INFANTILE RICKETS: THE SIGNIFICANCE OF CLINICAL, RADIOGRAPHIC AND CHEMICAL EXAMINATIONS IN ITS DIAGNOSIS AND INCIDENCE *

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It is difficult, indeed impossible, as will be shown later, to state categorically the incidence of rickets. In large cities this has been variously estimated at from 50 to 75 per cent. or more among artificially fed infants. In the course of caring for a large group of young children in a model institution, situated in the outskirts of the city, it occurred to us some years ago to inquire how frequently rickets developed under these favorable conditions. It seemed especially worth while to ascertain, by careful and continued observation, whether this disorder came about with the same frequency among these infants as among the infants in the average city home. Our group has comprised about 250 babies less than 18 months of age, who have been cared for during the past four years. A group of this kind, living under similar hygienic surroundings, and receiving at all times a carefully regulated diet, prepared in a central diet kitchen, presents an exceptional opportunity to follow nutritional conditions and particularly to observe disturbances at their earliest beginning. The babies were almost all of Russian Jewish parentage, a stock which is considered not peculiarly susceptible to rickets, or to other nutritional disturbances. All were free from clinical symptoms of syphilis and gave a negative Wassermann reaction—a test which, however, is of limited value at this time of life. Their diets were those most commonly used—pasteurized milk, dried milk, raw certified milk, given either in simple dilution or in special formulas.

In order to lend uniformity to the data, these examinations, some two thousand in all, were performed by the same person almost throughout the entire period. This survey included notation of the weight, shape of the head, craniotables, presence of teeth, bowing of legs and curvature of the spinal column, beading of the ribs, tonicity of the muscles, umbilical hernia, diastasis recti, enlargement of the spleen, etc. About three years ago monthly roentgenograms of the lower epiphyses of the ulna and radius and of the carpal bones became part of the routine examination, and for the past year a monthly analysis of the blood has been made, especially for its percentage of

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* From the Home for Hebrew Infants.

inorganic phosphate. It is these cases in which clinical, radiologic and chemical tests were carried out to which we shall devote particular attention. Most of the infants have been followed month by month for from six to twelve months, and many for a year or more. No case has been considered which has been under observation for less than four months.

In spite of these improved diagnostic methods, the recognition of rickets has become increasingly difficult, due to our realization of the complexity of this disorder. It is more and more evident that there is no pathognomonic sign, no sign which can be accepted as invariable evidence of the presence of rickets. Among the symptoms frequently emphasized as of value in this connection, are head sweating, inability to sit or to stand at the normal age, delayed eruption of teeth, poor tonicity of muscles. Without entering into a detailed discussion of these phenomena, it may be stated that they all proved unreliable. Head sweating is a symptom of minor importance because it is frequently absent and is by no means specific of this disorder. The age of learning to sit or to stand depends on various other factors. As an example of its lack of dependability, a rachitic breast-fed baby may be cited which sat up well at 6 months of age. This infant showed the distinctive signs of rickets (rosary, enlarged epiphyses, radiographic picture) to greater degree than any infant included in Table 4. It was omitted from this table because it was of Italian parentage. The most significant factor associated with delayed dentition has been, in our experience, not rickets but feeble-mindedness. The instances in which mentally backward children did not erupt a tooth until 12 or 15 months of age have been both numerous and striking. In these cases cod liver oil, given for six months, from three to six teaspoonfuls daily, did not induce dentition. On the other hand, there have been numerous cases in which the teeth erupted normally in the course of the development of rickets.

Craniotabes.—On account of the many qualifications with which it is attended, craniotabes must be regarded as an unreliable sign of rickets. In young infants, those under three months of age, there is the difficulty, insurmountable in many instances, of differentiating it from the cranial softening of the newborn, which is not truly rachitic. It has its greatest diagnostic significance somewhat later, after the sixth month of life. It was found at some time in one-third of the babies in our institution. As the incidence of rickets in bottle-fed babies is always greater than this, it is evident that it is not a constant sign. Indeed, in the mild or moderate type of disorder such as we have had under observation, due to the fact that cod liver oil or heliotherapy was begun as soon as the roentgen ray showed any changes, craniotabes was absent more often than present. Its absence, therefore, has no

diagnostic significance. By the time the infants arrived at the age of 6 months, or more, this sign was elicited only in 10 per cent. of the cases. In numerous instances the softening healed before, or even in the course of the development of the characteristic radiographic changes, so that had craniotabes been used as a criterion, the rickets would have been considered as cured. This quality, noted frequently by others, of complete healing despite a general advance in the rachitic process renders this sign unsuitable for a standard. Craniotabes has been associated in numerous instances with a normal content of inorganic phosphate in the blood, but frequently with an abnormally low percentage of calcium.

