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## Diarrhea of infancy

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D I A R R H E A O F I N F A N C Y

With Special

Emphasis on

T r e a t m e n t

R Young.

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## DIARRHEA OF INFANCY

Diarrhea of infancy is one of the most important subjects in the field of pediatrics. Its importance can be shown by the statement that the condition causes almost as many deaths as all other diseases of children combined. Each year, however, the incidence and mortality rate grows less, partially due to the improved living conditions of today and partially to the education of the layman and medical man concerning the disease.

In this paper I do not propose to discuss the whole subject of diarrhea but am limiting it to those forms of the disease caused by the action of microorganisms, primarily or secondarily, in the gastro-intestinal tract. Even in this respect I am limiting the subject. The dysenteries, although a specific infection of the gastro-intestinal tract, are not discussed as it is too broad a subject to be considered here. Also, in the United States, diarrheas as a result of dysentery are not as important as some of the other forms. A diarrhea, likewise, accompanies many infectious diseases of childhood but this type too is excluded as it is only a symptom of a primary disease and not a clinical entity in itself. I am limiting the subject also to the acute forms of diarrhea, mostly.

Primarily then there are three main forms which will fall in this class. They are fermentative, proteolytic

and infectious diarrheas. It is also generally agreed that paraenteral infection, especially of the upper respiratory tract, is a cause of diarrhea. Such forms will usually fall under one of the above types. Improper feeding also eventually may lead to one of the three types as will be shown later in this paper.

Diarrhea has often been considered as only a symptom and not a disease. However, in some instances in childhood it may be rightfully called a clinical entity. The condition as a whole is defined by Hodges(24) as an abnormal condition of the bowel accompanied by frequent evacuations. Snyderman(64) and Holt(25) give a similar definition. The number of stools in a case of diarrhea per day are limited by Urbach(67) to seven or more in the breast fed and three or more in the bottle fed. Ordinarily fermentative diarrhea is considered as that form due to organisms which normally inhabit the intestinal tract and which have a predilection for action upon carbohydrates. In proteolytic diarrhea the organisms have a predilection for protein. The differentiation between fermentative and infectious diarrhea as given by Hunter(28) is that in the former the diarrhea is caused by saprophytic bacteria normally found in the intestinal tract; in the latter it is caused by organisms introduced from without. Hay(23) believes that infectious diarrhea should be reserved for an enteritis due to known pathogens of the dysentery, enteritides or salmonella group. Strong(66) says infectious diarrhea is the result of invasion of the intestinal tract

where the local resistance has been lowered. For the greater part I have adhered to Hunter's definition, but it is apparent that there is a marked difference of opinion as to just what is included in the various types.

Goldberg(17) states that any deviation from normal function is quickly noticeable in the metabolism and nutrition of infants. Due to the sensitivity and immaturity of the gastro-intestinal tract Lynch(40) says diarrhea is especially liable to occur. In explaining Lynch(40) says that the nutritional demands of the infant require the intestinal tract to work at almost functional capacity. So, any impairment or diminution of secretion retards digestion and permits bacterial invasion of the food ingested or migration of organisms normally found in the lower gastro-intestinal tract and causing diarrhea. Toxic products are produced causing increased peristalsis which is an attempt by nature to get rid of the offending material. The summer months and overclothing predispose to diarrhea as the gastric secretions are reduced. Also, the incidence is greater in the artificial fed baby as there is more danger of contamination and variability in the composition of the food. Marriott(43) says that normally the digestive juice of the infant contains less pepsin-renin and hydrochloric acid than in the adult thus predisposing to diarrhea. Their gastric secretions are well adapted to start the digestive processes when breast milk is fed as small curds are formed in the stomach which inhibit bacterial growth, but with cows milk large curds

are formed. The acid condition in the infant fed on breast milk is retained in the upper intestine which also partially accounts for the lessened incidence of diarrhea, as bacterial growth is inhibited.

#### Classification:

There are many different classifications of diarrhea of infancy but the one I have adhered to mostly in this paper is that given by Pounders(58). He divides the diarrheas into four types, mechanical, fermentative, proteolytic and infectious. In the first type is usually considered those diarrheas due to overfeeding, underfeeding, irritating foods and the like. The second type is considered as being due to organisms acting on carbohydrate foods; the third due to their action on protein foods. In what is ordinarily considered as infectious diarrhea there is a definite invasion of the intestinal walls and other body structures. In general B.B.Jones(33) and T.Jones(34) agree with this classification.

Young(74) has a very good classification which is used to some extent in this paper. His five types include:

1. Irritative in origin from faulty feeding.
2. Primary gastrointestinal infection from contaminated food.
3. Due to secondary infection often from the upper respiratory tract, swallowed infected sputum and the like.
4. Symptomatic or toxic, as a symptom of many acute infections.
5. Specific infectious type.

In describing the relation between fermentative and

proteolytic diarrhea Goldberg(17) writes the following. Carbohydrate and protein digestion depends partially on non-pathogenic bacterial flora. Their action is somewhat antagonistic so that when the intestinal flora is normal they maintain a neutrality. When the digestive mechanism is disturbed due to infection, dentition, weather, diet and so forth the bacteria become pathogenic with a resulting excess of one causing either fermentation or putrefaction. The fermentative type Hodges(24) describes as occurring in infants under nine months of age and proteolytic diarrhea in those over nine months.

#### Etiology and Pre-disposing Factors

Lengthy articles have been written on the etiology of infantile diarrhea alone. No definite organism can be ascribed to the condition. However, in each case one or more organisms usually predominate and several such instances will be described. Besides the microorganisms themselves as a causation many other factors are given, which have been found by the various authors to influence their growth and the course of the disease. In a few cases where an epidemic or a series of cases are described the whole course is given rather than being broken up into various divisions, for obvious reasons.

That the body build of an infant may be a factor in diarrhea is probably rarely thought of. However, Bakwin(3) has shown in a study he has made that acute alimentary intox-



ication tends to occur in infants with narrow faces and shoulders. They also have smaller chests and are shorter in stature.

Diarrhea, as has been said before, does not always result because of organisms introduced from the outside. The most important bacteria normally in the gastro-intestinal tract as given by Blandt(5) are *B. bifidus*, *B. lactis aerogenes*, *B. coli*, *B. aerogenes capsulatis*, staphylococci and streptococci. When the acid chyme passes from the stomach to intestine it is practically sterile but when the gastric secretions are decreased as in many infections these organisms grow producing toxic and irritating substances with a resulting inflammation of the intestine and diarrhea.

The factors in relation to diarrhea as found by Daniel (13), in a series of 800 cases, were that most come on at the weaning time due to the ingestion of contaminated and undigestible food. In non breast fed babies food is often given too frequently and in too large amounts to a child normally deficient in acid. The undigested food particles become infected with bacteria which are forced into the intestine where they grow and produce fermentation. Streptococcus and *B. proteus vulgaris* are often the causative factors. Especially where there are large numbers of flies or the child is undernourished, nervous, syphilitic or tuberculous is there a greater susceptibility.

Bruce Young(74) of London has found that slum children are more susceptible to diarrhea due to unhygienic surroundings and that a low gastric acidity, avitaminosis and anemia

facilitate infection in the stomach. It has been found by Yampolsky(73) that most cases occur in the first child as the mother is untrained in the care and feeding of the infant. He also found that a combination of breast and artificial feeding was more harmful than either alone. Marshall(47) stated that the second summer of a child's life is the most dangerous period in relation to diarrhea as there is often less care in the dietary and the child runs about giving more opportunities for contamination and infection. On hot days Hardasty(70) points out the child gets thirsty so drinks large amounts of milk beyond his requirements which is too much for a normally sensitive gastro-intestinal tract and which may be a factor in the causation of diarrhea. He therefore advises giving large amounts of water to satisfy the child's thirst.. When breast fed babies get diarrhea Goldberg(17) believes it may be due to a too concentrated mother's milk and advises the mother to increase her fluid intake and decrease fat consumption and also to put the infant on barley water.

In explaining the role caused by B. coli in the causation of diarrhea Marriott(43) gives the following report. Malnutrition causes a lessened gastric secretion so organisms as B. coli grow in the upper intestine. Likewise cows milk with a higher buffer value than breast milk neutralizes the gastric acidity. Large curds are formed which act as mechanical irritants and enmesh and protect bacteria from the gastric secretions. The explanation of the effects of

overfeeding or unsuitable feedings may be due to unabsorbed bacterial culture media in the intestinal tract rather than to the foods themselves. Irritant foods also cause an increase flow of alkaline mucus which neutralizes the acid and tends to enmesh food particles and bacteria. Bacterial examination in diarrhea cases usually show the B. coli to be present in the upper intestine. They migrate up from the lower intestine due to the disturbance in the upper. The organism produces its effects either by actual invasion of the body or by the production of toxic products in the intestine which when absorbed produce serious symptoms. The organisms may pass thru the intestine mucosa to the lymph or blood stream, blood cultures often being positive. Some strains of B. coli produce histamine or similar substances which may be the offending factor. Histamine experimentally injected in small amounts causes vomiting and diarrhea and a condition resembling shock but when put directly in the intestine doesn't cause these symptoms. The explanation is that detoxification occurs in passage thru the liver and intestinal mucosa, but when the gastro-intestinal tract is damaged as in diarrhea no detoxification can take place.

The gastric secretion is very small in infants according to Neale(55) and any infection greatly diminishes it. The enzymes of lipase and amylase are especially low during the first year which may account for the rapid intolerance to fat and carbohydrate infants have in the presence of infection. Lack of ferments renders the food in the intestine

a good media for putrefactive bacteria which form a very toxic material. Catharrhal and eczematous children and those in which there is a lack of vitamins A and B are especially prone.

Organisms of the Salmonella group may enter by mouth causing a general body reaction with local lesions in the ileum and colon. Marriott(43). Some strains of streptococci may also cause an enteritis. Besides the definitely pathogenic, sporophytic bacteria may decompose food with the production of irritating substances. The gas bacillus infection comes in this class. The causative organism is suggested by Cookson (10) in the Lancet as being Oxidiam albicans.

