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A Nomogram for the Determination of Calcium Phosphate Saturation and Critical pH Level in the Saliva.

By

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A nomogram has been constructed by ÖBERG for calculations following the empirical formulas, advanced in an earlier paper by ERICSSON (1949), for examining the saturation conditions of hydroxy apatite in the saliva.

This work proceeded from BJERRUM's formulae for the solubility of hydroxy apatite at 37° C. It shows that this salt has quite a different solubility in saliva from that in the NaCl—HCl solutions used by BJERRUM. At physiological pH values near neutrality the solubility is several times greater in saliva. In spite of this high solubility the saliva on secretion is generally over-saturated and therefore tends to precipitate calcium phosphate. If the pH value falls, *e. g.* through enzymatic acid formation in the bacterial plaques, the degree of supersaturation is decreased until equilibrium is reached at a certain pH level; the degree of saturation is then unity. Below this pH level the saliva is unsaturated and conditions exist for dissolution of hydroxy apatite from the dental hard tissues. The level of saturation is therefore called the critical pH level.

The above-mentioned empirical formulae were derived on the basis of equilibrium experiments with saliva and pulverised dental enamel, and permitted calculation of the critical pH level and, for salivas below pH 6.4, also of the original degree of saturation, after the pH value, the calcium and phosphate concentrations

and the ionic strengths had been analysed. These calculations are useful in the estimation of the chemical resistance of the saliva to dissolution of the dental hydroxy apatite (caries, erosions) and the tendency of the saliva to precipitate calcium phosphate (dental calculus, salivary duct calculi; micro-precipitation according to WOLF & NEUWIRT, see ERICSSON, l. c., p. 18).

These calculations require the construction once and for all of the graphical connection between the pH value, the ionic strength and the dissociation constant of the phosphoric acid; and in addition, on each separate occasion some logarithmic or slide rule computation. The nomogram described here makes for considerable simplification and economy of time.

The principles and methods according to which a nomogram is constructed are given by ARKIN & COLTON (1936), DAVIS (1943) and GILJAM (1943) in their respective papers. The one presented here is a simple alignment nomogram in which the required value of the unknown variable is indicated by means of a sighting line between two given variables. The values of [Ca], [P], $[P]^1$, $[HPO_4]$ and $[HPO_4]^1$ are given in millimoles per litre (mM or mC), the others are unambiguous.

The nomogram permits:

1) determination of $\frac{K'' + A_H}{K''} = R$, an expression used in the following calculations and in calculation according to BJERRUM and SCHMIDT-NIELSEN (see ERICSSON, pp. 30—1, 34—5);

2) determination of the critical pH level of the saliva according to ERICSSON, formula (12), p. 81;

3) determination of the degree of saturation of the saliva as described in the same work, formula (11), p. 80.

Application of the Nomogram.

For reading off, a rule is used with which the marked values on the respective scales are sighted. To facilitate accurate and rapid readings a transparent rule, rotatable about an axis, is preferable, the axis consisting of a pin which can be moved along a marked straight line on the rule.

Determination of the R value from the expression $R = \frac{K'' + A_H}{K''}$.

The rule is placed through the analysed values of pH and μ

on the pH and μ^1 scales, respectively; the R scale then gives the value (R—1), and hence the required value is (R—1) + 1.

Determination of the critical pH level of the saliva.

On the [Ca] and [P] scales the analysed values are found and the rule placed through them. The rule is then rotated around the point of intersection of the sighting line and the A scale (auxiliary scale) until the value of the ionic strength on the μ scale is met. The value read off on the R scale is then *reduced* by one. The rule is laid through this (R—1) value and the ionic strength value on the μ^1 scale, and the critical pH value read off on the pH scale.

Determination of the degree of saturation of the saliva.

Starting with the analysed pH value of the saliva on the pH scale and the μ value on the μ^1 scale, the intersection of the resulting sighting line with the R scale is read off and *increased* by one.

The R value so obtained is combined with the P value on the $[P]^1$ scale. The $[HPO_4]$ value is read off where the sighting line intersects the $[HPO_4]^1$ scale. This value is found on the $[HPO_4]$ scale and the rule laid through this point and the Ca values on the Ca scale.

Through the obtained axial point on the pH scale and the μ value of the analysis on the μ scale is laid the final sighting line which gives the degree of saturation directly on the V scale.

The different moments in the determination of the critical pH level and the degree of saturation are given schematically above the nomogram.

On the original nomogram, reproduced here, to a scale of 1 : 3, the critical pH value and the degree of saturation were determined in a number of actual cases for which the corresponding values were also calculated entirely by numerical computations using four-figure logarithm tables. The differences were thus obtained to the third decimal place, and in exceptional cases to the second. As the effect of the total error of analysis has an order of magnitude of 0.1, the error in reading is insignificant.

Photostat copies of the original drawing of the nomogram may be obtained at cost price from the authors at the address below.

Summary.

A nomogram is presented which enables rapid determination of the hydroxy apatite saturation and critical pH level of the saliva according to empirical formulae advanced in a previous work by ERICSSON (1949).

Résumé.

Un nomogramme est présenté qui rend possible une détermination rapide de la saturation d'hydroxylapatite et le niveau critique de pH, suivant les formules empiriques d'un travail précédent d'ERICSSON (1949).

Zusammenfassung.

Ein Nomogramm wird vorgelegt, das schnelle Bestimmung ermöglicht von der Sättigung an Hydroxylapatit und dem kritischen pH-Niveau des Speichels gemäss empirischer Gleichungen in einer früheren Arbeit von ERICSSON (1949).

References.

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