Beading of the Ribs (Rosary).—Of all the direct clinical signs of rickets, beading of the ribs was found to be the most constant and reliable. Attention has been focused more and more on this sign in the 2,000 physical examinations which have been carried out in the course of this study, and lately its time of appearance has been compared with the advent of roentgenologic changes and a diminution in the inorganic phosphate of the blood. Beading occurs not only in rickets but in scurvy,¹ so that it is impossible to interpret its nature when latent scurvy may be present. This question arose in connection with a few cases at the time of admission, but could be disregarded in relation to all other infants, as they received orange juice daily. One cannot state categorically that beading never occurs in other clinical conditions; if it does, it is an exceptional manifestation, for there have been but two or three instances in which it could not be definitely linked with rickets. Six gradations of beading have been formulated, to the mildest of which ($\pm$) no significance was attached. Its value is greatest in the second half of the first year of life; during the first half of the second year it frequently becomes obliterated by the recession of the costochondral junctions, leading to the formation of the well known Harrison's groove. Where this groove is present the sign should be disregarded.

Tables 1 and 2 show the occurrence of beading of the ribs in its relation to radiologic changes and diminution of the inorganic phosphate of the blood. In Table 1, composed of three representative cases in which rickets developed on certified raw milk, it will be noted that beading frequently precedes the radiographic evidence, and that it may or may not antedate the chemical alteration of the blood. The third case serves to illustrate the marked distinction between the value of beading for early diagnosis and for beginning cure. This infant was cured rapidly by means of irradiations from the carbon arc lamp. In spite of the pronounced healing clearly shown by the roentgen rays as calcifica-

1. Hess, A. F., and Unger, L. J.: *Am. J. Dis. Child.* **19**:331 (April) 1920.

tion of the epiphyses, and by an analysis of the blood, the rosary did not diminish in size. This is frequently the case; in fact in some instances the costochondral junctions became more angular and firmer, probably as the result of calcification. Therefore, although beading may gradually disappear under specific therapy, its persistence must not be regarded as indicating failure.

Table 2 represents a comparative study of the first sign of rickets among the fifty-three infants supervised this year. Previous experience had led us to believe that beading of the ribs is a more reliable criterion in this respect than the radiographic picture. It will be seen that among the fifty-one cases of rickets, beading was the first sign in twenty-four

TABLE 1.—INCIDENCE OF SIGNS (RAW MILK)

	December	January	February	March	April
1. Rosary.....	+	+	+	+±	+±
Roentgen ray.....	Negative	Negative	Negative	Rickets	Rickets
Phosphorus.....	3.45	3.31	.....	3.23	3.17
2. Rosary.....	±	+	+±	+±	+±
Roentgen ray.....	Negative	Negative	Negative	Mild rickets	Mod. rickets
Phosphorus.....	3.22	.....	2.94	2.93	2.85
Carbon arc lamp					
3. Rosary.....	+	+±	+±	+±	
Roentgen ray.....	Negative	Mild rickets	Healing	Healed	
Phosphorus.....	4.00	3.69	4.29	4.25	

TABLE 2.—FIRST SIGN OF RICKETS (51 CASES)

