of the bicarbonate is very variable since it is dependent upon several factors other than the release of the sodium from its combination with the chloride. The fall in chloride is certainly partly due, and probably largely due to the mechanical loss through vomiting. At the same time dehydration increases. As this process continues an increase in protein destruction is shown by an increase in the nonprotein nitrogen of the blood and the urine.[6] The mechanical loss of fluids and salts with consequent dehydration may be largely responsible for the clinical picture and laboratory findings in cases of intestinal obstruction, yet it is also possible that the toxemia may be due, in part at least, to the absorption of some toxic body or bodies which destroy tissue protein. The increase in nonprotein nitrogen is certainly not due entirely to a retention from kidney insufficiency. The sugar and other constituents of the blood show little variation from the normal. The marked decrease[6] in the oxygen saturation of the venous blood is due largely to the slowed circulation rate, although it is conceivable that some reducing body may be a factor also.

The characteristic changes in the blood in the presence of intestinal obstruction, then, are (1) dehydration, (2) hypochloremia, (3) alkalosis, (4) increased nonprotein nitrogen, (5) accelerated tissue catabolism with increased nitrogen excretion, and (6) decreased oxygen saturation of the venous blood. In simple intestinal obstruction which has been brought about experimentally, a toxemia may be prevented by supplying sufficient fluid daily from the onset of the obstruction, in the form of physiologic salt solution; when the toxemia is well advanced the condition may be relieved by giving a hypertonic solution.[7] In clinical work often the dehydration has become very marked and the chloride store of the body greatly depleted, before the patient is first seen; in such cases it is wise to give a 3 per cent solution of sodium chloride which should be administered in 10 per cent glucose since food is always necessary. An operation should never be attempted in the case of

a patient in whom an intestinal obstruction is present until a sufficient amount of fluid and salt has been given to overcome the dehydration and hypochloremia.

In the presence of pyloric obstruction[8] the chemical changes are the same as those which are characteristic of intestinal obstruction. Pyloric obstruction develops more slowly than intestinal obstruction and is often allowed to progress for a longer time before operative interference is instituted. The alkalosis and hypochloremia are usually more marked since there is a greater loss of chloride by vomiting. The dehydration, the increase in nonprotein nitrogen, and the decrease in oxygen saturation of the blood, are striking. This condition should be treated in the same way as intestinal obstruction.

Experimental obstruction of the cardia and lower end of the esophagus[9] causes dehydration, an extremely rapid rise in the nonprotein nitrogen of the blood, and a decrease in oxygen saturation, but not much change in the chloride or carbon dioxide combining power of the plasma. The toxemia which may accompany this condition can also be entirely prevented by the proper use of a salt[10] solution. A case of this type is seldom seen clinically.

A fistula[11] [12] in the upper intestinal tract will bring about the blood changes which are characteristic of intestinal and pyloric obstruction. In this case there is an excessive loss of fluid and chloride, the nonprotein nitrogen rises rapidly and dehydration is very marked. The extent of these changes can be gauged only by a chemical study of the blood and the treatment must be based on the findings.

Prolonged vomiting from any cause such as the toxemia of pregnancy[13] will produce the same chain of events. In every case of vomiting the blood should be carefully studied and the treatment which is indicated by the findings should be given. In the case of paralytic ileus definite changes are often found in the blood although not to so marked a degree. Here the use of a hypertonic solution is of value not only for its general effect but especially for its marked effect in stimulating peristalsis.[14]

In the presence of peritonitis[15] the chloride content becomes less. In this case also the nonprotein nitrogen is increased and dehydration develops. For this condition the proper use of salt solution is of the greatest value just as it is in an uncomplicated case of paralytic ileus.

The chemical changes in the body which are the result of diarrhea and vomiting have been studied by Hartmann.[16] In the case

of diarrhea much fluid may be lost, causing a dehydration which may be serious enough to result in renal insufficiency. If there is no vomiting, the blood chemistry problem, as far as the acid-base balance is concerned, is quite different from that which is found in a case of intestinal obstruction. The bicarbonate is decreased and the chloride is increased; therefore the administration of sodium bicarbonate solution instead of sodium chloride solution is indicated.

If both vomiting and diarrhea occur a decrease in bicarbonate is evidenced by the fall in carbon dioxide combining power, and a decrease in the chlorides if the gastric secretions contain free hydrochloric acid. In such conditions, however, often very little hydrochloric acid is secreted so that the fall in bicarbonate is much more marked than is the fall in chloride.[16] Here again the indications for treatment are demonstrated only by a careful study of the blood chemistry.

TABLE I

Clinical Condition	*Dehydration*	*Non-Protein Nitrogen*	*Sodium Chloride*	*Carbon Dioxide Combining Power*	*Treatment Indicated*
Intestinal obstruction	+++	+++	−−−	+++	Hypertonic (1 to 3%) sodium chloride in 10% glucose solution.
Pyloric obstruction	++++	++++	−−−−	++++	Same.
High intestinal fistula	+++	+++	−−−	+++	Same.
Paralytic ileus	+	+	−	0	Hypertonic (3%) sodium chloride solution.
Peritonitis	++	++	−	−	Hypertonic (1 to 3%) sodium chloride in 10% glucose solution.
Diarrhea only	+++	+++	+	−−−	Sodium bicarbonate (5%) intravenously.
Diarrhea and vomiting	+++	+++	0	−−−	Same.
Cardiac obstruction	++++	++++	−	−	Sodium chloride (1%).

In table I the characteristic changes which take place in the presence of the conditions which have been discussed, are summarized, and the preferred treatment is indicated in each case.

SUMMARY

In all cases of disturbances in motility of the gastrointestinal tract of the types described in this paper, the ideal procedure is to determine:

1. The extent of dehydration, which is done by the use of the hematocrit, and by the estimation of the amount of plasma protein.
2. The amount of circulating bicarbonate, which is done by estimating the carbon dioxide combining power of the plasma.
3. The amount of plasma or whole blood chloride.
4. The level of nonprotein nitrogen in the whole blood.

In cases of intestinal and pyloric obstruction the chlorides are usually lost, out of all proportion to other elements, indicating the

administration of a hypertonic solution of sodium chloride, given with glucose preferably. Similar treatment is indicated in excessive vomiting in the absence of obstruction or of diarrhea, and also in cases of paralytic ileus.

Cases of cardiac obstruction in which concentration is evident, without loss of salts, are best treated by the administration of 1 per cent sodium chloride given intravenously.

If dehydration is due to diarrhea only or to diarrhea accompanied by vomiting with little hypochloric acid in the gastric secretions, the blood shows an increase in chloride but a great decrease in sodium bicarbonate. The condition must be treated by the intravenous administration of sodium bicarbonate with or without glucose.

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