THE
BOSTON MEDICAL AND SURGICAL JOURNAL.

NEW SERIES.]

THURSDAY, AUGUST 1, 1872.

[VOL. X.—No. 5.

Original Communications.

ON ARTIFICIAL FOOD FOR YOUNG INFANTS.

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Read before the Massachusetts Medical Society, at the Annual Meeting, 1872.

THE main object of this paper is to discuss some of the methods which have been proposed for getting rid of the objectionable reactions of cows' milk which tend to make it an imperfect substitute for human milk as food for young infants.

It has been usual to suppose that attention should be given chiefly to the chemical composition of milk, but the point which is of the greatest practical importance is, that the coagula of cows' milk are hard and lumpy, instead of being soft and flaky like those of human milk.

In order to avoid the formation of these coagula, small quantities of gelatine and starch are useful, although neither of them is directly nutritious, and either would be highly injurious if used in large quantities. The following treatise is far from being a complete compendium of the subject, and is by no means intended to serve as a popular guide.

The food and the feeding of the great majority of young infants happily does not require any interference on the part of physicians. The new-born baby, having been supplied with his only real needs, viz., a bath and a suit of clothes, ordinarily asks for nothing more than an opportunity to sleep for ten or fifteen hours, or if, ambitious to begin active life, he sucks his fingers and demands more serious occupation than sleeping, the breast of his mother stands ready to supply him with the luxury of an unnecessary meal (for a new-born child can never be really hungry), and if only a few drops of colostrum can be drawn from the nipple it answers every purpose, giving the child a chance to use the only organ he knows how to use with skill. The

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irritation of the nipple from the sucking stimulates the secretion of the breast far better than a stream of electricity, while the whole system of the mother is revived by the pleasure of handling and suckling her offspring. In many cases a baby will wake after its first sleep of twelve hours, let its voice be heard for a few minutes, and, having had a bath and perhaps a spoonful of water to swallow, will go to sleep again complacently and sleep for another twelve hours.

The doctor has in such cases, then, only to warn the mother to accustom her child to taking its meals at regular hours, and to regard nursing not as a means of quieting it, but simply of supplying it with nourishment.

A certain proportion of mothers, however, are either unable or unwilling to nurse their children, and in such cases the want will be best supplied by a hired wet-nurse. Some babies thrive even better with wet-nurses than with their own mothers, but as a rule this is not the case; and it is much to be regretted, on her own account as well as on the child's, when a mother gives up nursing. If she can give only part of the necessary food, it is in general better that she should give as much as she can, supplementing it with artificial food, rather than leave the nursing of her child entirely to a wet-nurse.

There are, however, many objections to the employment of wet-nurses which need not be mentioned here, and many babies are from necessity or choice brought up "by hand," i. e. on artificial food. These children require a kind of food resembling human milk as nearly as can be, and the impossibility of finding any food which is as suitable as human milk, would seem to account, at least in part, for the great number of substitutes which are recommended on every side, each one being represented as the most perfect substitute ever invented. Among these are the following:—

Milk diluted with water, either with or without sugar.

Cream diluted and sweetened.

WHOLE No. 2322

Cream mixed with whey, and sweetened.
Robinson's prepared groats.

Ridge's food.

Alkalized milk (with soda or potash).

Boiled milk.

Condensed milk.

Liebig's malt soup.

Savory & Moore's and other dry preparations of Liebig's soup.

Loefflund's and others' liquid preparations of the same.

Meigs's and Pepper's milk with gelatine and starch.

Flour porridge, oatmeal porridge, corn starch, crackers and milk, and even seed-cakes and milk are also very often given to the youngest children.

The diversity of opinion with regard to these preparations shows that the question as to the proper food for infants has not been sufficiently studied, and I shall therefore endeavor to trace out the connecting links between our scientific and practical knowledge of the subject. Physiologists do not tell us as much as we would wish with regard to the digestion of the infant, as compared with that of the adult, but happily the food which Nature provides for babies gives us an invaluable guide in the preparation of artificial food.

Our object, then, will be to supply that food which most nearly resembles human milk in its reaction upon the digestive system of the infant. We must keep in mind that the chemical expression of any substance does not give us the least idea of the characteristics of that substance. Thus, a bit of carbon may be either a diamond or a piece of charcoal, yet no one has succeeded in transforming the charcoal into the diamond. This is especially true of organic substances. In this way, a combination which contains the same proportion of chemical elements as human milk, may react very differently from human milk on the digestive organism. It is only by bearing this fact in mind that we shall be able to appreciate the difficulties of imitating human milk successfully. Different kinds of casein differ from each other as much as do charcoal and diamonds.