Stoessiger(65) of Great Britian differs from most American authors in believing that the incidence of infectious diarrhea is less among infants fed on cows than those fed on dried and canned milk. He says the latter contains less vitamin A which may be an important anti-infectious factor and which should offset the balance of less contaminated food as found in canned milk in favor of cows milk.

It is believed by Barbour(2) that one of the main pre-disposing causes of diarrhea in infancy is the eating of ice cream. The reason is that this food contains 250,000 to 2,000,000 bacteria per cubic centimeter while certified milk contains only 10,000.

In the newborn infant there is a certain amount of waste matter in the gastro-intestinal tract, according to Nelson(6), even before the infant takes food. This waste

may be infected by way of the mouth or anus. The organisms are usually spore-bearers of low oxygen tolerance, usually *B. welchi*. These disappear when breast milk is started due to the more favorable environment of other forms of organisms. In diarrheas due to this type the stools are very numerous, highly offensive and cultures in milk usually show stormy fermentation. The temperature is usually 3 to  $3\frac{1}{2}$  degrees above normal. As their growth is hindered by an acid medium sour milk should be given and soon the diarrhea and flatulence that accompanies the condition will clear up. Cases of this type may occur in other than new-born infants. Distension, cramps, temperature and diarrhea are the main symptoms. An investigation by Nelson(56) on the cause of the cases he noted should that the milk received from certain farms, when cultured, produced stormy fermentation. If such contaminated milk forms a large part of the child's diet the equilibrium between the aerobic and anaerobic types of organisms are disturbed with a preponderance of the latter, thus causing the above condition. Most cases will clear up with the use of lactic acid milk. Nelson places much of the blame on pasteurized milk as this process kills the spore formers and allows the milk to become a favorable media for non-spore formers as *B. welchi*. A remedy for the condition is inoculation of the pasteurized milk with lactic acid.

There are a series of cases reported by Jampolis(29) occurring in the Michael Reese Hospital, Chicago, due to *B. mucosus*. The outbreak of cases was insidious at first but after about two months many new cases appeared. The symp-

but after about two months many new cases appeared. The symptoms were dehydration, stupor, icterus, pallor and with a toxic facial expression. Temperatures of 99-103 degrees were recorded. The degree of prostration was out of proportion to the mild diarrhea. In most of the cases the diarrhea developed 4-7 days after birth. The stools averaged six per day and contained mucus but no blood or pus. Laboratory studies showed the red cells and hemoglobin to be slightly below normal and a leucocyte count usually of about 15,000. The mortality was very high in spite of good treatment. An investigation showed that several nurse maids had a positive *B. mucosus* stool culture. In the cases themselves the organism could be isolated from the nasal secretions, stomach, stools and intestinal mucosa. In most cases an hemolytic streptococci increased the severity of the disease. Pathological reports on autopsies showed the mucous membrane of the ilium as red, swollen, granular, covered with reddish grey mucus and infiltrated with leucocytes. In only a few cases was there involvement of the colon or any paraenteral infection.

Amense(1) has described a type of diarrhea occurring during the autumn months in Colorado. The cases were found mostly in infants fed on just milk and water. He believes that the cause is in standing water pools where large amounts of organic material grows during the warm months. Some of the organisms or organic material may be dissolved and after being piped to the city passes through the filters. Such

dissolved organic products may disturb the physiological processes of the infant promoting metabolic storms and arousing otherwise harmless bacteria to action in the gastrointestinal tract.

As normal infants can be fed comparatively large amounts of carbohydrate, protein and fat with no bad results, Marriott(43) believes there must be some other cause of diarrhea, especially in winter, as there is such little pathological change in the intestinal mucosa. Eighty-three per cent of 318 cases reported by Senn, Hartman and Marriott (46) at the St. Louis Childrens Hospital were due to par-enteral infection especially of the upper respiratory tract. In the cases that were undernourished the toxicity and mortality was found to be much higher. The upper respiratory or genito-urinary systems are most usually the offenders as the diarrhea is often coincident with their development. The diarrheas are more severe in cases with rhinopharyngitis or otitis media than from pyelitis or pneumonia probably because of the organisms swallowed causing an irritation to the pharynx and an outpouring of mucus. The strain of organism also is important. Those due to streptococci may give off a very irritating toxin with much diarrhea and vomiting while that due to staphylococci causes less severe symptoms. In cases of pyelitis the vomiting is present to a greater extent than the diarrhea probably due to reflex action causing pylorospasm which prevents passage of organisms from the intestine to the stomach. With insidious

cases mastoid involvement may be a complication due to the low resistance. The B. coli that are often found in these cases of otitis media find their way up the eustachian tube as a result of vomiting or by blood stream infection, a positive blood culture often being found. In most cases of diarrhea there is much bacterial activity in the upper intestinal tract. When conditions are altered in the stomach and intestine bacteria growth is not inhibited. Especially if contaminated food is eaten many organisms are found. If the food reaches the large intestine unabsorbed it is attacked by organisms normally found there and which soon get in the upper intestine causing fermentation and a resulting diarrhea. The most frequent causes of the decreased gastric acidity are malnutrition, excessive external temperatures and foods of high buffer values as cows milk which neutralizes the acid and irritates the pharynx and esophagus causing an outpouring of mucus.

The mechanism of paraenteral infection in relation to diarrhea is explained by Jones(33). The toxins absorbed from the infection interfere with the normal emptying time of the stomach and cuts down the secretion of gastric juice. Vomiting may be due to toxins, retention of food in the stomach or local irritation in the pharynx. Due to the toxins and diminished gastric secretions the digestive juices from the liver, pancreas and small intestine are diminished, consequently the food is not properly digested. The lowered acidity fails to kill the bacteria which therefore multiply



with the formation of toxic products.

It is stated by Warren(68) that many investigators have noticed a relationship between the occurrence of diarrhea and otitis media in infancy. In a series of 50 cases reviewed by him the average age was four months. The chief complaints were diarrhea, vomiting and anorexia. Fifty-eight per cent of the cases on admission showed a purulent otitis media in one or both ears while the remaining developed ear conditions while in the hospital. Forty-four of the patients were undernourished and forty-three artificially fed which indicates that artificial feeding may be a factor in its occurrence. He found also that breast fed babies recovered quicker and with less complications. His cases showed a sudden onset, rapidly progressing with green, watery, mucus stools. Hemoglobin examination indicated a secondary anemia in all tested.

Boehm and Halschow(7) have similar opinions as Marriott and Warren as to the relation of otitis media to diarrhea. In a large number of cases studied at the San Francisco Childrens Agency they have concluded that when the diarrhea does not respond to dietary management a careful examination of the ears should be made and if there is evidence of infection do an early paracentesis. If rapid recovery does not occur there is likely mastoid involvement and in this case mastoidectomy gives the best chances for recovery. They believe pus is often present behind the drum when there is little external evidence, and even without pus,

mastoid involvement cannot be ruled out. Their description of a typical ear finding is an opaque, grey typanum, no bright reflex or redness and very often a slight sagging of the superior posterior canal wall. The organisms found in most of their cases were hemolytic and non-hemolytic streptococci, strep viridens, staphylococci and B. coli. Postmortems usually showed either infantile atrophy or broncho-pneumonia. The gastro-intestinal symptoms were negative.

The following review of an article by Jampolsky(29) is a contradiction to the ideas of Marriott and Warren. He made five conclusions. 1. There is no relation between otitis media and diarrhea. 2. Many children partially weaned at an early age are being fed on canned milks rather than the better substitute, cows milk, resulting in diarrhea and underweight. 3. General weakness and undernourishment is the cause of diarrhea and otitis media in the South. 4. Lack of education of mothers predisposes to diseases and diarrhea. The conclusions made by Wishot in Jampolsky's article are found in the following statements. 1. Many believe infection of the mastoid is the cause of acute intestinal intoxication. 2. The onset of diarrhea is rarely characterized by a cold. 3. The majority of the cases are without clinical evidence of upper respiratory infection at the time they were toxic. 4. Many remained without ear infection during the entire course. 5. Many drums show abnormality just before death due to forcible ejection

thru the eustachian tubes. 6. Bilateral mastoidectomy as a cure was a failure.

The review of an epidemic of diarrhea by Harper(21) in the Medical Journal of Australia also refutes the ideas of Marriott and Warren as regards the relation of otitis media to the cause of diarrhea. In studying out the effect of climate on diarrhea he found that when the mean daily temperature reached 60-63 degrees F. epidemics of diarrhea began. The severity of the epidemic after this mark was reached did not depend on the temperature but found that the epidemics reached their height and began to fall before the mean daily temperature began a downward curve. Especially during the dry months were there more epidemics. He states there are some exceptions to the above conditions, however. Gafeter(15) reports similar results in studying the relation of diarrhea to climate and humidity. The source of infection, Harper believes, is usually from contact with carriers of the colon-typhoid group. As is the case with many authors the incidence of epidemic diarrhea was less in breast fed, well nourished infants and under the care of educated mothers. Discussing the bacteriology of epidemic diarrhea he believes it an infection of the intestinal tract associated with the presence of the colon-typhoid group but the definite cause of which is not known. Of 356 cases reported in 206 the organism did not ferment lactose while in 150 it did. In 137 cases one of the salmonella group was recovered, usually Paratyphoid A&B. Thirty of the epidemic cases came to

autopsy which showed bowel changes ranging from mere exudation into the mucous membrane and lumen with excess of mucus and catarrhal shedding of epithelium to gross erosion of the whole thickness of the mucosa. Invariably was found intense fatty degeneration of the liver.

#### Symptoms and Findings:

Marriott(43) in describing the symptoms of diarrhea says that when due to contamination of food with saprophytic organisms or paraenteral infection there is usually a high external temperature. The stools are increased in number and soft in constituency. They are a yellowish green to bright green in color and if fat has been in the diet contain soft white curds. If sugar is being fed the stools are acid. A little mucus is usually present, while blood is usually absent. If due to a paraenteral infection vomiting often precedes the diarrhea. There is some loss of weight in all types, anorexia, the infants suffer from abdominal pain and they are fretful and restless.