	Dried Milk	Raw Milk	Protein Milk	Total
Rosary.....	14	9	1	24
Roentgen ray.....	1	0	1	2
Blood phosphorus.....	4*	2	1	7
Rosary + roentgen ray.....	1	0	0	1
Rosary + phosphorus.....	5	2	1	8
Roentgen ray + phosphorus.....	2	0	0	2
Rosary + roentgen ray + phosphorus.....	2	3	2	7
Total.....	29	16	6	51

instances, and in sixteen instances occurred simultaneously with one or more other signs. This order of precedent, however, may not hold good for every diet and under all hygienic conditions. Rickets, associated with a certain diet, may be characterized by distinguishing lesions. In this respect the divergent histologic pictures may be called to mind which develop in rats fed a low phosphorus and high calcium diet, compared to that resulting from a diet low in calcium and high in phosphorus; the former is characterized by a broad band of cartilage not seen in the latter. Whereas the rickets associated with raw certified milk, or with breast milk, is accompanied by an early enlargement of the costochondral junctions, that associated with a diet of condensed milk has seemed to be characterized by bowing of the legs.

Roentgenogram of the Epiphyses.—The fact that beading of the ribs is a subjective sign, fluctuating according to the experience or the point of view of the examiner, lessens its value. It might be thought that radiologic examination of the epiphyses is purely objective and, therefore, not open to this criticism. It is true that it is easy to interpret marked rachitic lesions, those characterized by decided cupping of the ends of the bones, especially of the ulna, and by a diminished calcification of the shafts. But in endeavoring to discover early rickets many instances were encountered which led to questioning. Every month in the course of a scrutiny of about seventy-five roentgenograms there have been at least four or five films which could not be diagnosed satisfactorily. If this perplexity exists when previous roentgenograms are available for comparison, as well as a clinical record of the case, how much greater must be the uncertainty when the diagnosis has to be made from a single roentgenogram. The main obscurity has been the pathologic significance of what may be termed "slight spreading" or "spreading" of the ulna. In some instances this deformity has developed later into "slight rickets," in some it has remained stationary although other rachitic signs have developed.

This is merely one aspect which has rendered radiographic diagnosis unsatisfactory and disappointing. A criticism of wider applicability is that the roentgenogram frequently is negative, although beading of the ribs, the diminution of inorganic phosphate, and the general appearance of the infant clearly point to rickets. Table 2 shows that among fifty-one cases the diagnosis was first established by means of the roentgen ray in only two, and that only in ten other instances did it furnish evidence as early as the clinical or chemical tests. A survey of our complete data leads to the same conclusion. Two hundred and forty-four cases have been radiographed month by month by Dr. Charles Gottlieb, comprising almost 2,000 individual photographs. One hundred and forty-nine of these have shown rachitic changes roentgenologically. In how many did the roentgen ray and in how many did beading of the ribs give the first evidence of rickets? In thirty-one cases both appeared simultaneously, so that these must be deducted from the total, leaving 118 as a basis of comparison. In fourteen cases the diagnosis was first established by roentgen ray, and in 104 by beading of the ribs.

How can this comparative precocity of beading be explained? No doubt, it is partly attributable to the fact that we are not comparing the same articulations. The costochondral junctions are involved early in rickets, due probably to the rapid growth of the ribs, and could they be radiographed satisfactorily, the roentgen ray would not be so tardy in diagnosis. In our experience raying of joints, other than the wrist, furnishes still later information. In numerous instances several articulations of the extremities were examined roentgenologically, but in none

were lesions seen when the wrist joint appeared normal. There is another aspect which should be referred to. In the course of a general physical examination the epiphyses of the wrist were found enlarged in surprisingly few cases, far less than among the negro babies examined by us some years ago, or in the breast-fed babies represented in Table 4. This sign of rickets is very inconstant and is found most often in well nourished infants. It is of interest in this connection because the wrists may be enlarged to palpation and, nevertheless, be negative to the roentgen ray; in one instance where the epiphyses were distinctly enlarged, repeated roentgenograms were negative. Furthermore, in the great majority of cases in which rickets was diagnosed by roentgenograms of the wrists, the epiphyses apparently were normal in size and contour.

It should be borne in mind that these statements regarding the unreliability of roentgenograms apply solely to early diagnosis. In distinguishing the healing of the rachitic process, the roentgen ray is invaluable and gives evidence far in advance of simple clinical signs. Indeed, in this respect, as stated, beading of the ribs may be absolutely misleading. It is remarkable how quickly the epiphyses respond to specific therapy or to "change of season" by the formation of a more or less intense line of preparatory calcification. This response of the epiphyses to curative agents is so reliable that it has been employed by Mellanby in dogs² and by Howland and Park in infants,³ to demonstrate the specific therapeutic value of cod liver oil.

