PART 3: RELATIONSHIP TO ADEQUACY OF LACTATION

BY

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For at least 50 years observations have been made on the chloride content of women's milk. Some of the results suggest a relationship between the chloride content of the milk and either the adequacy of lactation or the milk yield; the chloride values below 50 mg. % being usually associated with adequate and those above 50 mg. % with inadequate lactation (Holt, Courtney, and Fales, 1915; Sisson and Denis, 1921; Widdows, Lowenfeld, Bond, Shiskin, and Taylor, 1935; Nozaki, 1934; Ishii, 1937). It has been shown in Part II that there is not only a relationship between the chloride content of milk and adequacy of lactation, but also a relationship between the electrical conductivity of milk and adequacy of lactation, the average values for both being lower in women with adequate than in those with inadequate lactation. However, a proportion of the women with poor lactation had milk of low chloride content and low conductivity while some women with adequate lactation had milk of relatively high chloride content and conductivity.

To decide whether the determination of either the chloride content or the electrical conductivity of women's milk was of practical value, a series of 538 specimens of milk from women in the second week to the fifth month of lactation inclusive were examined; 352 were taken from women with adequate lactation, and 186 from women with inadequate lactation. The mothers providing the samples of milk gave two specimens from the same breast, one before the 6 a.m. feed and the other before the mid-day feed (12 p.m. or 2 p.m.) on the same day.

A second series of observations involving the chloride estimation and the electrical conductivity measurement of milk taken from both breasts of each woman was considered necessary, in view of a number of anomalous results obtained in the first series. One hundred and thirty-six specimens of milk taken during the third week to fifth month of lactation were examined; 72 were obtained from mothers with adequate lactation, and 64 from mothers with inadequate lactation. The mothers providing samples gave one from each breast before the 6 a.m. feed and one from each breast before the mid-day breast feed. All specimens obtained from each mother were collected in separate containers and tested separately. In both series of cases, each sample amounted to about 8 ml. and was expressed into a special container that had been thoroughly cleansed, rinsed in distilled water, and dried in an oven.

All the mothers were apparently healthy and had given birth to a mature infant which fixed well at the breast and was fed at regular intervals five or six times a day. The infants were apparently normal at the time of the test. The choice of a mother with adequate lactation was made by noting that her infant was gaining weight while it was entirely breast fed. Women with inadequate lactation were selected by first finding a mother whose infant was healthy, but who was not gaining weight, or who required complementary feeds. Such infants were then test-fed for at least 24 hours. If the results showed that the babies did not receive 2 oz. milk per lb. body weight per day, they were considered to be under-fed.

The methods of estimation have been described in Part 1.

Results of Chloride Investigation

A summary of the results of both series of investigations on the chloride content is given in Fig. 1, which shows the mean chloride content of the early morning and mid-day milk specimens obtained from a given breast. The values obtained from mothers with inadequate lactation are generally higher than those from mothers with adequate lactation. In Fig. 1 the results are divided according to the time after parturition at which the milk sample was taken. For each of these weekly or monthly stages, a level has been chosen above which lies the majority of chloride values for milk obtained from women with inadequate lactation and below which lies the majority of values for women with adequate lactation. This 'critical' level for milk specimens taken in the third and fourth weeks of lactation is 75 mg. NaCl. per 100 ml. milk; for milk taken in the second month it is at 60 mg. NaCl., and for milk taken in the third to fifth months it is at 55 mg. NaCl. For milk taken during the second week of lactation, the division is not so clear-cut, and therefore, two 'critical' levels instead of one are necessary, the lower being at 75 mg. NaCl. per 100 ml. milk, and the higher at 112 mg. NaCl. per 100 ml. milk. Values below the lower critical level are usually associated with adequate lactation, while
those above the upper critical level are generally associated with inadequate lactation. Values lying between the two critical levels are without diagnostic significance.

If the mother's milk chloride lies below the critical level, it is likely that she can satisfy her infant on the breast. If it falls above, she is probably not producing enough milk to meet her infant's requirements. For 11.9% of the mothers with an adequate supply (series I) in the third week to fifth month of lactation the chloride test was misleading because the chloride values were above the critical level, which suggested that these women had inadequate lactation. Similarly, anomalous results were obtained for 17.4% of the mothers (series I) with an inadequate supply in the third week to fifth month of lactation whose milk had a chloride content below the critical level.

Some light has been shed on the origin of the majority of these anomalous results (series I) by the results obtained for the chloride content of milk taken from both breasts of women in the third week to fifth month of lactation (series II). In this series, 22 women were lactating adequately and 22 inadequately. It was noted that three of the women with adequate lactation and five of those with inadequate lactation had one breast functioning well and the other functioning badly, as judged by the comparison of milk chloride from each breast with the relevant critical chloride level. In such cases, therefore, the chloride test did not reveal whether or not these women were lactating adequately, and it was necessary to depend on the results of test-feeding of the infants to decide whether the mother's lactation was adequate.