The most severe diarrheas are found in the undernourished or those due to paraenteral infection according to the above author. In these cases the stools may number 15-20 in twenty-four hours, at first being green, acid and containing food elements, later becoming brown, watery, fluid and alkaline. Some blood is occasionally present and many leucocytes are found in them on microscopic examination of the stool. The infant may lose one pound per day. Their features

become sharpened, eyes sunken with a fixed far-away stare, the conjunctiva lose their luster and the skin becomes dry and inelastic. The temperature rises to 105-106 degrees F. If no treatment is given they may lapse into coma or go into convulsions. In these very severe cases the pulse is small, almost imperceptible, rapid and irregular. There is oliguria with a high concentration. Granular casts are usually found and albumin. Respirations instead of the normal abdominal become both costal and abdominal and the accessory muscles are used. It is of the air hunger type and is indicative of acidosis. The blood is thick and viscid. A leucocyte count of 15-20,000 is often present. Chemical analysis of the blood shows the serum protein, non-protein nitrogen and urea nitrogen increased, the blood chlorides usually high and the bicarbonate low.

Moncrieff(51) in describing the clinical features of a acute diarrhea in infants says that they vary with age and severity. In the severe forms the onset is abrupt and in a short time the body becomes wasted with a scaphoid abdomen, hollow eyes, depressed fontanelles and inelastic skin. As the condition becomes worse the external temperature may fall but the rectal temperature remain high. There are later signs of meningism, head retraction and other neurological signs. There is a whine with the eyes held half open, accumulation of secretion, rapid feeble pulse, anuria and air hunger. In older children more common is a gripping abdominal pain, vomiting and diarrhea, furred tongue and with less fever.

He warns against confusing the condition with dysentery.

Several differentiating points between the symptoms of fermentative and infectious diarrhea are given by Nixon(57). In the fermentative type the temperature is higher and declines in four to five days while the temperature is not so high in the infective type but lasts over a longer period. There is little abdominal distension, pain or tenesmus in the fermentative while in the infectious type the abdominal wall is flat and sunken and there is pain and tenseness especially over the colon. The stools of the fermentative type are green, watery, irritating, acid to litmus and contain undigested food while in the infectious type they are alkaline, brown color and non-irritating. Common to both types often are meningeal symptoms as muscular twitching, stupor, coma and convulsions.

The symptoms of diarrhea caused by an upper respiratory infection are reported by Jeons(31) in the Journal of the American Medical Association. There is a marked and rapid loss of weight, fever, diarrhea and intoxication characterized by stupor, pallor, and a greyish hue to the skin. The temperature curve is inconsistent. The diarrhea itself may be delayed but is rarely absent. Usually there are 8-20 mucus, foul smelling stools per day. Before drainage of the site of infection is established fluids are not retained and there is a great loss of weight. The infants often refuse food and there is anorexia. Urine examination may show casts and albumin. The leucocyte count is usually

13-30,000. Diarrhea due to sinusitis is longer in onset, there is a lower fever and most of the symptoms are of less severity. He believes feeding is not important in these cases.

#### Chemistry:

The exact chemistry of conditions that occur in the body as a result of diarrhea are not known. Therefore there are many theories, speculation and contradictions according to the different authors. Probably the reason for this is that the conditions vary greatly according to the resistance of the patient, severity of the infection, complications and so forth.

The three co-authors Hamilton, Kajdi and Meeker(19) made an investigation in 1929 to discover the cause of acidosis in infants as occurs in diarrhea. In their cases studied the carbon di-oxide combining power was used to represent the degree of acidosis present and the amount of base found as the bicarbonate. Their studies showed a total lowering of the fixed base in the serum in most cases. The chlorides were most usually found abnormal next, one-half of cases showing an increase over normal and the other half a decrease. Bicarbonate values were equally divided between normal and low and undetermined acids equally between normal and high. There idea was that acidosis in most cases was due to abnormal proportions between the chlorides and fixed base. Two types of chloride acidosis was described, a higher

base where the chlorides were increased more than the base and a low base where the chloride is decreased not in proportion to the base. In the case of the latter it may be explained by losses from the stomach and intestine of base not bound as chloride and not compensated for by the loss of hydrochloric acid and by vomiting. The loss of base bound as bicarbonate would not result in acidosis if an equivalent amount of hydrochloric acid was lost from the stomach.

It is thought by Pounders(58) that acidosis is brought on in the following manner. The reduction of the urine flow and volume allows the lactate ion to accumulate in the blood. Poor oxidation is present so the sulphate ion and phosphate ions resulting from the oxidation of protein are not properly eliminated by the kidneys. There is therefore an accumulation of these products at the expense of the base bicarbonate with loss of the latter from the stools which brings on acidosis.

The relation of acidosis to kidney function as given by Woods(72) may also be inserted here. The kidney forms acid urine from a neutral or alkaline blood so poor kidney function may lead to an excretion of base and a piling up of acid products.

An alkalemia instead of acidosis has been found in a few cases of diarrhea of infancy. Jarrell(30) gives three causes for this condition. They are: excess bicarbonate, the vomiting of hydrochloric acid and hyperpnea resulting



in a decreased carbonic acid. The symptoms of alkalosis as he states them are headache, lassitude, nausea, vomiting, fever and tetany. Hartman and Smith(22) assign the cause to the retention of base by the kidney depending on the lowered osmotic pressure of the blood depleted of its salts. Maizels and Mc Arthur(52) state the retention of base may be due to an altered threshold because of renal damage and the blood changes showing alkalemia are secondary to the kidney.

Dehydration is one of the main effects of diarrhea and an important part in the treatment is the overcoming of this factor. Hoog and Maples(26) have endeavored to show the effect of the parienteral tract on the acid bases tatus of the blood in dehydration and the loss of base and acid thru the urine and stools. In a series of 14 severe cases of dehydration with diarrhea reviewed by them a routine treatment was given of hypodermoclysis, .9% Sodium Chloride giving 20 c.c. per pound of body weight followed by a 10% solution of dextrose, 10 c.c. per pound of body weight. Fluids were forced and a diet of whole lactic acid or curd protein milk was given. In 13 of the 14 cases treated as the blood bicarbonate rose the chlorides fell. In practically all the phosphorus was not unusually high and the protein concentration in the blood decreased with treatment. The excretion of fixed acid and fixed base in the urine and stools averaged 1:1.37 which is a similar proportion to that found in blood serum. By fixed acids are meant the cations

as chlorine, phosphorus and sulphur and the fixed base, the anions sodium, potassium, calcium and magnesium. Those cases which were accompanied by vomiting showed little difference in the acid-base output from those who did not. The co-workers further state in their article that one of the factors recognized as the cause of acidosis is the excess loss of base in the stools. The lowering of the alkali reserve in the body depends chiefly in the accumulation of acids that fail in excretion thru the kidneys because of the diminished urinary flow. Often children with diarrhea give a history of oliguria often approaching anuria. Thus the acid products which are usually excreted thru the kidneys may accumulate in the blood, causing severe acidosis. The giving of sodium chloride and dextrose often brought about diuresis in the cases studied besides causing a general improvement. In all but one case when the urine volume was increased the acid output was greater. Where the urine output was high the condition improved more rapidly. When sodium chloride is injected much more sodium is retained than chlorine which has a greater tendency to help dehydration. Hoog and Maples (26) do not use sodium bi-carbonate in their treatment as they say it only relieves the acidosis temporarily and unless the dosage is carefully regulated there is danger of kidney damage. This is Schloes(61) idea also. Its use is only indicated when the base of the serum is reduced which one can only tell by blood examination and which takes considerable time. Treatment on this account should not be

postponed too long. Thick oliguria is an indication for more fluids as it helps remove from the body the accumulated acid radicals. It is the idea of Schloss(61) that the main factor in the treatment was to increase the urine flow.

An article by the co-authors Senn, Hartmen and Marriott (46) show that alimentary intoxication or severe diarrhea in infants is secondary to a disturbance of the equilibrium brought about by loss of salts, water and inorganic material from the body. In a series of 318 cases reported at the Childrens Hospital, St. Louis, the average ph was 5.65 and the extremes 4.6-6.5. In dehydration there is a diminution of blood volume with increased viscosity due to protein and cell concentration which interferes with the normal circulation in carrying oxygen and food and relieving carbon di-oxide and waste from the tissues. In such cases the urine secretion almost ceases with a consequent retention of urea and other wastes. The loss of large amounts of gastro-intestinal secretions also helps lead to electrolytic imbalance of body fluids which produces acidosis. The main factors in producing acidosis may be summarized as: greater loss of fixed acid than base, inability of the kidneys to excrete enough fixed acid bound to ammonia and maintain the normal bicarbonate concentration of the blood, and occasional production of organic acids(due to circulatory failure or starvation). The blood plasma may appear to be normal even with a great loss of fixed base and chlorides due to the water loss, which one should bear in mind. When the bicarbonate

is lowered one-fourth, severe acidosis occurs. After the fluids are restored the so called nutritional edema may present itself due to a depletion of the body protein. Oliguria results which impares kidney function which through electrolytic imbalance interferes with the recovery of acidosis or alkalosis.

The loss of fluid in diarrhea, as regarded by most authors, is intercellular. Butler and Mc Kann(8) have tried to show that the intracellular fluid loss is just as important as the intercellular. Dehydration results from the loss, due to vomiting and diarrhea of gastro-intestinal secretions with the withdrawl from the blood plasma of water and materials wsed in the construction of these secretions. The volume and composition of the blood plasma is maintained for some time by the interstitial fluid. When this is depleted the blood volume falls and the electrolytes of the plasma are disturbed. Butler and Mc Kann think intra-cellular fluid is also withdrawn. This contains more potassium instead of sodium as in interstitial fluid and the phosphates replace the chlorides. Thus substances as NaCl used to replace interstitial fluid would not repair the loss of intracellular fluid. Gamble, Blackfan and Hamilton(16) have also shown that loss of interstitial fluid interferes with the intracellular fluid. Even tho this fact is recognized, the author does not advocate the replacement of sodium chloride for potassium phosphate solutions but believes that with further study new methods of treatment will be brought out.

