Stewart's acid-base theory and its importance in medical and biological research

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Traditional theories of acid-base balance are based on the Brønsted-Lowry definition of acids (proton donors, from 1923) and the Henderson-Hasselbalch equation (from 1916), but they are incorrect in several aspects and this has halted scientific and medical advancement.

In 1981[1], Dr. Peter A. Stewart (1921-1993) presented a quantitative method for the calculation of pH in biological systems, which is based on an alternative definition of acids and bases, similar to General Definitions of Solvents [2], where an *acid* is a substance with negative charge (Anion: Cl^-, SO_4^{2-}, HCO_3^-), which increases the concentration of the "Lyonium" ion (H^+ in water) and which reduces the concentration of the "Lyate" ion (OH^- in water), and a *base* is a substance with positive charge (Cation: Na^+ ,K^+, Ca^{2+}, Mg^{2+}), with opposite reactions in water. Stewart's theory[1] separates variables as on their effect on water, therefore *independent variables* modify other variables but are not themselves modified: Strong Ion Difference (SID = Strong Cations – Strong Anions), CO_2 partial pressure (pCO_2) and serum proteins (total albumin , A_{TOT}). *Dependent variables* are those whose concentration of ions are modified by pH (*i.e.* H^+, OH^- HCO_3^-, $CO_3^=$, HA, A^-). Also, Stewart's theory is based on three laws of chemistry: 1) *Electroneutrality principle:* The sum of all positive ions must be equal to the sum of all negative charges; 2) *Law of Mass Action*: Every chemical reaction reaches a dynamic equilibrium defined by an equilibrium constant: $K_W = [H^+]*[OH^-]/[H_2O]$, and 3) *Law of Conservation of Matter*: The quantity of a substance remains constant: $[HA] + [A^-] = [A_{TOT}]$.

Mathematically, Stewart's theory supersedes the Henderson-Hasselbalch equation ($pH = pKa + \log [A^-]/[HA]$) which generates a circular relation: pH affects the dissociation of the acid HA, which in turn affects the pH, and it can only use one variable at the time. To avoid this, Stewart used a system of six simultaneous equations to predict the behavior of the different ions in the body fluids, where the overall equation is:

$$[SID] + [H^+] - K_C * pCO_2 / [H^+] - K_A * [A_{TOT}] / (K_A + [H^+]) – K_3 * K_C * pCO_2 / [H^+]^2 - K_W' / [H^+] = 0$$

Through a series of successive iterations, a value of hydrogen ion concentration is found that produces a "cero" value ($\pm 1*10^{-6}$) and then this H^+ value is used in all other equations to find the dependent variables). Results are presented as Gamblegrams or as lines in time.

Stewart's theory presents an improvement for the evaluation of acid-base balance in patients and their treatment. It allows to build mathematical models for several biological systems and to propose alternative hypothesis for several cellular and physiological mechanisms [3].

[1] Stewart PA (1981). *How to Understand Acid-Base. A Quantitative Acid-Base Primer for Biology and Medicine*. Edward Arnold. ISBN 0-7131-4390-8.
[2] Germann, A.F.O. (1925) A general theory of solvent systems. *Journal of the American Chemical Society*, 47, 2461-2468
[3] Häubi Segura, Carlos U. (2004). *Teoría Ácido-Básico de Stewart: Aplicaciones prácticas de una nueva teoría del balance del pH en los sistemas biológicos*. Editorial Cigome, Toluca, México. ISBN: 970-94211-0-7