# ELECTROLYTE STUDIES IN LEPROSY

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A review of the biochemistry of leprosy up to 1938 was published by Villela in 1938 ([5]), and another covering the period from 1938 to 1954 by one of us in 1955 ([2]). These reviews include reports on serum proteins, calcium, inorganic phosphorus and the alkali reserve; magnesium has been recently reported from this laboratory ([3]). The advent of more practical laboratory techniques has led to a phenomenal expansion of studies in human biochemistry. Studies of potassium, sodium and the acid-base balance have become part of every-day clinical medicine. Since the status of the electrolytes potassium and sodium in leprosy has not been reported, it is desired to add to basic information this report of a study of electrolytes occurring in the blood of leprosy patients.

## MATERIALS AND METHODS

This study was based upon 143 cases of leprosy, including 128 of the lepromatous and 15 of the tuberculoid types. Of the 100 uncomplicated lepromatous cases, 85 were clinically active (i.e., bacteriologically positive) and 15 were clinically inactive or arrested (i.e., bacteriologically negative). Another 24 lepromatous cases were undergoing reaction of the erythema nodosum leprosum type, and in 4 others there was complication by amyloid nephrosis. Of the 15 tuberculoid cases, 8 were classed as active and 7 as inactive on the basis indicated. There were 110 males and 33 females. Their ages ranged from 16 to 73 years. The duration of leprosy was from 1 to 53 years. Parallel analyses were performed on 18 nonpatient controls.

Each patient was seen before the day of bleeding to ascertain the presence or absence of erythema nodosum leprosum or other types of reaction. The patients' charts were reviewed and tabulations were made of race and sex, of type, activity and duration of disease, and of presence or absence of amyloid nephrosis. The patients who had had radiograms of the hands or feet months or years previously were x-rayed again for evidence of progressive absorption.

Analyses were made of the carbon dioxide combining power and pH of the plasma, and serum was used for the determinations of proteins, calcium, phosphorus, potassium, sodium, magnesium and chloride.

Approximately 25 cc. of venous blood was collected in the post-absorptive state. Five cc. of this was delivered into specially constructed tubes containing a small amount of anticoagulant and heavy neutral paraffin oil to prevent absorption of atmospheric gases. This was centrifuged and the plasma used for the determinations of the carbon dioxide combining power and the pH. Serum obtained from the rest of the specimen was used for all other determinations. All analyses were completed within 48 hours.

The carbon dioxide estimation was made with the Van Slyke blood-gas apparatus. The pH was determined by means of a Coleman electrometer at room temperature and corrected to 38°C. The serum proteins were estimated by the method of Wolfson ([6]), who utilized the biuret reaction of Weischselbaum. Serum magnesium was determined by a spectrophotometric method. Serum calcium was determined by the method of Clark and Collip, and the inorganic phosphorus by the Benedict Theis method. These methods have been previously published from this laboratory ([7, 8]). The Whitehorn method was used for the determination of serum chlorides ([1]). Serum potassium and sodium were determined by flame photometry using a Coleman Jr. flame photometer attached to a Coleman Jr. spectrophotometer.

## RESULTS

The data obtained are shown in Tables 1 and 2. In Table 1(*a-c*) are the minimum, maximum and average values of the serum electrolytes in

TABLE 1.—*Range of serum electrolytes in the 18 normal controls and the 142 leprosy cases studied.*