A study has been made by Gerstley(18) to determine the role of carbohydrates in its effect on diarrhea. Additions of carbohydrate were made to breast and cows milk from a low to high % and little change was noted in the difference of progress of the cases. There was only slightly more acid found in the stools of those given high carbohydrate diets. His conclusion was that the role played by carbohydrate in diarrhea is overdrawn although infection does enhance the fermentation of carbohydrate. He concluded also that the nervous tension of the individual as a result of his environment was a large factor in the continuence of diarrhea.

Diagnosis:

The diagnosis of diarrhea in infancy is usually not hard to make and there are very few conditions with which it must be differentiated. After a general diagnosis is made the type of diarrhea must be determined as the treatment varies somewhat. The most important condition to differentiate it from is intussusception, which will be described later.

According to Neale(55) one of the main factors in making the diagnosis is an accurate history including the qualitative and quantitative feedings. If pyrexia or tachycardia is present the diarrhea may be of an infective nature. There should be an adequate search for paraenteral infection especially of the upper respiratory tract. Marriott (43) believes that especially if there is fever and vomiting

preceeding is there a more possibility of a paraenteral infection. He describes also the stools of a simple hunger diarrhea which must not be confused with the stools of the more severe types. They are not large but numerous, dark colored and contain little food remnants. Indiarrrhea from overfeeding little faith can be placed in the character of the stools but more significance is the finding of one food in excess in the diet.

There are several distinct differences between the fermentative and proteolytic types. The main difference in the onset, Jones(34) states, is that in the former it is less abrupt. A very good differentiation between fermentative and proteolytic diarrheas is outlined by McIlwaine as follows:

	Fermentative	Proteolytic
Cause	High sugar feedings Condensed milk Malted foods	High protein feedings High milk protein
Onset	Sudden, loose stools for several days	Longer period of derangement
Stools	Large, watery, green, acid, little odor	Not large, brown, foul, alkaline, not watery
Buttocks	Marked irritation	Little irritation
Anorexia	Not marked	Not marked
Dehydration	More noticeable	Less noticeable
Restlessness	Marked	Child somnulent and comatose
Skin	Loose, in folds	Doughy feel
Weight	Apparent weight loss	Weight loss not so noticeable
Acidosis	Due to loss of fluids	Due to toxemia

In the infectious type of diarrhea the symptoms are more severe most usually. Blood and pus will usually be found in the stools and there is almost always an accompanying tenesmus and abdominal pain. The temperature is also

usually higher in the infectious type. Hunter(28) differentiates between infectious diarrhea and intussusception in that the onset is more acute in the latter with marked abdominal pain and shock. Blood and mucus are homogenously mixed in the stool, all the mucus being blood stained and resembling current jelly. Later there is no fecal matter in the stools. The temperature is not so high and vomiting is more pronounced with involuntary muscle spasm. A tumor like mass may sometimes be found on rectal or abdominal examination.

A study of the cytology of the stools in diarrhea has been made by Zahorsky(75). He regards the finding of more than ten cells per low power field in a stool diluted 2:3 with water as indicative of an infectious process. This method of diagnosis is only rarely resorted to however.

#### Pathology and Pathogenesis, Prognosis:

Considering the severity of some types of diarrhea of infancy very little is found as to pathology in the intestinal mucosa. With very severe infections Jarrell(30) says there may be a superficial inflammation of the gastrointestinal tract, acute inflammation of the kidney and an enlarged, fatty liver. The pathology of fermentative diarrhea as described by Hunter(28) is that of a mild catarrhal inflammation. In infectious diarrhea there is a catarrhal inflammation, ulceration and hyperplasia of Peyer patches and a pseudo-membrane formation.

The main effects of diarrhea on the body are given by Neale(55). There is a loss of the tissue fluids and intestinal secretions and a disturbance of the acis-base balance equilibrium. Toxic bacterial and undigested food products may enter the body and the absorption of undigested protein may cause an anaphylactic phenomena. This may be the explanation of protein sensitization, producing allergic states in children. There is often a degenerative change in the kidney and a toxic effect on the heart causing tachycardia and arrhythmia with damage to the nervous system, often with coma. Especially if dehydration is present are the infants more susceptible to the toxic substances.

Marriott(43)says there are four main effects of diarrhea on the body. They are: diminished absorption of food resulting in partial starvation, loss of water, loss of mineral salts especially fixed bases and toxemia from the intestinal bacteria. With diarrhea the amount and absorption of what is eaten is decreased so that it is insufficient for the needs of the body. Consequently athrepsia often results. As much as 25 to 50 % of the fats are lost by way of the bowel in the form of fatty curds, neutral fats and soaps. A portion of the ingested carbohydrate is also destroyed by bacteria causing acids and carbon dioxide to as much as 50% of the intake. Proteins are the best absorbed the loss being only about 15%. In diarrhea the water absorption is poor which accounts for the watery stools, resulting in dessication of the body or dehydration.



The mortality rate of diarrheal diseases is misleading as seriously sick infants are liable to get a terminal diarrhea and this is given as the cause of death. As with most diseases, however, the prognosis depends upon the severity of the infection and the ability of the patient to overcome and resist it. The successful combating of the complications of malnutrition, dehydration and acidosis very greatly improves the prognosis. The earlier the condition is diagnosed the less likely the danger of encountering complications, is also an important factor. It is the belief of Hunter(28) that with the fermentative type of diarrhea if the infants survive the first three days it will recover while in the infectious types death comes on usually in the second week. The latter has a more tendency to become chronic. Several interesting statistics on the mortality rate of diarrhea are noted by Wilkin(69).

1. One in one-hundred infants under two years of age die of diarrhea.
2. Sixty percent of all cases last less than one week and eighty-five percent less than two weeks.
3. Fifty-four percent develop gastro-intestinal disturbances during the second summer.
4. Thirty-four percent develop gastro-intestinal disturbances during the first summer.

## TREATMENT

## Prophylactic Treatment:

Marriott(43) advises breast feeding as one of the best prophylactic measures in the prevention of diarrhea of infancy for several reasons. The danger of infections organisms entering the gastro-intestinal tract is greatly lessened than in the case of artificial feedings. Breast milk is readily digestible and makes conditions unfavorable for bacterial growth. There is also less danger of starving the infant. If artificial feeding must be used he says that boiled milk is the best in preference to pasteurized, dried milk is better than boiled and evaporated milk is the best. A modified milk is used so as to reduce the size of the curds and neutralize the buffer substances. The size of the curds may be reduced by heating, addition of acid or by dilution. In using the latter method, however, there is some danger in underfeeding. As bacteria do not thrive in acidified milk, heat treated acidified milk would be the best. The ratio of the carbohydrate content and milk should not be below 1:10 or above 1:20. He also emphasizes the importance of sufficient water intake, keeping up the nutrition and the treatment of paraenteral infection.

In Hygiea Marriott(45) gives instructions to the mothers. The babies room should be well ventilated and care should be taken not to overclothe. Plenty of fluids should be given to prevent dehydration. Mothers are advised not to give the baby cake, candy or titbits from the table and the

baby should not be forced to eat. A sponge bath with tepid water can be given in hot weather.

Cleanliness of food preparation and a common sense diet of not too much sugar or fat are two important features advocated by Moncrieff(51) in the prophylaxis of diarrhea in infants. Marshall(47) expressed his idea of how to eradicate severe diarrhea in infants by the following sentence, "If every baby could be born of healthy parents, in a good hygienic environment, breast fed, protected from acute infectious diseases, given clean wholesome food, kept cool during the warm months, given plenty of water and if the mildest diarrhea was treated as if it was the severest, the condition as we now see it would be history."

In an article devoted entirely to the prophylactic treatment of diarrhea, Crumbley(12) advises feeding the child whenever it is hungry and not by a definite schedule. The mother herself should eat a well balanced diet and when she first notices looseness of the stools fruits and juices, vegetables, soups, fresh meats and meat broths should be withdrawn from the diet. He asserts that milk is not particularly harmful until the total count is around 1,000,000 per c.c. The mother should be advised not to add more than one new food to the diet at a time and then in very small amounts at first. All food should reach the stomach in a finely divided state. Carter(9) in the Lancet recommends that the mothers wash their hands thoroughly after handling soiled napkins and before handling food to avoid infection.

Lourie(39) brings up a new idea in the prophylactic treatment when he says that dirty "comforters" may be a source of infection. All bed clothes and other clothes warmed by the body should be kept clean to avoid infection by this route. Condensed milk is advised against as it contains too much carbohydrate(55%) and is deficient in protein and fat. A well balanced, mixed diet is best after the ninth month. Lourie is the only one I have found in the literature who believes that raw milk should be used in preference to pasteurized or boiled milk. His cases made much more progress and were more resistant to infection when fed on raw milk. The argument he puts forth is that partial sterilization kills harmless saprophytic organisms and allows harmful anaerobic organisms to multiply. T.S.Jones and R.B.Little (35) in studying the bactericidal properties of cows milk also state, in this respect, that the power to inhibit the growth of streptococcus is destroyed in cows milk by boiling or pasteurization.

#### General Treatment:

The general principles of treatment as given by Marriott(42) are:

1. Recognition and suitable treatment of paraenteral infection.
2. Rest of the gastro-intestinal tract.
3. Giving of food adapted to a limited digestive capacity.
4. Restoration and maintenance of the fluid balance.
5. " " " " " " mineral "
6. Blood transfusion in severe cases.

Marriott in most of

Marriott in most of his writings seems to be partial to that phase of treatment dealing with the removal of focus of infection. In all cases he advises looking at the ears first, as they are the most likely cause. In a series of cases reported by Warren(68) he incised the drums of 37, 6 ruptured spontaneously and in 6 mastoidectomy was performed. Cultures usually showed staphylococci. His cases showed a rapid loss of weight during the first three or four days after which a gradual favorable change took place over several weeks. His conclusions were that myringotomy favorably influenced the course of the disease while mastoidectomy usually proved fatal.