From one point of view, nothing so nearly resembles human milk as the milk of the lower animals (cow, goat, ass, &c.). Goats' milk and asses' milk resemble human milk more nearly than cows' milk, as regards the proportions of the chemical elements, but since both the former are difficult to obtain, and asses' milk is hardly to be had in this neighborhood at all, they do not seem to have any practical advantages over

cows' milk, which is at all times easy to get and which will therefore be treated as the type of all.

The following remarks refer only to very young children, especially those less than three or four months old. At the age of six months the time of the greatest difficulties in artificial feeding has passed by.

Cows' milk usually contains, as is well known, much more casein and less butter than human milk, so the following rule for manufacturing human milk was easily arrived at:—Take the upper two-thirds of the milk after it has been standing long enough to allow the cream to rise, dilute it with water and add a little sugar. A very great many children have thriven well on this diet, and in such cases it is by far the most convenient food to give, but it was the failure of it in some cases that led to the manufacture of other preparations, with which the market is now flooded.

It is a common mistake of nurses, and I fear sometimes also of physicians, to believe that starchy substances boiled in milk make a more hearty, that is, a more nutritious food than milk alone. There can be, however, no greater error than to suppose that starch is, to an appreciable degree, directly nutritious. There is, as is well known, no starch in milk, nor any other insoluble hydrocarbon, and the digestive organs of the young infant are not adapted to changing any appreciable amount of starch into a soluble substance. A large portion of the starch ingested by young infants passes through the bowels unchanged.

The bad effects of amylaceous food show themselves not only at the time of dentition, but perhaps more decidedly at a later period, when children often develop symptoms of rachitis. Perhaps the most marked immediate effect is constipation, resulting in dyspepsia and irregular diarrhoea. The starch clogs up the intestines, till a slight catarrh comes to sweep out the hardened masses, after which the accumulating process begins, and again a catarrh gives another period of temporary, and, to a certain extent, natural relief; but this process cannot go on long without causing a very considerable irritation, and the child is fortunate if it escapes merely with distention of the intestines. It is much more likely to have to suffer for a long time with chronic catarrh of the intestinal tract. Let us, then, rid ourselves of the idea that starch is a part of the natural food of infants, and regard it as an entirely foreign substance. This is, however, no reason for refusing to

use it in food, if we find that in any way it may be made to assist digestion, and on this point I shall speak later.

On comparing the various chemical analyses of milk, we are struck by the variableness of the amount of casein, butter and sugar contained in the various specimens, a fact which would of itself lead us to suspect that the mere difference in the relative proportions of casein, butter, &c., did not constitute the most important difference between the two kinds of milk.

Thus, the amount of casein has been found in various percentages, varying from 1.2 to 8.9 per cent., while the average is stated at 4.8 per cent. for cows' milk, and from 1.9 per cent. to 4.3 per cent. for human milk, the average being 3.9 per cent.

LIEBIG'S MALT SOUP.

Baron Liebig was led to attempt to make an artificial food for young infants by the fact that two babies, both related to him (one of them his own grandchild), were deprived of mother's milk. Both of the children thrived exceedingly well on the newly invented food.

According to his theory, all food could be divided into nitrogenous and non-nitrogenous substances, nitrogenous being used to support and nourish the body, non-nitrogenous to sustain the heat of the body. The latter is supplied in human milk by butter and sugar, and Liebig proposed to make up the deficiency of these in cows' milk by means of dextrine obtained from starch through the agency of malt. As is well known, the starch in grain is changed to dextrine by germination, and when the germinating grain is put with starch and subjected to a gentle heat, the same change extends to the starch. It is too much to demand of the digestive apparatus of the infant to effect these changes in the starch unaided.

Even though more recent investigations have shown that this theory of nutritive and combustible food can only be admitted within very narrow limits, yet this food, as suggested by Liebig, in fact suits babies exceedingly well, and, practically, too much can hardly be said in its praise. It has a sweet taste, and is almost never refused by the babies. Being slightly laxative, it is well adapted to children who are constipated from debility or unsuitable food.

It was observed by a lady who gave a great deal of personal and careful attention to her baby, that though his health improved steadily while taking Liebig's soup, he did not gain flesh nearly as fast as he did

with milk. This baby had been brought into a very dyspeptic and constipated state by the injudicious treatment of the monthly nurse, and no attention was spared to improve his condition. Several times Liebig's soup was given up and resorted to again, because he could not get along with cows' milk, and every time the same observation was made. I do not know that this has been noticed in other cases.