| | Carbon dioxide combining power mEq/L | pH | Total protein | Albumin | Globulin | Total calcium | Inorganic phosphorus | Potassium | Sodium | Magnesium | Chlorides |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | gm. per cent | | | mgm./% | gm./% | mEq/L | | | |
| | (a) *Controls, 18 cases* | | | | | | | | | | |
| Minimum | 25.20 | 7.40 | 5.8 | 3.2 | 2.2 | 8.7 | 3.1 | 3.7 | 135.0 | 0.9 | 102 |
| Maximum | 31.99 | 7.45 | 7.0 | 4.1 | 3.0 | 10.5 | 4.5 | 5.0 | 152.0 | 1.2 | 121 |
| Average | 27.68 | 7.43 | 6.5 | 3.7 | 2.6 | 9.3 | 4.2 | 4.0 | 138.0 | 1.1 | 114 |
| | (b) *Tuberculoid leprosy, 15 cases* | | | | | | | | | | |
| Minimum | 17.55 | 7.37 | 6.0 | 2.5 | 1.6 | 8.5 | 3.0 | 3.90 | 121.0 | 0.37 | 96 |
| Maximum | 29.47 | 7.47 | 6.4 | 4.6 | 3.7 | 11.1 | 5.1 | 5.80 | 149.0 | 1.20 | 105 |
| Average | 25.57 | 7.40 | 6.2 | 3.8 | 2.4 | 10.0 | 3.9 | 4.54 | 135.8 | 0.80 | 103 |
| | (c) *Lepromatous leprosy without complications, 100 cases* | | | | | | | | | | |
| Minimum | 17.55 | 7.32 | 5.0 | 2.1 | 2.2 | 6.45 | 2.8 | 2.60 | 120.0 | 0.37 | 96 |
| Maximum | 32.85 | 7.47 | 7.8 | 4.8 | 5.5 | 11.40 | 5.6 | 6.10 | 150.0 | 1.60 | 111 |
| Average | 25.87 | 7.40 | 6.3 | 3.8 | 3.6 | 9.63 | 4.2 | 4.57 | 135.9 | 0.74 | 104 |
| | (d) *Active (bacteriologically positive) lepromatous leprosy, 85 cases* | | | | | | | | | | |
| Minimum | 17.68 | 7.32 | 5.0 | 2.1 | 2.2 | 6.45 | 2.8 | 2.60 | 120.0 | 0.37 | 96 |
| Maximum | 32.85 | 7.47 | 7.8 | 4.8 | 5.5 | 11.40 | 5.6 | 6.10 | 150.0 | 1.60 | 111 |
| Average | 26.33 | 7.40 | 6.4 | 3.8 | 3.6 | 9.68 | 4.1 | 4.6 | 136.7 | 0.74 | 104 |
| | (e) *Arrested (bacteriologically negative) lepromatous leprosy, 15 cases* | | | | | | | | | | |
| Minimum | 17.55 | 7.32 | 5.4 | 3.0 | 2.2 | 8.35 | 2.8 | 2.60 | 129.0 | 0.41 | 96 |
| Maximum | 31.86 | 7.47 | 6.8 | 4.3 | 3.5 | 11.4 | 5.6 | 5.80 | 150.0 | 1.27 | 108 |
| Average | 25.65 | 7.40 | 6.2 | 3.8 | 2.4 | 9.84 | 4.0 | 4.51 | 136.3 | 0.79 | 102 |
| | (f) *Lepromatous leprosy with erythema nodosum leprosum reaction, 24 cases* | | | | | | | | | | |
| Minimum | 16.83 | 7.35 | 5.0 | 1.8 | 1.6 | 6.45 | 3.0 | 3.10 | 127.0 | 0.37 | 96 |
| Maximum | 30.28 | 7.50 | 7.3 | 4.3 | 5.5 | 10.50 | 5.5 | 6.10 | 148.0 | 1.60 | 108 |
| Average | 24.96 | 7.41 | 6.3 | 3.4 | 2.9 | 9.40 | 4.3 | 4.48 | 135.3 | 0.75 | 103 |
| | (g) *Lepromatous leprosy complicated with amyloid nephrosis, 4 cases* | | | | | | | | | | |
| No. 836 | 17.55 | 7.41 | 5.7 | 3.7 | 2.0 | 9.9 | 6.6 | 3.7 | 131 | 0.41 | 108 |
| No. 1401 | 29.47 | 7.47 | 5.5 | 3.4 | 2.1 | 9.9 | 4.7 | 2.9 | 140 | 0.68 | 108 |
| No. 1740 | 13.50 | 7.30 | 4.5 | 1.8 | 2.7 | 7.5 | 12.0 | 3.1 | 120 | 0.37 | 87 |
| No. 2108 | 10.80 | 7.35 | 4.6 | 2.0 | 2.6 | 5.0 | 8.8 | 4.2 | 130 | 1.02 | 99 |