Centers of Ossification of the Carpus.—The relation of the development of the carpal centers to the early diagnosis of rickets may be dismissed in a few words. The time of appearance of these centers seems to depend primarily on rate of growth, and to be influenced mainly by factors which affect this rate. An exception may be made to this statement in regard to premature infants, which generally show delay in the appearance of the carpal centers. The cases of rickets under consideration, which in most instances were so mild as to escape casual diagnosis, and were detected only by means of refined methods, showed no retardation of growth in weight or in length and likewise no delay in carpal development. As an illustration of the lack of interrelationship between rickets and carpal development, the case of a breast-fed baby may be cited which developed rickets when 4 months of age, although two carpal centers were manifest before she was 2 months of age.

2. Mellanby, E.: Medical Research Committee Special Report, Series 38, London, 1919.

3. Howland, J., and Park, E. A.: Arch. Pediat. **37**:411, 1920.

Inorganic Phosphate of the Blood.—Recently Howland and Kramer⁴ reported that the inorganic phosphate of the serum is regularly reduced in infants during active rickets. In the course of the past year this test has been included in the monthly examinations. For this purpose the Bell and Doisy colorimetric method was used, with the modification that paraffined tubes were employed instead of adding oxalate to the blood. The normal plane of inorganic phosphate, as determined by this method, is approximately from 4.0 to 4.8 mg. per 100 c.c. of blood. Percentages of 3.75 mg., or less, were considered within the rachitic range. It would lead too far afield, nor is the time ripe, to discuss in detail the significance of a diminution of the inorganic phosphate of the blood. We have met with cases of undoubted rickets where the blood phosphate was not decreased, and some where it was found to be below 3.75 mg. per cent., and an observation of several months showed no clinical or radiologic evidence of rickets.⁵ In one instance of this kind where the diet had been raw certified milk, histologic examination of the epiphysis of the ulna was negative. There are evidently factors other than rickets which tend to a reduction of the inorganic phosphate of the blood. Recent investigations lead to these deductions. In this connection experiments on the rickets of rats should be borne in mind, which clearly show that although low inorganic phosphate of the blood generally accompanies rickets, the diet may be so constituted that the inorganic phosphate is greatly diminished and yet rickets not result. Hess and Lundagen⁶ have shown that there is a marked seasonal tide in relation to the inorganic phosphate of the blood, that in almost all infants there is a tendency for this constituent to fall gradually during the winter months, reaching its lowest ebb in March, gradually rising to its flood in the summer season.

In spite of these factors, rickets seems to be the most important clinical disorder associated with low phosphate, and although the test cannot be considered pathognomonic of rickets, it is of distinct value in early diagnosis. The percentage of phosphate seems to bear some relation to the nature of the diet, a diminution coming about more often and earlier on dried milk or on protein milk than on raw milk. It cannot, however, be brought back to the normal, or regularly increased by adding large amounts of phosphate to the dietary (K_2HPO_4 , 2 gm. daily). Table 2 shows that in seven of fifty-one cases this sign preceded all others, and that in seventeen other instances it was noted simul-

4. Howland, J., and Kramer, B.: *Am. J. Dis. Child.* **22**:105 (Aug.) 1921.

5. In three cases of this kind cod liver oil was given for one month, from March 20 to April 20, and brought about decided increases in the inorganic phosphate of the blood: from 3.58 mg. to 4.03 mg., from 3.03 mg. to 4.21 mg., from 3.55 mg. to 4.11 mg.

6. Hess, A. F., and Lundagen, M.: *Proc. Soc. Exper. Biol. & Med.* **19**: 1922.

taneously with one or other signs. It is, therefore, to be regarded as an early phenomenon of rickets. Unless a consecutive series of tests is available for comparison, an analysis showing low inorganic phosphate does not indicate whether the rachitic process is healing or advancing. When, however, previous figures are at hand, this test generally will be found of value in judging the trend of the disorder. It cannot be relied on in this regard. Instances have been encountered in which roentgenograms showed healing and the inorganic phosphate had increased but little; for example, cod liver oil was given to an infant from May 12 to June 13 and the inorganic phosphate rose only from 3.33 to 3.54 mg., whereas the roentgen ray showed definite healing. The most reliable criterion of healing is the roentgenogram.