SUBSTITUTES FOR LIEBIG'S SOUP.

Both powders and liquid extracts are made, for which it is claimed that Liebig's soup can be made from them merely by the addition of milk. I believe, however, that Liebig has never sanctioned any of these preparations. Several powders are made in Europe. The only one that is brought to this country is that of Savory & Moore, who claim that it is recommended by Dr. Lankester and others, and that it is supplied to the royal nurseries of England. Even Victoria has given her recommendation! Perhaps we are not favored with the same quality which is supplied to the princes of England, but certainly that which comes to us is a most disagreeable preparation. It is really no representative of Liebig's soup, for it is full of starch, and contains little if any dextrine. It contains many small fibres of the husks, which must be irritating to the bowels, while most babies do not like it, and it is not well borne by the stomach. Older children can undoubtedly take it, as they can any preparation of starch, but for young infants it is very objectionable.

The only liquid extract which is to be had here, as far as I know, is that by Liebig in Dresden. The taste is more agreeable than that of Savory & Moore's preparation, but by no means as agreeable as that made according to Liebig's direction, directly from the malt. The extract is, however, recommended, as are also the others made in Europe. I have had no experience of them.* Some authors speak of the preparation of Liebig's malt soup as being very complicated. This is not practically the case. Any one who has once seen it made, will have no difficulty in making it again.

Condensed milk is a yellowish substance of the consistency of honey, with a very sweet taste. It gives a slightly gritty sensation in the mouth, and under the microscope is seen to be a granular mass crowd-

* Since this was written an attempt has been made to substitute Liebig's preparation for Liebig's soup at the Massachusetts Infant Asylum, but it was speedily abandoned, as the children who took it had violent attacks of diarrhoea.

ed with crystals of sugar. (Chiefly cane sugar, partly milk sugar.) The reaction is alkaline. It is made by evaporating fresh, sweetened milk in a vacuum. Whether any alkali is added, or whether it is alkaline because the milk is perfectly fresh when the process of condensation begins, I do not know. When water is added to it, the granular look fades out and globules of butter make their appearance, while the crystals gradually disappear. In the condensed state it does not ordinarily become acid, even when kept in a warm place, but when diluted it does not seem to keep sweet any longer than ordinary cows' milk. It sometimes seems to suit children who cannot take fresh milk. Whether this is due to the fact that being diluted just before using, it is each time equivalent to milk fresh from the cow, or whether its alkalinity makes it more suitable, I cannot say. It was quite evident from the experiments which will be cited that it does not digest more quickly than cows' milk. The taste is agreeable, and, as far as my experience goes, it is well borne by infants.

An interesting set of experiments by Biedert, of Giessen (*Untersuchungen über die chem. Unterschiede der Menschen- u. Kuhmilch*. Inaug. Dissert. 1869), develops some of the differences between human and cows' milk. This writer comes to the conclusion (purely theoretical, I believe) that a mixture of cream and whey, as recommended by Prof. Kehrér, makes the food which mechanically most closely resembles human milk. This conclusion is drawn from the following facts: While the addition of a few drops of artificial gastric juice to human milk is followed by a precipitation of light feathery coagula, the addition of the same amount of gastric juice to cows' milk causes the precipitation of a coagulum which is large, continuous and hard, and which fills the whole vessel. If the milk be shaken during coagulation the coagula are smaller, but the small coagula do not dissolve any faster than the large ones.

He also reports that the cows' milk had to be diluted with twelve times as much water before it began to coagulate in a manner even similar to the human milk. He therefore concludes that the difference in the amount of casein did not account for the difference of coagulation. Nor was it caused by the different reaction, for acid added to human milk did not make the coagula less flaky, nor did the addition of alkali to cows' milk make the coagula less hard, even when the milk was made strong-

ly alkaline. He maintains that the coagulation set in while the milk was still alkaline. The only effect of the alkali was to delay the coagulation. Other reactions of cows' milk were very different from those of human milk. Excess of artificial gastric juice added to human milk either caused the formation of coagula which were speedily dissolved, or none at all were formed. In this case, when more milk was added, precipitation followed. The coagula of cows' milk, he reports as dissolving much more slowly. He therefore concludes that not pure cows' milk (Küttner), nor alkalized nor diluted milk, nor that protected (Falger) in a milking apparatus from contact with the air, nor Liebig's soup, is the most appropriate food for young infants, but recommends that the milk should stand for twelve hours, when the cream is skimmed off, the remaining milk curdled, the whey mixed with the cream and a little sugar of milk added. That is, he concludes that it is only by removing the casein that we can avoid the unfavorable effects of it.