the 18 nonpatient controls, the 15 cases of tuberculoid leprosy, and the 100 lepromatous cases without complications. In Table 1(*d-e*) are the evaluations of the serum electrolytes in the active and arrested cases of lepromatous leprosy. In Table 1(*f*) are listed the results in the 24 lepromatous cases with the erythema nodosum leprosum type of reaction. The results in 4 cases of lepromatous leprosy complicated with amyloid nephrosis are shown in Table 1(*g*). Table 2 shows the numbers of patients exhibiting values within the normal range in all of the analyses.

Of the 115 uncomplicated leprosy cases the results in 39 (33.9%) were within normal range of all tests performed, while 76 cases (66.1%) were abnormal in one or more of the tests. A reversed albumin-globulin ratio occurred in 33 of the 85 active lepromatous cases, in 1 of the 15 arrested cases, and in 1 of the 15 tuberculoid cases, although the total serum protein was within the normal limits in all but 2 lepromatous cases. These results are in accord with previous work reported from this laboratory ([4]).

With few exceptions, the blood-protein findings follow a definite pattern which varies quantitatively, depending upon the duration and severity of the disease. In uncomplicated leprosy the total proteins are usually within the normal range, the serum globulins show a perceptible increase, while the serum albumin decreases so that the albumin-globulin ratio becomes inverted. In the same individual total serum proteins and their fractions may display significant quantitative fluctuations on different occasions, although the inversion of the albumin-globulin ratio will persist.

The lepromatous and tuberculoid cases showed arithmetic averages within the normal range of our controls except in the following: Serum globulins showed a higher average value in the active lepromatous cases; and serum chlorides were slightly lower in both types of the disease. The carbon dioxide combining power was below the minimum normal value of 25 mEq/L in 20 of the lepromatous cases and in 1 tuberculoid case. Serum calcium was below normal in 8 lepromatous cases and 1 tuberculoid case. Potassium was below normal in 2 cases. Sodium was slightly decreased in 27 of the lepromatous cases. These abnormalities occurred chiefly in the active lepromatous cases. Asymptomatic hyponatremia is encountered in chronic debilitating diseases, and this may account for the slightly lower levels noted in our patients.

With respect to the findings in the 24 lepromatous cases with erythema nodosum leprosum reaction, the averages closely resemble those of uncomplicated lepromatous cases but test variations existed in individual patients. Five of these patients showed values within the normal range in all tests performed, while in 19 of them there were values below the minimum normal range in one or more tests. These are listed as follows:

| *Test* | *Cases below minimum normal* |
|---|---|
| $CO_2$ | 7 |
| Total protein | 1 |
| A/G ratio, reversed | 6 |
| Calcium | 4 |
| Chlorides | 7 |
| Potassium | 1 |
| Sodium | 12 |
| Magnesium | 7 |

The values found in each of the four lepromatous cases complicated with amyloid nephrosis are given in Section (*g*) of Table 1. Case 1740 showed abnormal values in all of the tests. The tests in Case 2108 were abnormal except in pH, magnesium and potassium. In Case 836 the values for carbon dioxide combining power, sodium and potassium were low, while phosphorus was elevated. Case 1401 had normal values in all tests except potassium.

The numbers of cases of the several groups in which normal serum electrolyte values were found are summarized in Table 2.

TABLE 2.—*Numbers of leprosy cases with normal serum electrolyte values.*

| Case group | No. of cases | Normal values in all analyses |
|---|---|---|
| Lepromatous, active (bacteriologically positive) | 85 | 21 (24.7%) |
| Lepromatous, arrested (bacteriologically negative) | 15 | 9 (60.0%) |
| Lepromatous with erythema nodosum leprosum | 24 | 5 (20.8%) |
| Lepromatous with amyloid nephrosis | 4 | 0 (0%) |
| Tuberculoid (8 active, 7 inactive) | 15 | 9 (60.0%) |

The following x-ray changes of the hands and feet were noted in films taken 6 to 27 months apart. No definite relationships existed between bone changes and total serum calcium and phosphorus.

