Renal Regulation of Acid Base Balance

by

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Abstract

A mathematical model has been developed to describe the reabsorption of bicarbonate in the kidney. The model is parameterized to simulate the reabsorption in the rat proximal convoluted tubule. The "total CO_2" reabsorption rate (including HCO_3^- and H_2CO_3 as well as CO_2) is predicted as a function of the following physiological parameters: transcellular potential difference, bulk radial velocity, intracellular pH, cell membrane permeabilities, and CO_2 hydration reaction rate in the cells and at the brush border.

The model is based on a scheme in which all protons generated within the cells, by a combination of uncatalyzed and enzyme-catalyzed hydration of CO_2, are secreted into the lumen to titrate HCO_3^- , forming CO_2 and H_2CO_3 . The results for total inhibition of the responsible enzyme (carbonic anhydrase) are consistent with the most recent experimental findings. For the fully catalyzed reaction in the cells and at the brush border the difference of HCO_3^- out of the cells is rate limiting for the intracellular generation of protons. The results show that the HCO_3^- generated within the cells diffuses out at both the brush border and basolateral membranes. There is net diffusion of HCO_3^- from the cells to the lumen (secretion) whether the intracellular reaction is catalyzed or uncatalyzed.

With normal enzyme activity diffusion of CO_2 from lumen to cells accounts for almost all of the net reabsorption of CO_2 . With enzyme inhibition, however, H_2CO_2 accounts for most of the remaining total CO_2 reabsorption.

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