Having been unable to obtain anything more than a short review of the dissertation in which these experiments were published in detail, I have made use of the kind offer of Prof. Bowditch to go over some of the same ground again at the Physiological Laboratory of the Harvard Medical College. Biedert speaks of the easier coagulation of human milk after it is twenty-four hours old, but does not say anything, as far as I know, about corresponding changes in cows' milk. Cows' milk which is still warm coagulates in much softer lumps than that which has been exposed to the air for some time. Whether these soft coagula dissolve any quicker than the harder ones, I cannot say, as the cow that supplied me with warm milk went into the country before my observations were completed. I am disposed to think that Biedert lays too much stress on the greater ease of solution of human casein as compared with cows' casein. I found that large coagula from cows' milk dissolve much more slowly than the small coagula of human milk, but the smaller coagula made by diluting the cows' milk before coagulation do not have the same advantage over human milk.

I was also unable to confirm Biedert's observation that the addition of an excess of gastric juice had the effect of preventing the formation of coagula of human milk, or of dissolving them as soon as formed. A very large quantity of gastric juice was added to coagula from human milk without dissolving them except after many hours.

It is true that if an excess of hydrochloric acid be added, and the test-tube be shaken violently, the flakes of casein disappear; but in this case the coagula are merely broken up to a fine powder, and are not really dissolved, and the same change takes place without shaking, though more slowly. I shall show later that this is also the case with cows' coagula.

The casein from Borden's condensed milk, diluted to about the density of common milk before coagulation, did not dissolve so fast as the coagula from common milk.

It was found that the preparation, proposed by Meigs & Pepper, of milk with a small quantity of gelatine and starch, coagulated in lumps which were much softer and more flaky than those from pure milk, and the flaky coagula disappeared more rapidly than did the hard from pure milk. At the same time there was no evidence that they really dissolved any more rapidly. It was found that hydrochloric acid (of two per cent. or greater strength) caused all coagula to break up into fine, microscopic particles which give to the fluid again the appearance of uncoagulated milk, so that the fact of the disappearance of the lumps is not enough to prove digestion. If the fluid, in which the coagula has thus been broken up, be allowed to stand, a thick cloud rises to the surface which, at the slightest shake, falls and permeates the whole fluid; but if the casein be not only broken up, but digested, the cloud at the surface is very thin, by no means so white as the undigested one, and only sinks and mingles with the clear fluid after a violent shake, then giving it a translucent, gray look, with no resemblance to the appearance presented by the undigested mixture which is like pure milk. It would seem that where the casein is undigested, enough fat remains in connection with the fine particles of coagula to make it tend to the surface, although it can be shaken down very easily, but when the casein is digested, the fat rises to make a thin layer at the top, which, being much lighter than the fluid, is shaken down with difficulty. Casein from cows' milk does not, then, dissolve more slowly than the same amount of human casein, and it would seem, therefore, highly probable, that the casein of cows' milk is not objectionable because it is indigestible, but because it is naturally hard and irritating, and our object should be not to take it away from infants' food, thereby depriving the food of the only part which contains nitrogen, but to endeavor to keep it in the food and make it less irritating to the bowels.

In healthy children fed at the breast, the intestinal mucous membrane is never touched by anything hard. The coagula of human milk never contract into hard masses, and the natural dejections are not harder than hasty-pudding, though they are perhaps not more free from casein than many discharges of children fed with cows' milk, where the bowels are irritated by the hard lumps of casein. It does not necessarily follow that more casein of human milk is absorbed than of cows' milk, so long as the bowels still remain in a healthy condition, although from cows' milk we may find lumps of casein from the size of a millet seed to that of a pigeon's egg. The healthy discharges of nursing infants also contain large amounts of casein (Wiederhofer), (Emile Allix, Paris, 1867, fat fifty-two per cent., bile pigment with fat sixteen per cent., coag. casein and mucus eighteen per cent., fluid and waste sixteen per cent. [after Simon]). It is in order to make the reaction on the bowels, of cows' milk, more like that of human milk, and not with any idea of giving direct nourishment, that Meigs & Pepper recommend the addition of a small quantity of gelatine and starch, and the experiments above cited would seem to confirm this idea. Their process is as follows (Meigs & Pepper, *Diseases of Children*, p. 304):—

"A scruple of prepared gelatine (or a piece two inches square of the flat cake in which it is sold) is soaked for a short time in cold water and then boiled in half a pint of water until it dissolves, about ten or fifteen minutes. To this is added, with constant stirring, and just at the termination of the boiling, the milk and arrowroot, the latter being previously mixed into a paste with a little cold water. After the addition of the milk and arrowroot, and just before the removal from the fire, the cream is poured in, and a moderate quantity of loaf sugar is added. The proportions of milk, cream and arrowroot, must depend on the age and digestive power of the child. For a healthy infant, within the month, we usually direct from three to four ounces of milk, half an ounce to an ounce of cream, and a teaspoonful of arrowroot to a half-pint of water. For older children, the quantity of milk and cream should be gradually increased to a half or two-thirds milk, and from one to two ounces of cream. We seldom increase the quantity of gelatine or arrowroot."