THE INCIDENCE OF RICKETS

As stated, there are no reliable statistics of the incidence of rickets. This is true of urban and of rural communities, but especially so of the latter. Various approximations have been made—some years ago by

TABLE 3.—INCIDENCE OF RICKETS UNDER 18 MONTHS
221 NECROPSIES (SCHMORL)

Number of Children	Age, Months	Total Rickets		Rickets Absent	
		Cases	Per Cent.	Cases	Per Cent.
34	4-6	33	97	1	3
53	7-9	50	94	3	6
75	10-12	73	97.3	2	2.7
59	13-18	58	98.3	1	1.7
221	.....	214	96.7	7	3.2

Kassowitz, more recently by Findlay and by Thompson, and for colored infants by Hess and Unger—all based on estimations or on simple physical examinations. No attempt has been made to use the roentgen ray to obtain more accurate data. Nor has any inquiry of this kind been confined exclusively to a short period of the year, for example, to one or two of the winter months, when rickets flourishes. The test of the blood for inorganic phosphate is, of course, too recent an innovation to have been employed for this purpose.

To our knowledge there is but one study of the incidence of rickets from a pathologic point of view—that of Schmorl⁷—a routine investigation of cases as they came to necropsy for one cause or another. A study of this kind has the great advantage of being able to discern, and therefore to include, active as well as inactive, incipient as well as healed rickets. A table has been prepared summarizing part of this investigation (Table 3), namely the data bearing upon 221 necropsies made on infants under 18 months of age, the age period embraced by

7. Schmorl, G.: *Ergebn. d. inn. Med. u. Kinderh.* **13**:403, 1914.

our study. On consulting this table it is seen that more than 96 per cent. of the infants showed lesions of rickets and that histologic changes were absent in only seven of the 221 cases.

In a clinical study the percentage of rickets will depend to a far less extent on the diet of the infants than on incidental factors. It will vary greatly according to the variety of the diagnostic methods and the care and understanding with which they are employed, and also according to the season or even the month of the year when the examinations are carried out. All agree that the diet in which rickets develops least often is breast milk. In order to ascertain its incidence on this diet, a careful examination of twenty-five breast-fed infants, similar in nationality to those in our institution, was carried out in a baby welfare station. A glance at the weight in relation to the age of these babies—varying from 4 to 10 months—shows that they were an exceptionally well developed group⁸ (Table 4). The test for inorganic phosphate was omitted. The result of this study is reproduced in the table. It will be noted that ten babies, or 40 per cent., showed rickets by roentgen ray, nine had decided beading of the ribs (+), and seven had craniotabes. Leaving craniotabes out of consideration, and including only such cases as showed rickets either roentgenologically or by beading, it is found that thirteen of twenty-five, or more than one-half, had rickets. This high percentage may seem surprising. It is due to the fact that the investigation was carried out at the end of March, a time when every potential case of rickets had developed and none had undergone spontaneous cure. Most of these infants had to depend on breast milk to protect them from rickets and were deprived of the powerful adjuvant of sunlight. In this respect breast milk is not endowed with a marked factor of safety.

Our experience with bottle-fed babies coincides in general with the pathologic report of Schmorl.⁷ If the most refined tests are employed and careful examinations are carried out at a time when the incidence is highest, almost all artificially fed infants will be found to have a certain degree of rickets. This, of course, does not apply to the exceptional infant who receives an abundance of sunlight.⁹ This year, at consider-

8. In view of the theory which suggests a lack of fat soluble vitamin as the determining factor in rickets, it may be remarked that the mothers also were well nourished. Many of them consumed a quart of milk a day; on account of religious scruples they do not eat oleomargarine but only sweet butter. In this connection reference may be made to a breast-fed infant in our institution which developed rickets. It was the baby of a wet nurse whom we know to have been on a liberal diet which included fresh vegetables and one or two quarts of milk daily.

