STUDIES IN SERUM ELECTROLYTES

XIX. NOMOGRAMS FOR CALCULATING MAGNESIUM ION IN SERUM
AND ULTRAFILTRATES

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Nomograms are presented for the calculation of the concentration of magnesium ion in both serum and ultrafiltrates of serum from measurement of concentrations of total serum protein and total serum magnesium. The values for the concentration of magnesium ion may be obtained as follows: (1) Locate the point of intersection of the vertical and horizontal lines through total serum protein and total serum magnesium values, respectively. (2) The concentration may then be read, or interpolated, on the scale of the slanting lines (see Figs. 1 and 2).

Nomograms were derived from the equation

\[ Mg^{++} = \frac{([Mg]) - ([P]) - K + \sqrt{4K([Mg]) + ([P] + K - [Mg])^2}}{2} \]

where \( Mg^{++} \) or \([X]\) = \( Mg^{++} \), \([P]\) = total protein, \([Mg]\) = total magnesium, all in milliequivalents per kilo of \( H_2O \).

This equation was shown to agree with direct measurements of magnesium ion in the preceding paper by Copeland and Sunderman (1). The constant, \( K \), for this equation was based on measurements made on seventeen normal individuals. On the assumption that these results may be extrapolated to levels observed in pathologic conditions, the nomograms have been extended to include values outside the range of observation. Satisfactory agreement with observation has also been obtained with \( Mg^{++} \) concentrations at levels up to 6.0 m.eq. per liter of serum.

Equation 1 is equivalent to

\[ [X]^2 + (33.77 + [P] - [Mg])[X] - 33.77[Mg] = 0 \]

where 33.77 is the value of \( K \) in Equation 1 as found by Copeland and Sunderman (1).

Sunderman (2) found that the weight of water in gm. per kilo of serum may be calculated as gm. of \( H_2O \) per kilo of serum = 4225.6 - 3225.6G, where \( G \) is the specific gravity of the serum.

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Fig. 1. Calculation of concentration of magnesium ion in ultrafiltrate from measurements of total protein and total magnesium in serum.

Fig. 2. Calculation of concentration of magnesium ion in serum from measurements of total protein and total magnesium in serum.
If
\[
f = \frac{1000}{G(4225.6 - 3225.66)}
\]
then \( f \) liters of serum will contain 1 kilo of water.

From the data of Copeland and Sunderman (1) it is noted that the factor for converting \( \text{Mg}^{++} \) per liter of ultrafiltrate to \( \text{Mg}^{++} \) per kilo of \( \text{H}_2\text{O} \) is 1.004, and that 0.242 multiplied by the gm. per kilo of \( \text{H}_2\text{O} \) in serum protein gives milliequivalents per kilo of \( \text{H}_2\text{O} \) in serum protein. Therefore, Equation 2 becomes

\[
(1.004X)^2 + (33.77 + 2.42fP - fMg)(1.004X) - 33.77fMg = 0
\]

where \( X = \text{Mg}^{++} \) in milliequivalents per liter of ultrafiltrate, \( P = \) total protein in gm. per 100 ml. of serum, and \( Mg = \) total magnesium in milliequivalents per liter of serum.

Equation 3 is charted in Fig. 1 for fixed values of \( X \) at 0.2 intervals between 0.6 and 7.0 \( \text{Mg}^{++} \) in m.eq. per liter of ultrafiltrate. The mean value of \( f \) for the seventeen normal sera of Copeland and Sunderman (1) was 1.065, s.d. = 0.003.

For charting Equation 3, \( f \) was considered constant and taken to be 1.065.

Moore and Van Slyke (3) found that

\[
G = \frac{P + 343(1.007)}{343} \quad \text{or} \quad G = 0.00292P + 1.007
\]

Since the per cent ultrafiltrate in serum is approximately \((100G - P)/G\), then,

\[
X = \frac{100GZ}{100G - P}
\]

where \( Z = \text{Mg}^{++} \) in milliequivalents per liter of serum.

Hence, Equation 3 may be rewritten:

\[
(4) \left( \frac{100.4GZ}{100G - P} \right)^2 + (33.77 + 2.42fP - fMg) \left( \frac{100.4GZ}{100G - P} \right) - 33.77fMg = 0
\]

Equation 4 is charted in Fig. 2 for fixed values of \( Z \) at 0.2 intervals between 1.0 and 6.0 \( \text{Mg}^{++} \) in m.eq. per liter of serum.

**SUMMARY**

Two nomograms are presented for the calculation of magnesium ion in serum and in ultrafiltrates of serum, respectively, from measurements of total protein and total magnesium in serum.

**BIBLIOGRAPHY**

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