The extent to which unilateral breast dysfunction accounts for anomalous results in the milk chloride test depends on its frequency. Judging from the series of 44 cases, it was present in three out of 22, or 13.6% of mothers with adequate lactation, and in five out of 22, or 22.7% of mothers with inadequate lactation. It is to be expected that the accuracy of the test could be considerably increased by testing both breasts.

When considering anomalous results obtained in the first series, another explanation must be kept in mind. In two mothers in the second series of 44 cases, the milk from both breasts had a chloride content below the critical level and yet the milk output was inadequate. This type of breast function may be due to hypoplasia of the gland tissue. Breast disorders of this nature cannot be detected by the milk chloride test and will, consequently, remain a source of error.

In conclusion, it can be said that the milk chloride test is a valuable indication as to whether or not a
mother is lactating adequately, particularly if both breasts are tested and the results are in agreement. If the chloride content of milk from one breast is below the critical level, while that of milk from the other breast is above the critical level, no definite decision as to the adequacy of lactation can be made and in such a case it is desirable that the mothers’ infants should be test-weighed.

It seems clear that in a few cases mothers may have a low chloride value for milk from both breasts and yet have an inadequate milk yield. The type of case, however, appeared to be of infrequent occurrence, only two being encountered in 44 cases. The fact that they do exist reduces the value of this test as a method of assessing adequacy of lactation.

Results of Electrical Conductivity Measurements

A summary of the electrical conductivity measurements of both series of cases is presented (Fig. 2) in a similar way to those of the milk chloride investigation. Fig. 2 shows that the conductivity values of milk taken from mothers with inadequate lactation are generally higher than those for milk taken from mothers with adequate lactation. As in the case of chloride values, it is possible to fix a ‘critical’ level for each stage of lactation below which lies the majority of values for women with adequate lactation, and above which lies the majority of values for women with inadequate lactation. The critical level of milk specimens taken during the third and fourth week of lactation is at $225 \times 10^{-5}$ ohm$^{-1}$ cm.$^{-1}$; for milk taken in the second month of lactation it is at $210 \times 10^{-5}$ ohm$^{-1}$ cm.$^{-1}$; and for milk taken in the third to fifth month of lactation it is at $200 \times 10^{-5}$ ohm$^{-1}$ cm.$^{-1}$. For milk taken in the second week, two critical levels are used for diagnostic purposes, the lower one at $225 \times 10^{-5}$ ohm$^{-1}$ cm.$^{-1}$ and the higher one at $275 \times 10^{-5}$ ohm$^{-1}$ cm.$^{-1}$. Values below the lower critical level are generally associated with adequate lactation, while those above the upper critical level are usually associated with inadequate lactation. Values lying between the two critical levels are without diagnostic significance.

The importance of the critical levels in distinguishing cases of good lactation from those of bad lactation is shown by the fact that 92·1% of the women (series I) with an adequate supply in the third week to fifth month of lactation had values
below the relevant critical level, and 89·9% of the women (series I) with an inadequate supply in the third week to fifth month had values above the critical level.

The results of the electrical conductivity estimations made on milk obtained from a series of 44 women who had both breasts tested during their third week to fifth month of lactation have elucidated some of the anomalous conductivity results obtained in the first series. Thus, in the series of 44 women, three women with adequate lactation and five with inadequate lactation have unilateral breast dysfunction as judged by the electrical conductivity test. These findings are similar to those obtained in the second series of observations on the milk chloride test.

The incidence of unilateral breast dysfunction in the series of 44 cases is three to 22, or 13·6% of mothers with adequate lactation, and is five to 22, or 22·7% of mothers with inadequate lactation. The percentage is considerable, and it is probable that many of the anomalous cases noted in the first series had unilateral breast dysfunction. In order to detect such cases, and thus to increase the accuracy of the electrical conductivity test, milk from both breasts must be tested. In cases of unilateral breast dysfunction adequacy of lactation cannot be assessed by the conductivity test alone.

There was one other anomalous result in the second series, apart from those due to unilateral breast dysfunction. In this case, the conductivity value of milk from both breasts was below the relevant critical level, and yet the mother was lactating inadequately. A similar result was obtained from the chloride values of the same woman. The explanation is obscure, but the phenomenon is possibly due to hypofunction of the breast, resulting from lack of secretory tissue.

The conclusions drawn from the investigation on the electrical conductivity of milk are similar to those for the investigation on the chloride content of milk. The electrical conductivity test is a valuable indication of the adequacy of lactation, particularly if both breasts are tested and the results from both are similar. If the conductivity value of milk from one breast is below the relevant critical level, but that of the other is above the critical level, no definite decision on the adequacy of lactation can be made. In such cases, the infants should be test-weighed.

