Serum Magnesium Levels in the Newborn and Older Child*

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In the past, reluctance to determine the serum magnesium level in the newborn infant has been due in part to the relative unreliability of methods hitherto employed (Wacker and Vallee, 1958), and the need for large amounts of blood, particularly where repeat determinations are proposed.

In 1964 Rice and Lapara described a rapid, accurate ultramicro method for the determination of ionic magnesium using Mann's Dye. In contrast to the commonly used Titan Yellow method, this method has the advantage of being unaffected by the presence of calcium gluconate (Anast, 1963), making it particularly useful for the determination of the behaviour of magnesium during the course of exchange transfusions (Bajpai, Sugden, Stern, and Denton, 1966).

It is established that hypomagnesaemia in the adult can give rise to clinical symptoms (Hanna, Harrison, MacIntyre, and Fraser, 1960). Recent interest in magnesium levels in the newborn infant has been stimulated by the report of hypomagnesaemia associated with convulsions (Davis, Harvey, and Yu, 1965), and neonatal respiratory depression secondary to hypermagnesaemia from maternal magnesium sulphate administration (Fishman, 1965). In a previous report from this laboratory, we have been able to demonstrate a fall in serum Mg^{++} levels during the course of exchange transfusion with citrated blood accompanied in extreme cases by electrocardiographic changes (Bajpai *et al.*, 1966). The present report gives our findings in detail using the ultramicro method to determine the Mg^{++} levels in the newborn, changes during the

first days of life, and a comparison of capillary as opposed to venous blood for these determinations.

Methods and Materials

Blood was analysed for serum Mg^{++} from a total of 56 newborn infants within the first week of life. For venous blood analysis a No. 21 scalp-vein needle was placed in the antecubital vein and the blood was allowed to drip directly into a dry glass test-tube. For cord blood, the blood was similarly expressed into the tube. With capillary determinations a heel prick sample was collected in a similar manner, with the blood being allowed to drip into the tube directly from the warmed heel. The blood was allowed to clot and then centrifuged at 2,000 r.p.m. for 10 minutes. The supernatant serum was then removed and frozen until time of analysis within 24 hours.

The basis of the determination is a colour change from blue to purple, resulting from the addition of Mg^{++} to Mann's Dye. 5 ml. Mann's Reagent* was placed in an acid washed test-tube. To this was added 0.02 ml. serum, using a Beckman plastic micropipette. The tube was then capped with Parafilm and inverted several times to ensure mixing. After allowing the sample to stand for 10 minutes to permit the reaction to occur to completion, the resultant colour change was read in a Beckman Model B spectrophotometer, using 1.0 cm.² pyrex cuvettes, and compared to a known 2 mEq/l. magnesium standard. Total time of determination, including calculation, averaged less than 20 minutes. All determinations were done in duplicate with agreement to within 3% (± 0.04 mEq/l.).

All the infants in the study had serum Mg^{++} determined on the first day of life. In 27 of the 56 infants successive determinations were done on the 3rd and 5th day as well. Paired simultaneous venous and heel capillary samples were studied in 16 infants. Cord blood was available for analysis in 18 cases. Of the 27 infants in whom determinations were done after the 3rd day of life, 22 were bottle-fed and 5 were breast-fed.

Received November 4, 1965.

* Supported in part by Public Health of Canada Research Grants, No. 604-13-79 and 604-7-482.

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* The preparation of the reagent from Mann's Dye. Sodium 1-azo-2-hydroxy-3 (2, 4-dimethylcarboxanilide) naphthalene-1 (2 hydroxy-benzene-4-(sulfonate)) is detailed in the method of Rice and Lapara (1964). Similar details are given for the preparation of the other solutions and diluents used and the formula employed in the final calculation.

The artificial feeding consisted of a standard formula containing a 2% or 4% fat, evaporated milk. (Usually the formula is changed from the partly skimmed (2%) to the full (4%) evaporated milk on the 5th day. However, the mineral composition of the formula remains the same.)

To compare our findings in the newborn with values for older children, venous blood from 64 infants and children ranging from 1 to 16 years was analysed, using a similar method to that outlined above.

Results

Mean values for newborn. The mean value for serum Mg^{++} in the 56 infants studied was 1.51 ± 0.12 mEq/l. (range 1.20-1.80 mEq/l.). The bell-shaped distribution of the sample may be appreciated from Fig. 1. When serial values are analysed it is apparent that there are no significant changes with time in the first week of life (see Fig. 2), though the cord blood level tends to be somewhat higher than the ensuing levels in the infant's serum.

Venous v. capillary values. The comparison between simultaneous venous and capillary samples (Table) shows a slightly higher level in the venous blood. Thus, the mean venous level for the group was 1.51 ± 0.11 mEq/l. as opposed to 1.45 ± 0.03 mEq/l. for the capillary samples. The differences are not significant ($p > 0.05$), and interpretable data are thus obtainable from either source.