1. X-rays were consistently negative in 64 lepromatous and in 4 tuberculoid cases.

2. Atrophy was present but no change was found to have occurred in 30 lepromatous and 6 tuberculoid cases.

3. Increasing atrophy, determined by comparing two sets of films taken

from 6 to 18 months apart, was observed in 2 lepromatous and 3 tuberculoid cases.

4. Marked increase in atrophy was seen in 4 lepromatous and 2 tuberculoid cases.

## COMMENT

The normal volume and composition of the body fluids are maintained in health and disease by a number of mechanisms. Osmotic forces, cellular metabolic activity, the kidneys and the cardiovascular, respiratory and gastrointestinal systems all contribute to this regulation. Consequently, in clinical disorders of electrolyte metabolism, pathogenetic factors may be obscured by compensatory adjustments.

## SUMMARY

The alkali reserve and serum electrolytes have been studied in 18 normal individuals and 143 leprosy patients, of whom 24 lepromatous cases had the erythema nodosum leprosum type of reaction and 4 were complicated with amyloid nephrosis.

In the 115 cases of uncomplicated leprosy, 100 lepromatous and 15 tuberculoid, 76, or 66.1 per cent had abnormal values in one or more of the tests; 39, or 33.9 per cent were within the normal range in all tests performed.

Reversal of the albumin-globulin ratio was found in 33 of the 85 active (i.e., bacteriologically positive) uncomplicated lepromatous cases. The carbon dioxide combining power was below the minimum normal value of 25 mEq/L in 20 of the lepromatous cases, and sodium was slightly decreased in 27 of them. Serum chlorides were slightly below normal in 17.

The average results obtained in the 24 lepromatous cases with erythema nodosum leprosum resemble those of uncomplicated lepromatous leprosy, although there was no constant correlation. Variations in one or more of the tests existed in 19 cases, while 5 showed values within the normal range in all of the tests performed.

Of the 4 cases with amyloid nephrosis, none showed normal values in all tests.

No definite relationship existed between bone changes and the total serum calcium and phosphorus.

## RESUMEN

Se estudiaron la reserva alcalina y los electrolitos del suero en 18 sujetos normales y 143 leprosos, teniendo 24 casos lepromatosos de éstos una reacción de tipo de eritema nudoso leproso y estando 4 complicados con nefrosis amiloidea.

En los 115 casos de lepra sin complicaciones, 100 lepromatosos y 15 tuberculoideos, 76, o sea 66.1 por ciento, mostraron valores anormales en una o más de las pruebas; 33, o sea 33.9 por ciento, quedaron dentro de los límites normales en todas las pruebas ejecutadas.

Se observó viraje de la proporción de albúmina-globulina en 33 de los 85 casos lepromatosos activos (es decir, positivos bacteriológicamente) sin complicaciones. La propiedad de combinar bióxido de carbono quedó por debajo de la cifra normal mínima de 25 mEq/L en 20 de los casos lepromatosos, y el sodio estuvo ligeramente disminuído en 27 de ellos. Los cloruros séricos estaban ligeramente por debajo de lo normal en 17.

Los resultados medios obtenidos en los 24 casos lepromatosos con eritema nudoso leproso se parecen a los de la lepra lepromatosa sin complicaciones, aunque no hubo constante correlación. Hubo variaciones en una o más de las pruebas en 19 casos, en tanto que 5 revelaron valores que quedaban dentro de los límites normales en todas las pruebas ejecutadas.

De los 4 casos con nefrosis amiloidea, ninguno reveló valores normales en todas las pruebas.

No hubo relación bien definida entre las alteraciones óseas y los totales de calcio y fósforo séricos.

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