If no pathology is found in the ears Marriott advises an immediate period of starvation, the length of the period depending on the age, nutritional condition, severity of the diarrhea and the child's reaction to starvation. Reed(60) quotes Finkelstein as saying this should not be longer than 12-18 hours. Only water is given during the starvation period by Marriott. Following this gastro-intestinal rest period a type of diet is given which is non-irritating, readily digestible, provides a poor culture media for bacteria and brings about normal chemical conditions of the gastrointestinal tract. A food of low fat content is desirable as too much fat delays the emptying time of the stomach and predisposes to vomiting. Skim or partially skimmed milk serves this purpose. The milk is treated to reduce the size of the curds by heat or acidification or by the use of

dried or evaporated milk. The milk should be sterile and as carbohydrate furnishes a good culture media for bacteria only moderate amounts should be given and this in a form that is readily digestible and absorbable and also easily fermented as milk sugar or cane sugar. A food which aptly meets the above requirements is protein milk.

Enough fluid must be given to maintain the water balance. It is better to give small amounts of water frequently rather than large amounts at less frequent intervals, as the total intake will be more. If the infant won't take fluid by mouth, paraenteral means must be used. Intravenous administration should be used in acute cases of anhydremia to restore quickly a depleted blood volume. Larger amounts may be injected by the subcutaneous or intraperitoneal methods. For intravenous use glucose 10-15% is best used and for subcutaneous or intraperitoneal use saline or Ringers solution. The salt solutions restore the mineral balance as does also the food taken. In very severe cases the giving of citrated whole blood improves the circulation, absorption and digestion and provides material for the damaged body cells that they may maintain a better resistance to the infection.

The general principles of treatment as summed up by Moncrieff(51) are:

- v 1. Treat the child as a whole and don't pay too much attention to the stools.
2. Good nursing, with care to the mouth, buttocks, warmth, good ventilation and a sunny room.

3. Starvation
4. Infectious precautions

In some respects he differs from the general treatment prescribed by Marriott. He advocated a starvation period of from 12-24 hours giving much fluid at this time in the form of sodium chloride, drams one-half to a pint of water, when awake. Subcutaneous sodium chloride 10-15 c.c. per pound of body weight, is injected in both flanks. This may be repeated in six hours if it is absorbed. One pint at 100 degrees F. may also be injected intraperitoneally. He does not advocate the intravenous method except in rare cases as the veins are too collapsed so as to make entry difficult and sometimes only possible in the hands of an expert. Blood transfusions are absolutely contraindicated as the blood is already too concentrated and there is a danger of death from heart failure or uremia due to the excess demands made on the heart and kidney. An initial cathartic of one or more drams of castor oil is indicated to eliminate the toxins in the bowel. After starvation and the acute phase is over start on diluted breast milk if breast fed and otherwise on a low fat, non-fermentable sugar, high protein mixture gradually. As the gastric acidity is lowered use skim milk (dried) with dextri-maltose or lactic acid. Such a mixture is prepared by using one pint of boiled skim milk, one-half pint water and adding sixty minims of B.P. lactic acid while stirring well. Before putting the child on full cream a half-dram dried milk

may be used. Vitamins A and B are indicated in concentrated forms.

Hartman, Senn and Marriott(46) in an article in the Journal of Pediatrics summarize their treatment under five headings. 1. Restriction of food. 2. Isotonic solution of sodium r-lactate to relieve acidosis and partially to relieve the dehydration. Ten c.c. of a molar solution of sodium r-lactate is used per pound of body weight diluted with five volumes of distilled water. One-half of the solution is injected intravenously and one-half subcutaneously and intraperitoneally. 3. Administration of buffer salts paraenterally (Hartman's solution, described later) which prevents the recurrence of acidosis. 4. Administration of dextrose solution to furnish fuel, relieve ketosis and to reestablish the glycogen reserve. Use 6% subcutaneously or with buffer salts 10% may be used intravenously. Three c.c. is given per kilo per hour. A rapid injection of glucose should be avoided as this causes glycosuria, embarrassed circulation and edema, temperature and chills. 5. Citrated whole blood when the fluid balance is restored.

The three authors say that transfusions establishes the plasma protein, reduces nutritional edema, restores the chemical balance and causes the red cells to function normally which prevents anemia after the dehydration is overcome. If the diarrhea continues a physiological buffer solution should be given two or three times per day by the intravenous drip method. During the starvation period



acidified or buffered water helps prevent the growth of intestinal organisms. Use lactic acid in 100 millimolar strength and sodium lactate 50 millimolar or Hartman's solution which is:

Lactic Acid U.S.P.		15
Sodium Hydroxide	10%	20
Aqua distillata	q.s.	100

M&Sig: Dilute 1:10 with water and sweeten with saccharine.

After the starvation period, dried protein milk with the above buffer solution and gradually adding Karo or dextrin-maltose to the diet. When the patient is getting 6% carbohydrate and is getting the required amounts of food sufficient for his age, evaporated milk diluted with equal volumes of buffer solution or 1% lactic acid and with the addition of 5-7% carbohydrate may be substituted for the protein milk mixture. More calories are given by this means. J.B.Young(4) says never to feed the patient while the stools are still liquid, but give much fluid. Even the greatly dehydrated a starvation period of six hours or longer is necessary. The first step in active treatment when the patient is vomiting is gastric lavage. A large red rubber catheter may be used washing out the mucous and curds from the stomach till clear with warm water. Sodium bicarbonate, drams one to the pint, is also a good solution. After lavage the vomiting will usually stop and the infant thereafter can retain water. Colon lavage may be performed with a soft rubber catheter connected with a funnel. The hips should be raised and the water column should not have

a drop of over two feet. This may be repeated twice a day. Fluid dehydration is combated by sterile water every half hour after feedings in a little bottle or spoon. If the subcutaneous method is used many puncture sites should be made and this is very painful.

Young(4) believes the intraperitoneal route and the fluid is absorbed rapidly. There is no danger in this method if there is no abdominal distension and the bladder is empty. The site for injection is one inch below and to the right of the umbilicus. Interdermal anaesthesia should be used first then a large 10-20 c.c. syringe with needle replacing it. One ounce more than the age of the child in months should be injected. Collodion is spread over the puncture site afterwards. Care must be taken not to distend the peritoneal cavity with fluid as this may cause circulatory failure of hypostatis pneumonia.

After the starvation period he advocates the use of dilute lactic acid milk. For the first forty-eight hours feed every two hours starting with one-half ounce to the feeding and gradually increasing two drams at a time. Dextrin-maltose grains ten may be added to each feeding and thirty grains to each feeding by the fourth day. The feeding interval on the fourth day is also increasee to three hours, two ounces for each. Add fat very gradually. Between each feed kalin may be given by mouth.

Instead of plain water during the starvation period barley water or weak tea is advocated by Lynch(40). He

also only gives a cathartic when the case is seen early as otherwise it only causes too much irritation. Fluids are given by mouth when possible but if dehydration is too great Ringer's solution, 100 to 300 c.c. is given intraperitoneally. The subcutaneous method is too painful and apt to cause shock. Although intravenous fluids are hardest to give, he thinks this way is best as there is little danger of flooding the system and it is continuous. Where the diarrhea causes the buttocks to become excoriated a high protein, non-acid skim milk diet is best. Three to five ounces of a mixture composed of skim milk ounces ten, well packed casesc ounces four, water ounces twenty, saccarine ~~ounce~~<sup>grain</sup> two and given every three to four hours after starvation is a good formula. After two or three days dextri-maltose two tablespoons may be added gradually increasing to six. A diarrhea case with a proteolytic stool should be fed a carbohydrate diet of thin gruel for the first day or so after starvation. Such a gruel may be made from eight tablespoons of wheat flour and thirty ounces of water, adding salt and saccarine. As the stools get less foul either of the following mixtures can be used. Portions of a mixture of three to six ounces of protein milk, six tablespoons of dextri-maltose, thirty ounces of water and twelve tablespoons of powdered lactic acid milk or twenty-four ounces of skim milk, six tablespoons of dextri-maltose and six ounces of water. Where acid mixtures are preferred, regardless of the type of stool use either of the following: twelve

tablespoons of powdered protein or powdered lactic acid milk and thirty ounces of water giving three to six ounces every three to four hours or twenty-four ounces of buttermilk and six ounces of water giving three to six ounces every three to four hours. Carbohydrates are added in a day or so in the form of dextrin-maltose.

In the last few years many articles have been written on the raw apple diet in the treatment of diarrhea of infancy. This form of treatment has been long known in Germany. E. Moro(23) of that country recommends 500-1500 grams of grated raw apple for two days depending upon the age of the child. Wolf(71) found it was often necessary to continue the diet as long as four days.

Bernberg(4) described his method of treatment as follows. The diet consists of scraped, raw apples, completely ripe and mellow. After the apples are peeled and cored they are scraped with a knife or rubbed on a grater. One to four tablespoons are given every two hours for forty-eight hours. If the child craves liquids, weak black tea in small amounts are used. Banana pulp can be added if the child objects to the raw apple diet alone. After two days the patient is put on a transitional diet containing no milk or vegetables. An example is, 7:30 A.M. cooked cereal, toast and one cup cocoa; 12:00 Noon, soup with rice, potato gruel, scraped beef and toast; 3:00 P.M., toast and tea; 6:00 P.M., cereal or cottage cheese, toast, banana and cocoa. A regular diet is returned to gradually adding milk, vegetables and fruit last.

Several theories have been put forth as to the interpretation of the results obtained from the raw apple diet. Moro(53) says it provides a non-irritating filling, tranquilizes the motor apparatus of the intestine and acts as a mechanical purificant and absorptive. The tannic acid protects the surface from chemical, mechanical and bacterial irritants. Kuhlbrugge(37) attributes the results to the fruity acid present. Malgoth(42) claims it is due to the pectin in the juice and due to the colloidal and buffer action which absorbs endogenous and exogenous poisons and regulates the H ion concentration. The calcium and magnesium in it inhibits peristalsis and the cellulose forms a favorable media for the bacteria in the intestine.