RIDGE'S FOOD.—PREPARED GROATS.

Both of these are of service if used for the purpose just mentioned in very small

quantities: As food proper for young infants they are useless and injurious, being merely fine preparations of grain entirely deprived of the husks. When treated with iodine, under the microscope, each particle becomes intensely blue. Ridge's food is supposed to be made of wheat. The barley from which Robinson's groats are made, is supposed to be useful in as far as it contains more of the salts which are necessary to human milk than do other grains.

Farina, maizena and corn starch (which are different names for the same thing) may be used in the same way, their only disadvantage being that they easily become rancid, and contain but little gluten, while, of course, they are subject to the objection raised against all forms of starchy food, that, if used in too large quantity, they cause constipation, with its attendant train of troubles.

Cows' milk alkalized with bicarbonate of soda or potash, is less often vomited than pure cows' milk, and under its use the dejections contain fewer and smaller lumps of casein; but this is not because the coagulation is put off for a very long time. The milk is speedily acidified by the gastric acid which is continually secreted in the stomach, for hard coagula in an acid fluid are often vomited in a few minutes after a meal of alkalized milk. Probably the alkali, by neutralizing the acid temporarily, prevents the too rapid coagulation of the whole mass, and thereby prevents the formation of very large coagula.

Biedert's observation that the coagula of alkalized milk were formed later, but were just as large and hard as those from acid milk, is not really opposed to this idea, for the test tubes used in Biedert's experiments were kept perfectly still, while the contents of the stomach are continually in motion.

Among the poorest people in Boston, one of the most common articles of food for young babies is seed-cakes and milk. The aromatic seeds are supposed to act as a carminative, and to make this form of food peculiarly suitable in cases of colic. The poor victim screams with stomachache, but his screams are only considered cries of hunger, and all he gains is the undeserved epithet of a greedy fellow and another spoonful of seedcake and milk.

No form of pap or porridge is suitable for children under six months. Porridge made of fine flour is very constipating and causes collections of hard fæces in the bowels, which are carried off naturally from time to time by an attack of diarrhœa.

Oat meal is not so liable to constipate as much as fine flour, because the irritation caused by the husks of the grain stimulates the bowels continually. Even this irritation will, however, be too severe for the tender mucous membrane of young infants, and be the cause of an annoying chronic catarrh of the bowels. Its action on young babies is also very irregular and uncertain, and not at all as satisfactory as that produced on the digestive apparatus of older children and adults.

Drinks for children of arrowroot, sago, &c., are probably useless, except for the infinitesimal amount of nourishment which they contain, which is worth no consideration. On the other hand, an infant should not be allowed to suffer from thirst. Cool water is often taken with avidity, and after an obstinate attack of crying, a few spoonfuls are often enough to quiet the child completely.

Let us, then, bear in mind that the only proper food for a new-born baby is the milk of its mother; that her place is best supplied by a wet-nurse; that the great obstacle to the use of cows' milk is not the insolubility, but the irritating character of its coagula; that this may be avoided to some extent in many ways, among others by the addition of a little starch and gelatine for the purpose of effecting a mechanical separation of the particles of coagula; and, finally, that for any other purpose starch and gelatine are never to be used.

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THE CIRCULATION IN SEA-SICKNESS.

By JAMES J. MACDONALD.

In an article which lately appeared in the *British Medical Journal*, the writer, Dr. Alderson, offers a theory for the explanation of sea-sickness, based on the changes which are said to take place in the circulation of the blood in consequence of the tossing of the ship, and on the effects of these changes on the brain. That an abnormal condition is produced in the brain in consequence of disturbed circulation is unquestionable. That the motion of a ship causes such a disturbance is doubtless true, and that sea-sickness is a result of this disturbance may also be true; but the reasons given to explain this abnormal condition seem very imperfect and unphilosophical. It will be evident upon consideration that the effects produced are not the result of the causes which he assigns.

The statements upon which the theory is