9. Nor does it apply with equal force to the baby born in the winter, and who at the end of March—the peak of the rickets season—is but 3 or 4 months of age. It has seemed that infants born about the beginning of February were least likely to develop rickets; they are subjected to only a few months of lack of sunlight and then enjoy a prolonged period of intense sunlight. Under ordinary conditions rickets does not develop after the beginning of May.

TABLE 4.—INCIDENCE OF RICKETS IN MARCH AMONG 25 BREAST FED INFANTS (BABY WELFARE STATION)

Case	Age, Mos.	Weight, Lbs.	Condi- tion	Head	Fontanelle, Inches	Cranio- tabes	Teeth	Rosary	Epi- physeæ	Bow Legs	Sits	Pot Belly	Diag- nosis Recti	Umbil- ical Hernia	Muscles	Spleen Palpa- ble	Radiograph		Remarks
																	Epiphyses	Carpal Centers	
1	6	13-14/16	Good	.....	2×2	+	0	+	0	+	0	0	+	0	Good	0	Rickets	2	Receives cereal
2	9	21-2/16	Good	.....	$1 \frac{1}{4} \times 1$	+	4	0	0	0	Sits	+	+	0	Good	0	Spreading	2	
3	6	14-12/16	Good	.....	$1 \frac{1}{4} \times 1 \frac{1}{4}$	+	0	Slight	0	0	Sits	+	+	0	Good	0	Rickets	2	
4	4	12	Good	.....	$1 \frac{1}{2} \times 1 \frac{1}{2}$	+	0	Slight	+	0	0	0	+	+	Soft	0	Rickets	1	
5	4	12-8/16	Pale	Square	$1 \frac{1}{2} \times 1 \frac{1}{4}$	0	0	+	+	+	0	0	+	0	Fair	0	Rickets	2	
6	9	12	Good	.....	$\frac{3}{4} \times 1$	0	0	Slight	0	0	0	0	0	0	Good	0	Negative	2	
7	4½	10	Fair	.....	$\frac{3}{4} \times \frac{3}{4}$	0	0	+	+	+	0	+	+	+	Poor	4 cm.	Negative	3 and radius	Had measles; indoor 3 months; receives cereal and broth
8	6	18-8/16	Good	.....	$1 \frac{1}{4} \times 1$	0	0	0	0	0	Sits	0	+	0	Good	0	Negative	2	
9	8	16-12/16	Poor	.....	$\frac{1}{2} \times 1 \frac{1}{2}$	0	0	+	0	0	Sits	0	+	+	Poor	0	Spreading	2	Outdoors once a week
10	6	19	Good	.....	$1 \frac{1}{2} \times 1$	0	0	Slight	0	0	0	0	+	0	Fair	2.5 cm.	Rickets	3	Outdoors once a week;
11	8	15	Fair	.....	$\frac{1}{2} \times 2$	+	0	+	+	+	0	+	+	+	Poor	0	Rickets marked	1	receives milk with zwiebach
12	5	18	Fair	.....	$1 \frac{1}{2} \times 1 \frac{1}{4}$	+	0	Slight	0	0	0	0	+	0	Soft	0	Rickets	2	Outdoors every day
13	6	15-8/16	Good	.....	1×1	+	0	Slight	0	+	Sits	+	+	0	Soft	2.5 cm.	Spreading	2	Never outdoors
14	9	20-8/16	Good	.....	$1 \frac{1}{2} \times 1$	0	0	0	0	+	Sits	+	+	0	Soft	4.0 cm.	Negative	2	
15	6	17-7/16	Good	.....	$1 \frac{1}{2} \times 1$	0	0	0	0	0	0	0	+	+	Poor	0	Negative	2	
16	4	15-6/16	Good	.....	$\frac{3}{4} \times \frac{3}{4}$	0	0	0	0	0	0	0	+	+	Good	0	Rickets (?)	2	Never outdoors
17	4	10-14/16	Fair	.....	$1 \times 1 \frac{1}{4}$	+	0	0	0	0	0	0	+	+	Poor	0	Negative	2	
18	5½	16	Good	.....	$1 \frac{1}{2} \times 1 \frac{1}{2}$	+	0	+	0	+	0	0	+	+	Fair	4.0 cm.	Rickets	2	Out every day
19	4	11-11/16	Pair	.....	$\frac{2}{2} \times 2$	0	0	0	0	0	0	0	+	0	Good	0	Negative	0	Out every day
20	5	16-4/16	Good	.....	$1 \frac{1}{4} \times 1$	0	0	0	0	0	0	0	+	0	Good	0	Negative	0	Out every day
21	9	17-7/16	Fair	.....	$1 \frac{1}{2} \times \frac{3}{4}$	0	2	+	0	0	Sits	+	+	0	Good	0	Negative	2 and radius	Out every day; re- ceives cereal
22	6½	16 11/16	Good	.....	$1 \frac{1}{2} \times 1 \frac{1}{2}$	0	0	0	+	+	0	+	+	0	Fair	0	Negative	2	Out every day; re- ceives cereal
23	5	16	Good	.....	2×2	+	0	+	+	0	0	+	+	0	Good	0	Rickets moderate	2	Out once a week
24	7	16-9/16	Good	.....	$1 \times \frac{3}{4}$	0	0	+	0	0	0	+	+	0	Good	0	Rickets	2 and 1	Out every day
25	4	16	Good	.....	$1 \frac{1}{2} \times 1 \frac{1}{2}$	0	0	0	0	0	0	0	+	0	Fair	2.0 cm.	Negative	2	Out every day
Total						7 +	...	9 +	5 +	..	..	..	..	..	....	...	10 rickets		