Breast v. bottle feeding. In the infants studied beyond the third day, mean levels for the 22 artificially-fed infants were 1.50 ± 0.11 mEq/l., while the 5 breast-fed infants had a mean level of 1.46 ± 0.07 mEq/l. Neither of these values differs appreciably from the mean value for the total group (see above).

TABLE
Paired Venous and Capillary Serum Mg^{++} Levels

Case No.	Venous Blood (mEq/l. Mg^{++})	Capillary Blood (mEq/l. Mg^{++})
1	1.70	1.40
2	1.70	1.50
3	1.50	1.40
4	1.60	1.36
5	1.50	1.36
6	1.40	1.50
7	1.36	1.60
8	1.55	1.40
9	1.65	1.40
10	1.40	1.40
11	1.50	1.40
12	1.54	1.40
13	1.40	1.40
14	1.40	1.40
15	1.40	1.60
16	1.60	1.60
Mean	1.51	1.45
S.D.	± 0.11	± 0.03

FIG. 1.—Serum magnesium in 56 infants in first week of life. The dotted lines show the limits for the standard deviation.

FIG. 2.—Serum magnesium during first week. The mean values are joined by the dotted line. The outside limits indicate the standard deviation in each group.

Comparison with older infants. Mean value using venous blood for the 64 older infants and children in the group was 1.82 ± 0.14 mEq/l. A similar bell-shaped distribution was obtained for the group (see Fig. 3).

Discussion

The figures reported here for Mg^{++} in the first week of life are comparable to, though slightly lower than, those reported by Anast (1964): using the Titan Yellow method (Orange and Rhein, 1951), he obtained a mean value of 1.92 ± 0.27 mg./100 ml. over the first 5 days of life. In comparable units this equates to 1.57 mEq/l. It should be noted, however, that this is a value using heel prick blood. The comparable figure in our series based on the venous capillary comparison would be 1.45 mEq/l.

From the point of view of clinical suitability, the

FIG. 3.—Serum magnesium in 64 children aged 1-16 years. The dotted lines show the limits for the standard deviation.

method used in this study is both rapid and truly ultramicro. Although the theoretical need is for 0.02 ml. serum, the use of a blank plus the technical problems of pipetting require the order of 0.1 ml. serum for the determination. The use of a blank tube in the determination permits an accurate adjustment for the presence of both bilirubin and mild haemolysis, which is frequently present in the sera of newborn infants (Michaëlsson and Sjölin, 1965). The ability to use very small amounts is a distinct advantage in the newborn infant with a usually high haematocrit and where repeat determinations may be desired.

The absence of interference by the presence of calcium or gluconate makes this the method of choice in the investigation of serum Mg^{++} during exchange transfusion (Bajpai *et al.*, 1966), and when dealing with convulsive disorders where prior or concurrent calcium therapy is being carried out.

As seen from Fig. 2 there is no real difference in levels throughout the first week of life. It is interesting to note, however, that the mean cord level (1.64 ± 0.12 mEq/l.) is somewhat higher than the ensuing levels in the first week of life. While the difference in the mean values is not very impressive, the individual values show the identical trend in all 15 cases in which paired cord and subsequent venous samples were available (Fig. 4).

The comparison of the venous versus capillary pairs indicates that the latter are quite satisfactory for routine clinical purposes.

The values obtained with this method for older children are within the range usually accepted for adults (Batsaikis, Stiles, and Wang, 1963).

There were only a small number of breast-fed infants in the study, but no differences were shown

FIG. 4.—Cord level greater than subsequent infant level in 13 of the 15 cases. In 2 cases (No. 10, No. 12) there is no change. There is no case where cord level was lower than infant level.

between the 5 breast- and 22 bottle-fed infants. The striking uniformity of values is not in agreement with the suggestions made by others that breast-fed infants show a higher (Anast, 1964; Gittleman, Pinkus, and Schmertzler, 1964) or lower (Di Cagno, Balocco, and Castello, 1963) Mg^{++} level in the serum. Ideally, such studies should be accompanied by information about haematocrit levels to allow for variations in hydration of the infants.

Conclusion

Data on serum Mg^{++} levels in 56 newborns and 64 older children, using a rapid ultramicro method, is presented. No appreciable changes could be found in the first week of life, though cord blood levels tended to be somewhat higher than the subsequent sera levels. No differences were noted with breast as opposed to bottle feeding. The lack of any significant differences between venous and capillary blood allows the confident use of capillary samples for this determination in the newborn period.

We should like to express our thanks to Dr. E. Harpur, Director, Department of Biochemistry, Montreal Children's Hospital, for her help in establishing the method and reviewing the manuscript.

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