In 1927 a series of tests with bacteriophage was tried by Krenz(36) on a group of cases with diarrhea but nothing definite resulted from the investigation. In Australia, Harper(21) tried the use of bacteriophage in the treatment of epidemic diarrhea but with unsatisfactory results. He therefore resorts to glucose 5% and orange juice by mouth and intraperitoneal saline. Food is withheld until the toxic symptoms are overcome, later adding food of low fat value but fairly high in carbohydrates. As the amount of glucose is decreased intravenously more carbohydrate is added to the feedings.

Giving only of such solutions as are absorbed in the upper part of the intestinal tract are advocated by Neale(55) in the British Medical Journal. The milk is replaced by

water, physiological saline, weak tea, Ringer's solution and 2% glucose all of which are absorbed in the upper part of the gastrointestinal tract, thus resting the lower part. Ten c.c. of normal saline can be given per pound of body weight twice a day. In expert hands he believes it is a simple procedure to inject 5% glucose into the superior longitudinal sinus at the anterior fontanelle or the internal saphenous vein of the leg is sometimes used. All glucose solutions should be freshly made. When indicated, 15 c.c. of blood per pound of body weight may be injected into the longitudinal sinus. The blood must be allowed to enter very slowly for fear of overdilation of the right heart. If gaseous distension is present use rectal lavage which also promotes comfort. The infant should be kept in a warm room of average humidity as the body temperature is easily affected. In cases where the thermo-regulatory mechanism is out of order an incubator of the "Hess" type described by Hess of Chicago is best used. Where cyanosis is present Blondt (5) recommends an oxygen tent.

Mariott(44) in the Southern Medical Journal says the treatment of diarrhea should be directed toward four main objects.

1. Correction of abnormal conditions in the gastrointestinal tract.
2. Giving of food within the digestive and absorptive limits of an impaired gastro-intestinal tract.
3. Food should be free from bacteria.
4. Any abnormal conditions should be corrected.

The decreased gastric and duodenal acidity can be corrected

by food which won't neutralize the acids such as protein milk or lactic acid milk, or Hartman's solution. This latter solution is acid and remains so even in the presence of much alkali or when mixed with whole milk or protein milk.

In beginning treatment Marriott used this buffered solution instead of water. A moderate amount of Karo or dextri-maltose can be safely added as the sugar is not acted upon by the bacteria in such a strong acid, also 5-7% sugar is absorbed as fast as the acid. After a few of these feedings protein milk is started, being brought up to the customary value by Hartman's solution rather than water. Unsweetened evaporated milk and buffered solution in the proportion of 2-3 also forms a good mixture. To either of these two types of feedings a small amount of carbohydrate may be added. There is no danger in feeding these indefinitely as buffered solution metabolized in the body leaves excess base to correct any existing acidosis. Soon the bacterial flora of the intestine decreases and the diarrhea stops. These mixtures are effective whether the infection is primarily enteral or paraenteral except that it will have to be kept up for a longer time in the presence of the latter. In those diarrheas due to a paraenteral infection the patients are usually undernourished so often local treatment of the infection does not bring remarkable results. Operative wounds heal slowly in these cases and the mortality rate is high.

The type of diarrhea should always be determined first, according to DeHart(14) before treatment is instituted. If the case shows no dehydration and is of lesser severity a cathartic of castor oil can be given. When food is started it should be of that type directed toward changing the culture media of the intestines. In the fermentative type the organisms thrive on carbohydrates and the excessive fermentation hinders fat digestion so feed a high protein diet as protein milk and in two or three days a little Karo can be added. The protein milk is then gradually substituted for skim milk. In the infective type protein milk is contraindicated so give a high carbohydrate diet with low protein and fat. Begin with cereal waters and cane sugar, replacing gradually with boiled skim then boiled whole milk. Complications frequently met with are acidosis and suppression of urine. With severe cases characterized by a pinched skin, ashen facies, depressed fontanelles, sunken eyes, wrinkled skin, toxemia, vomiting, oliguria and irregular respirations fluids should be given in large quantities. If vomiting and diarrhea are present fluids per mouth or bowel are ineffective so give 200-300 c.c. of normal saline subcutaneously with a fifty c.c. Leuer syringe and repeat in six to eight hours.

Contrary to most authors Nixon(57) recommends calomel as the purge of choice. Contraindications to its use are profuse, watery stools, vomiting and symptoms of collapse. If these symptoms are present apply external heat, give



strophanthus, brandy or morphine by hypodermic. If convulsions are present, hot mustard baths and afterwards high colonic irrigations, or with many convulsions use chloroform or sodium amytal. Where there is pain and tenesmus and the mucus in the stools is blood streaked laudinum and starch water can be used rectally. Hot turpentine stupes over the abdomen relieve pain and distension. After the purge, fluids in the form of cereal or sugar water before feedings in the breast fed and the nursing period reduced one or two minutes. Bottle fed babies are best fed with protein milk and cereal water in  $\frac{1}{2}$  dilution and gradually adding  $\frac{1}{2}$  milk and finally whole. He suggests increasing the feedings one-half ounce at every second feeding on the second day and every feeding on the third day. It should be always born in mind that nourishing food must be given to prevent inanition.

Strong(66) divides the treatment of diarrhea of infancy under four divisions, acidosis, dehydration, elimination and feeding. Under the first heading he advocates the giving of a mild cathartic if seen within the first twenty-four hours. Castor oil can be given if there is no vomiting. Some authors give syrup of rhubarb, magnesia mixtures or salines. An example is

Sodium Sulphate	gr. xx
Sodium Bi-carbonate	gr. xx
Sodium Citrate	gr. x
Glycerine	m. xx

The above perscription is put in anisi water and a portion is given every hour until the stools are watery. Such a

mixture also supplies alkalies. The continued use of castor oil or calomel, irritates the intestinal mucosa and is harmful. Mustard baths or packs favor elimination thru the skin, and is also good for high temperature or nervousness which might otherwise terminate in a convulsion.

Under acidosis Strong says the condition is often due to starvation, so food should not be withheld too long. Improvement is always noted when the water equilibrium is established again. This can be done by the use of sodium bicarbonate or sodium citrate by mouth or better by injecting 90 grains of dextrose in 120 c.c. of freshly distilled water into the longitudinal sinus, in younger children. In older children the external jugular or median basalic vein is used. The intra-sinus method for administration of fluid is accessible and convenient but it should be used with great caution for fear of infection being introduced. If vomiting is persistent then wash the stomach with 1-2% sodium bi-carbonate, normal salt or Ringer's solution and allow 150-200 c.c. to remain in the stomach.

He overcomes dehydration by subcutaneous saline or Ringer's solution given between the scapulae, or over the anterior chest or abdomen. By putting a catheter through the nose into the stomach 100-200 c.c. of fluid can be retained in this way. Salines by rectal infusion is of little aid as the rectal sphincter soon relaxes and so the fluid is not retained. This combined with the diarrhea present creates a slimy, green swamp for the patient to lie in.

Intraperitoneal saline can be introduced by using a blunt lumbar puncture needle. The technique follows which varies in some respects from that described by Young(74). The skin is prepared with iodine and alcohol. With the patient in recumbency with the hands and arms tied the skin and subcutaneous tissue is picked up between the thumb and index finger and the needle, pointing upward is inserted at an oblique angle at a point just below the umbilicus in the midline. The peritoneum is penetrated and the fluid allowed to flow in by gravity until the abdomen is distended. It should be given at a temperature not below that of the body, nor too fast for fear of embarrassing the respiratory or circulatory systems. The wound is covered with a sterile dressing and the operation repeated if necessary in 12-24 hours. Injections may also be made external to the lateral rectis muscle or between the costal margin and the left anterior superior spine of the ilium. For small infants 100-200c.c is used and for larger 300-400 c.c.

In the feeding, the author (Strong,66) advises, as most authorities do, the use of protein milk after the period of starvation. The initial amount should be one to one and one-half ounces six to ten times per day and gradually increased to four ounces per pound of body weight. The total amount, however, should not exceed thirtytwo ounces. Dextrin-maltose or Karo are the best carbohydrates to use and either in 1% dilutions at first and later increasing to 7%. The protein milk is substituted after several weeks to whole

milk. The use of barley water and rice water is discouraged as they do not contain sufficient calories to overcome starvation. When the change is made to whole milk, calcium casienate is best added.

In cases where the temperature is very high it may be reduced by the use of cool soda enemas, sponging and ice bags to the head, as stated by Amense(1). When food is rejected after 12-24 hours he uses a continuous nasal drip for twelve hours or more and cautiously returns to food again. When transfusions are not available whole blood from a suitable donor can be injected intramuscularly. All laxatives are contraindicated. If acidosis is present very good results are obtained by one to three units of insulin

Most authors agree that the ideal food in the treatment of diarrhea of infancy is protein milk. They vary only as to the amounts and proportions used. Hodges(24) uses one-third protein milk and two-thirds water. Lactic acid milk is used in the same proportions. The indications he has for giving protein milk mixtures are, intestinal indigestion, fermentative diarrhea of a severe type and in cases where the carbohydrate metabolism is upset. Indications for carbohydrate feedings are putrefactive diarrheas, mild infectious diarrheas, dehydration and acidosis. Blau(6) emphasizes the fact that feeding is the most important principle in treatment and although protein milk is the best food to use in diarrhea, carbohydrate should be substituted as soon as possible in order to avoid starvation.

Protein milk contains only one-half the number of calories as cows milk so an easily assimilated carbohydrate should be added.