**Discussion**

In the past it has been shown that women between the second week and the fifth month of lactation and with a milk chloride content of less than 50 mg. % usually lactated adequately but those with a milk chloride of more than 50 mg. % usually lactated inadequately (Sisson and Denis, 1921; Nozaki, 1934; Widdows et al., 1935; Ishii, 1937). The chloride level of 50 mg. % quoted by previous investigators is analogous to the five critical levels selected in the present investigation.

The factors which may be responsible for the marked variation in the chloride content of milk being detected only in the present series of women are numerous. The nationality, climatic conditions, and diet of the women differed from those investigated in the past. It is probable that the salt intake for each series of women under investigation was not constant, and if the intake had been increased (Baldassi, 1941) or diminished sufficiently (Sacco, 1932, quoted by Dickinson, 1935) the chloride content of their milk might have altered. Differing methods of milk sampling may also account for the lack of uniformity in the results obtained by different investigators.

**Summary**

Estimations of the chloride content and electrical conductivity have been made on specimens of milk taken from 420 women with adequate lactation, and 250 women with inadequate lactation, and the results obtained from the two groups compared. The women examined had been lactating for periods ranging from two weeks to five months.

The conclusions drawn from the comparison of the results obtained from the two groups of chloride examinations were the same as those obtained from a comparison of the electrical conductivity values. The two methods of estimation used were equally efficient and both were quick and simple to perform.

It has been shown that the majority of adequately lactating women have milk with a lower chloride content and conductivity value than women lactating inadequately. Thus it has been possible to select both chloride and electrical conductivity values above which most values were for women with inadequate lactation and below which they were usually for women with adequate lactation.

Either the chloride or the electrical conductivity values for women's milk gave a good indication as to the adequacy of lactation, particularly if the milk from both breasts was tested.

Anomalous results limit the practical value of both the chloride and conductivity estimations as a test for adequacy of lactation; in a small proportion of cases a low chloride or conductivity result was obtained in the presence of inadequate lactation and in 18% of a small series of chloride and conductivity estimations made on milk from both breasts separately a high milk yield from one breast and a low yield from the other was demonstrated.

Explanations have been offered for anomalous results. The clinical significance of the anomalous
result which indicated that there was a high milk yield from one breast and a low yield from the other was doubtful, and in such cases further investigation is necessary before deciding the best method of feeding the infant.

The influence of the stage of lactation upon the chloride content of women's milk is discussed.

REFERENCES

PART 4 : RESULTS AND THEIR RELATIONSHIP TO MILK YIELD AND TO DURATION OF LACTATION

BY

R. A. MILLER and I. I. A. JACKSON

It has been shown that the estimation of electrical conductivity and chloride content of women's milk are of equal value as methods of determining the adequacy of lactation. It is evident that these tests would prove of practical value if it were shown that the electrical conductivity or chloride content of milk from one breast could be correlated with the daily milk yield from that breast, and similarly if these tests when performed on milk taken from women in the first month of lactation were shown to give some indication of the length of time these women would breast-feed their infants. This paper deals with the investigation of these two problems.

Daily Milk Yield from One Breast Correlated with Electrical Conductivity and Chloride Content

For the correlation of the daily yield from one breast with the electrical conductivity and chloride content of the milk a series of observations was made on women who were breast-feeding their infants. The mothers who were subjected to the investigation were apparently healthy and had infants who fixed well on the breast. Each had been lactating from between two weeks to five months. Forty-nine mothers in the first month of lactation and 61 mothers in the second to fifth month of lactation were tested. The amount of milk secreted by one breast in a day was measured by weighing the infant before and after it was put to that breast. The residual milk was not expressed and measured because this could not be supervised or performed skilfully by every woman who was examined. Every specimen used for conductivity and chloride tests consisted of approximately 4 ml. of milk. One specimen was taken before the early morning feed, one before the mid-day feed, and one before the evening feed, and each was taken on the day that the baby was test-weighed.

Results

The average daily milk yield for one breast for women secreting milk of a particular electrical conductivity is shown in Table 1A.

The minimum yield was 0·5 oz. when the conductivity of the milk was 371 to $390 \times 10^{-5}$ ohm$^{-1}$ cm.$^{-1}$, the maximum yield was 13·1 oz. with a conductivity of 170 to $190 \times 10^{-5}$ ohm$^{-1}$ cm.$^{-1}$. From Table 1A it is apparent that there is an inverse

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<th>Table 1A</th>
<th>RELATIONSHIP OF THE MEAN ELECTRICAL CONDUCTIVITY VALUE OF MILK FROM ONE BREAST TO THE DAILY YIELD FROM THE SAME BREAST</th>
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<td>Group</td>
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