able expense, we attempted to prevent rickets by means of feeding a large number of babies on certified raw milk. In spite of this excellent diet they developed evidences of mild rickets in the course of the winter. Of the entire group of fifty-three infants, only two were entirely free from signs of this disorder; if we do not accept low inorganic phosphate as equivalent to rickets, seven additional cases must be considered as negative, making nine in all. In our opinion certainly all of these seven cases should not be excluded, as a diminution of inorganic phosphate generally is associated with rickets. It should be borne in mind that these figures do not apply to one month of the winter but to the entire period ending in April. The incidence of rickets increases steadily month by month throughout the winter, being far greater in March than in January, the decrease beginning toward the end of April (in the temperate zone), depending somewhat on local climatic conditions and especially on the character of the season.¹⁰ If these fifty-three cases are judged by the classic text book description of rickets, only nineteen fall into this category. This indicates how difficult it is to state the frequency of rickets, and how its incidence will appear to be high when intensive examinations are employed. These newer diagnostic methods enabled us, however, to begin treatment at the earliest moment, so that many cases were cured in January or February by means of cod liver oil or heliotherapy, which would not have been recognized under ordinary circumstances until some months later when they had become more evident.

CONCLUSIONS

With our broader conception of rickets, diagnosis has become increasingly difficult. Of the immediate clinical signs the most reliable is beading of the ribs, to which more attention should be paid. The great disadvantage of this sign is that it does not aid in differentiating between the active and the inactive phases of the disorder.

Roentgen ray examination of the epiphyses has proved disappointing. Frequently it does not demonstrate lesions at a time when the diagnosis can be established definitely by other methods. A negative roentgenogram has, therefore, little value in deciding the question of early rickets. It is a most valuable sign, however, in judging whether rickets is healing or whether a therapeutic agent is of value.

The inorganic phosphate of the blood is generally diminished in rickets in the early stages, long before the roentgen ray gives evidence of the disorder, and frequently as early as, or earlier than, beading of the ribs. It is not, however, pathognomonic, as there are other factors

10. The winter of 1920-1921 was particularly mild, and rickets was correspondingly mild and began to disappear early; the previous winter was exceptionally severe leading to marked rickets and a prolongation of its season.

leading to a diminution of inorganic phosphate. On the other hand, rickets is occasionally met with where the blood analysis is normal in this respect.

A group of well nourished breast-fed infants, examined clinically and by roentgen ray at the end of March, showed rickets in more than 50 per cent. of the cases.

Rickets is not only more prevalent in the winter but its incidence increases month by month until April. It is far more frequent in March and April than in December and January. If its incidence is studied when it is at its flood, and use is made not only of the ordinary clinical signs, but also of the newer methods of diagnosis (roentgen ray and chemical tests) we shall find that almost all bottle-fed infants give some indication of rickets.