Tenesmus is often a symptom of the severe diarrheas. Wilson(70) believes this is due to the acidity of the colon contents so advocates the giving of high enemas of 10% sodium bicarbonate. This should not be repeated more than once in twenty-four hours. Peristalsis can be minimized if water and other fluids are given at body temperature. In infectious diarrhea organisms in the intestine use carbohydrates as food but produce no toxins as is the case where proteins are acted upon. So milk sugar should be used in 5% dilutions, frequently repeated. After a day or so cereals can be started and in a week gradually replace the protein. Potatoes may cause relapses due to the peculiar character of the starch capsule so give this food sparingly. Blood transfusions and salines are indicated in cases where the patient breathes very deeply and is very nervous. Wilson warns of the danger of using any other solution but saline intraperitoneally.

Where vomiting is present the initial purge can be brought on best by the use of calomel, grains one-tenth to one-fifth every one-half hour for ten doses and followed in two or three hours by two or three drams of milk of magnesia. The above use of calomel is put forth by Pounders(58)(59) and in this respect he probably stands alone. He makes definite distinction in his treatment of the various types

of diarrheas as, fermentative, proteolytic, infectious and mechanical. For the first type the main standby is, of course, protein milk; for the second type various forms of carbohydrate as Karo and dextri-maltose. In the infectious type the organisms grow on either carbohydrate or protein but as before stated toxic products are formed only on a protein media. Therefore, carbohydrate is indicated in the form of Karo, dextri-maltose or lactose. Such articles of food as cream of wheat may be added early and later add toast, crackers and pure stick candy. In severe cases where diarrhea, oliguria and dehydration have persisted for a long time, he believes saline increases the acidosis so uses 6% glucose. The glucose should be autoclaved, kept dry and dissolved in double distilled water before using. Twenty c.c. may be given per kilo. For the infectious type colonic irrigations of 1% boric acid do good while for the fermentative type use 5% sodium bicarbonate. Occasionally when blood is present in the bowel movements an astringent is needed. Snyderman(64) uses a .5% tannic acid solution at 100 degrees faranheit. This is allowed to run in and out of the bowel once a day.

Many authors are now using insulin and glucose together in the treatment of severe diarrheas of infancy. The rationale of this treatment as explained by Woods(72) is that the oxidation of carbohydrate burns up the incompletely oxidized acids in the system. Where acidosis is present or potentially so and there is a lag in the response of the

patient, insulin is added which speeds up the oxidation process. When glucose is used with insulin a 10% solution is best otherwise only a 5% solution can be used. One fiftieth of the body weight is used at each injection. Epinephrine should be kept handy in case a hypoglycemic reaction occurs. Enough alkalies are perscribed in the form of sodium bi-carbonate until the urine becomes alkaline. This also helps overcome the acidotic changes. When indicated, blood transfusions build up the blood content, supply fresh antibodies and supplies the necessary salts and hemoglobin to help overcome the infection. Citric acid milk is preferred over lactic acid milk to correct a deficient gastric acidity. It tastes better, has a vitamin content and has a stimulating power on the oxidation processes within the body. It is made simply by adding lemon juice to milk. Jones(33) states that lemon and orange juice is harmless even to very small infants.

Often times when water is given a child with severe diarrhea it will ve vomited. This does no harm, however, according to Jarrell(30) as even tho it is vomited it helps wash out the stomach and later it may be retained. His indication for a cathartic is intestinal distension, fever and foul stools. The stomach can be washed out with a sodium bicarbonate solution(drams one to the pint) and afterwards give a mixture containing bismuth subnitrate and tincture opium camphorata in a vehicle of lactate of pepsin.

If vomiting is present Lourée(39) gives repeated doses of calomel(one-fifteenth to one-sixth) and which also allows the administration of fluids. For fluids 5% glucose is better than water as it is retained longer in the tissues. Three don't's mark the close of his article in relation to diarrhea. They are: don't give small amounts of food too soon as the diarrhea will continue, don't fail to give sufficient fluids and don't produce athrepsia after having cured the anhydremia.

In diarrhea due to paraenteral infection, Masters (48) believes the diet should not be changed, that is if is proper. Contrary to some pediatricians he says protein milk should be always used in diarrhea, with the addition of sugar as dextri-maltose or Karo, not less than one ounce to the quart. He also advises giving glucose intraperitoneally which seems to be out of common accord. If the child is not getting enough food 400-500 c.c. can be given every six to eight hours. At the close of Master's article in the Texas Medical Journal, Dr. A.S. Mitchell of Houston, Texas mentions the fact that glucose had best not be given intraperitoneally as it causes too much distension. Dr. G.B. McFarland also in the discussion, states that the feedings should be more conservative than the author states, and that in diarrhea due to paraenteral infection it is usually of the putrefactive type.

Hunter(28) gives fluids to his patients in the form of soda mint water, drams one every five minutes, (no more



and no less). The fluid intake is also increased by giving high saline irrigations per bowel. If the intrasinus method is used to give fluids it is best to use a guard. Cultures of lactic acid bacillus or B. acidophilus may be helpful in changing the flora of the intestinal tract.

Diarrhea due to excessive fermentation is often accompanied by excoriated buttocks. Mc Ilwaine(49) uses zinc oxide ointment and tells the mother to keep the buttocks as dry as possible. The treatment for this condition as prescribed by Jones(34) is to separate the buttocks so as to allow the air to come into contact with the inflamed parts. If this doesn't clear them up apply calamine lotion or Lassar's paste. In his treatment of proteolytic diarrhea, barley water with dextri-maltose and lactose added is used as this will change the flora of the intestines in 24-48 hours. If tenesmus is present as is often the case in infectious diarrhea, salt and soda enemas can be tried and if this fails use either tannic acid drams one to the quart, starch water and laudinum or a cocaine suppository( $\frac{1}{4}$  grain for a three year old child). As is also thought by Hunter(28) and Mc Ilwaine(49) bacterial cultures and tablets may be of some value.

Mulherin(54) advocates clean cows milk but does not say it is better than pasteurized or boiled milk as does Lourie(39). Four to eight tablespoons are added to the amount used in 24 hours for the constipating effect. The calcium caseinate combines with the fats of the cows milk

forming soapy stools which constipate. The casein is dissolved in an equal amount of water, added to the milk and boiled for one minute. Instead of barley water to furnish protein, crackers and zweiback is substituted. In the discussion of Mulherin's article Dr. R.C.Maddox of Rome, Georgia advocates the intraperitoneal transfusion of citrated blood. His reasons are that it furnishes liquid and food, is not as hard to give as intravenous transfusions and non-matched blood can be used as well as matched. He says diarrheas should be treated as one would a typhoid case, giving a sustaining food, as most will die of starvation.

Smith(63) agrees with Masters(48) in saying that diarrheas due to paraenteral infection need no change in formula. Where bulging of the ear drum is present, phenic acid and glycerine are applied with a cold pack. If there is bulging of the drum a paracentesis should be done. To reduce distension castor oil can be given but this is often sickening and upsets the stomach. Collonic irrigations reduce distension but are otherwise of no value. When the catheter is put into the bowel the child strains causing very severe pain.

In breast fed babies Smith(63) says sour milk should be given as organisms won't grow in it. The mother should be warned to empty her breasts at each feeding time in order to keep the gland functioning. If the infant won't take the sour milk it may be sweetened with saccarine(one grain to the pint) or corn syrup. The sour milk is continued

only a few days when skim lactic acid milk is added but as this has a value of only ten calories per ounce, sugar must be added. Dextrin is the best sugar even to it is digested slowly. Lactose and cane sugar are too laxative. Red Karo is a good sugar as it contains a mixture of sugars and causes less fermentation in the intestinal tract. The main organism responsible for the infection may ferment one type of sugar and not the other types. Occasionally the baby won't take the sour milk at all. Then give cooked sweet milk and add one dram of 10% argyrol to every four ounces of milk to prohibit the bacterial growth. This should not be continued longer than 36 hours, however for fear of argyria. Crawford(11) uses argyrol in the proportion of 1:300.

In bloody diarrhea(infectious diarrhea) Smith(63) believes the acidosis is due to acetone bodies while in cholera infantum(likely severe fermentative or proteolytic diarrhea) the acidosis is of the lactic acid type. For the former he gives glucose and insulin and for the latter normal saline intraperitoneally. Sometimes there is almost a complete suppression of urine. With these cases saline is freely given followed by 5% glucose in an hour. If the glucose is given first there is a tendency for further dehydration. Salty broths may make the child more thirsty so he takes in more fluid but their food value is practically nil.

In the comments on Smith's article several new ideas in relation to otitis media are put forth. Dr. H.T. Mann of Texarkana, Arkansas, says that when the ears do not heal

after paracentesis it may be due to adnoid or tonsil infection. Dr. Paul H. Powers of Pine Bluff, Arkansas recommends the instillation of ice water in the ears every ten to fifteen minutes which will usually relieve the inflamed ears without paracentesis, that is if the patient has been seen before an abscess has formed. In relation to vomiting that often occurs in diarrheas due to paraenteral infection Dr. Powers(above) leaves a 25% dextrose or lactose solution in the stomach after it has been washed with soda. In severe cases atropine or chloretone may have to be used.

In speaking of the diet of older children, Johnson (32)uses starchy foods as the diarrhea is usually of the putrefactive type, due to the mixed diet. These infants are most often over ten months old. Four to five tablespoons every five hours of farina, cream of wheat or rice and barley flour is given in the form of a cereal or thick gruel. In still older children such foods as zweiback, stale bread dried in the oven or saltine crackers can be fed.

Malted milk is thought to be the best type of food by Carter(9) as it is better tolerated than skim milk. Two ounces are given every three hours to infants under three months and three ounces for those over three months of age. This amount may be increased if they are not satisfied. The food value is fairly high, three teaspoons equaling forty-five calories. This is gradually supplanted with cows milk starting with ten drops per day. The malted milk is continued until the acute stage is over.

The use of lactose as the sugar of choice is discussed by Skole(62). He summarizes the ideas of Morse(76) on the subject. Lactose is the sugar of choice in infant feeding as it is the only sugar present in human milk so seems reasonable that it is the most suitable for the growth of the young child. It is also more slowly and completely absorbed than other disaccharides which is conducive to the development of a normal, fermentative flora in the gastrointestinal tract. Few organisms utilize lactose before it is broken down so it is a protection against bacterial action. It should be given in 5-7% solutions in frequent and small amounts so a continual supply of lactose is brought to the intestine. There is little danger of producing sugar indigestion. The lactose may also be given in cereal water containing .75 to 1% starch. In the intestine lactose is broken down to dextrose and galactose. The former is absorbed and the latter changed to glycogen and reconverted to dextrose before being absorbed. The author (Skole,62) believes it is especially indicated in infective diarrhea. His clinical observations show that lactose does not cause diarrhea or increase the severity of symptoms and instead of a loss there was a gain in weight. The fact that the lactose treatment is not thoroughly understood is brought out by the statement by Marriott in his new book on infant nutrition. He says, "lactose cannot be used with as great a safety or fed in as large a quantities as other carbohydrates."

### Medicinal Treatment:

The medicinal treatment of diarrhea of infancy is very individualistic, depending upon the author. Some drugs are highly recommended by some while the same are equally condemned by others.

Opium--Marriott(43) gives this drug in the form of paregoric when the diarrhea is severe and prolonged and with much water loss. It relieves pain and allows rest but should not be given if there is abdominal distension. Dosage is continued until physiological effect is shown by pupillary constriction. In young infants the dose is five minims and in larger ones ten to fifteen minims. This may be repeated in two to three hours for six or seven doses. Goldberg(17) and Harper(21) also recommend paregoric for the relief of pain and also hyperperistalsis with too many bowel movements. The use of opium compounds is advised by Moncrieff(51) when the acute stage of dehydration is over. Opium should be given in the sub-acute stage when there is no abdominal distension according to Lynch(40) and Masters(48) and in this respect they are similar to the idea held by Moncrieff(51). Wilson agrees with Goldberg (Wilson 70 and Goldberg 17) as to when opium should be given but he gives it in the form of Dover's powder. Paregoric is only used as a stimulant by Marshall(47) and when mixed with chalk and a vehicle for prostration by Strong(66). Pounders(58) believes that if too much paregoric is given it decreases peristalsis to such an extent that toxic products are retained.

However he does advise its use where there is much pain, tenesmus and a tendency for prolapse of the rectum. The indications for opium as reported by Smith(63) are profuse, frequent, watery stools with painful tenesmus. The only two authors I found using morphine for rest are Harper(21) and DeHart who gives it in doses of one-sixtieth of a grain to a six month old infant. Neale(55) considers morphine as dangerous and Amense(1) says opium is of no use whatsoever even in large doses.

Bismuth--The action of bismuth as stated by Wilson (70) is that it inhibits the growth of bacteria in the intestine, promotes healing and diminishes peristalsis. The action of the drug as given by Marriott(43) is that it coats an irritated intestinal mucosa and is slightly antiseptic. He discourages the use of the bismuth subnitrate form as it may be reduced to the nitrite and give toxic signs. The best form is the subcarbonate in large doses but its value is doubtful. He is agreed with in this respect by Masters(48). Carter(9) says that bismuth should be given only after the diarrhea has continued for over ten days. It is prescribed in only subacute cases by Lynch(40) and then in doses of fifteen to thirty grains every three or four hours. The drug is reserved by Harper(21) only for those cases where the stools are numerous but in all other respects the infant appears well. Bismuth is ineffective according to Amense(1). When bismuth is used by Hodges(24) drams one of acacia is added to hold it in suspension.

Atropine--Marriott(43) believes there is an indication for atropine where there is marked gastro-intestinal spasm. It relieves colicky pains but may lead to an elevation of temperature. With severe pain it is given by Neale(55) and Lynch(40) in doses of one one-thousandth to one eight-hundredth of a grain.

Kaolin--Kolin is of doubtful value (Marriott,43) but it may help absorb toxins. Two to three teaspoons of the drug can be given in a little water after feedings. Young (74) also uses kolin in his treatment of cases but says that the drug is hard to give by mouth so should be given by lavage. One ounce of kolin to two ounces of hot water are used.

Anti-coli Serum--When the infection is due to B. coli twenty to thirty c.c. of the serum may be helpful according to Marriott but the improvement does not show up for several days.

Chloral--For restlessness Moncrieff(51) gives  $\frac{1}{2}$  grain of chloral in water every four hours to a child six months old.

Stimulants--A mustard bath or camphor(5 minims of a 1-20 solution in olive oil) are perscribed by Moncrieff(51) for collapse. Adrenalin or brandy(30 minims in water and repeat every two to four hours) can also be given. The following authors, Amense(1), Marshall(47), Pounders(58) and Strong(66) give caffeine, the latter giving it in one-tenth to one-half grain doses. Amense, Pounders and Strong



also give adrenalin in 1:1000 solution to combat circulatory failure.

Chalk--Creta preparata, ten to twenty grains is perscribed by Goldberg(17) for alkalinity and to solidify the intestinal contents.

**Conclusion:**

In this discussion of diarrhea of infancy the various opinions of the different authors have been given without bias or preference to any certain line of thought. No individual opinions have been stated. The whole subject is of such a nature that contrary opinions would likely be the rule. It is left up to the reader to decide just what stand he will take, depending on the individual characteristics of each patient, his own ideas and experiences.

R. Young

## CASE REPORTS

Case No.1 Bibliography (Am.J.Dis.Child.,43:1101-1117, May'32)

A white girl, age four months, admitted to the hospital 9-22-30. A diarrhea had started seven days previous. At first the stools were green becoming copious, watery and containing undigested food. They numbered 15-20 per day. Vomiting became worse until not even water could be retained. Patient would awake from sleep frequently emitting a piercing cry. On the night before admission the respirations were labored and rapid. Patient was breast fed one month when put on condensed milk. Physical examination showed an acutely ill infant, severe dehydration, sunken eyes, restless and fretful. Respirations were deep and sighing. They averaged forty per minute. Pulse was rapid, temperature 104.4, systolic pressure of 90, hemoglobin 101%, red cells 5,360,000, white cells 15,000, specific gravity of serum 1.037, % of cells 35.6 and % of plasma 64.4. Findings interpreted as a marked blood concentration and at the same time clinical evidence of acidosis. Because of the high hemoglobin and red cell count transfusion was decided as unnecessary. Treatment was 150 c.c. of 5% dextrose intravenously at four and eleven P.M. on Sept, 23. One ounce of 5% dextrose to which three grains of sodium bicarbonate was added was given at intervals of about an hour. Digalen-Roche and putressen in full doses. Eighty c.c. of the fathers serum with forty c.c. of a 5% solution of dextrose was given at 8:00 P.M. as the patient still appeared toxic

and wished to raise the immunity against infection that so often occurs in this type of acutely ill infant. Unsweetened evaporated milk two-thirds strength with calcium caseinate and corn syrup was given in one ounce quantities starting on 9-23. Patient was discharged on 9-25 and examination of the blood at that time showed a hemoglobin of 66%, red cells 3,660,000 and the specific gravity of the serum was 1.027. Given evaporated milk at home. Further course was uneventful.

#### Case No.2 Bibliography (29)

Infant born 11-12-30, weight 3285 grams. Put in a private nursery and four days later developed a diarrhea with six to eight watery, greenish-yellow stools per day. Baby was put in isolation with a special nurse, as other cases had been found in the same nursery previously. Culture of the stools showed streptococci and bacillus mucosus predominating. The diarrhea continued for several days with severe emaciation and dehydration. Recovery was gradual. After discharge from the hospital patient developed a suppurative otitis media. Later contracted impetigo.

#### Case No.3 Bibliography (43)

White boy, age four years. Complaint of vomiting a few hours after eating green apples. Very irritable and had abdominal pain. On the second day a mild diarrhea developed with green stools. On the third day blood was found

in the stools which had changed to a whitish color with much mucus. There was much straining and pain on defecation. Temperature was 102-103.5. Abdominal pain and tenderness present. On the fifth day there was rectal collapse with pain and bleeding. Stools numbered twenty in 24 hours, some being composed of only mucus. By the sixth day the patient had become stuporous with a temperature of 104. Delirium and twitching of the hands until the tenth day when some improvement was noted the patient becoming rational. The bowel movements also decreased in number. Toxic symptoms reappeared on the eleventh day with death in a few hours from toxemia and dehydration.

#### Case No.4 Bibliography (68)

Patient four months of age admitted to the hospital 11-7129 with the complaint of frequent stools. History- On 10-22-29 mother was taken to the hospital so patient consequently put on Reolac. Began to have diarrhea 48 hours later. Physical examination-Patient crying constantly and rolling head from side to side. Both ear drums red and bulging. Purulent discharge from nose. Throat slightly inflamed and tongue coated. Liver 3 centimeters down. Buttocks excoriated. Hemoglobin 80%, red cells 4,190,000, white cells 24,550, unanalysis negative. Treatment- Double myringotomy done on 11-7-29 and a moderate amount of pus obtained. On 11-8 and 11-9 saline was given subcutaneously but without improvement. Child died on 11-9-29 without

evidence of mastoid involvement.

Case No. 5 Bibliography (68)

Female, age one year. Became ill on 8-28-28 with the two chief symptoms of vomiting and diarrhea. Stools were very frequent with blood and mucus. Child became toxic and had a convulsion. She was admitted to the Childrens Hospital in a dehydrated condition. There was the typical appearance of toxemia and collapse, fontanelles sunken, eyes sunken, sensorium dulled but the reflexes unchanged. Stools were green, liquid and contained much mucus. Temperature was 102 rising rapidly to 105, pulse 130-160, respirations 25-45. The hemoglobin was 85%, a leucocytosis was present and the urine carried much pus. A transfusion of 150 c.c. of whole blood from the mother was injected into the small saphenous vein of the left leg. Glucose was given and also caffeine for cardiac collapse. Feedings were of powdered protein milk with small doses of whiskey between feedings. The toxemia progressed with the child dying on the 10th day. Autopsy showed injection of the intestinal mucosa and broncho-pneumonia of the right lower lobe.

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