Participation of the Vasa Recta in the Renal Medullary Concentrating Mechanism: A Steady State Model

by

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Abstract

A steady state model of the renal medullary blood supply and its participation in the water conserving kidney has been developed. Important aspects of the model, neglected by previous investigators, include nonzero transcapillary volume fluxes, accurate representation of the plasma and cellular compartments of blood, and a nonzero reflection coefficient to sodium chloride of the descending vasa recta.

Two boundary conditions and three parameters, unavailable from sources in the literature, have been predicted by iteration on other experimental data in the rat. Successful estimations of these values were obtained when descending the vasa recta sodium chloride reflection coefficients lies between .1 and .65. Initial blood flow rate at the site of entry into the descending vasa recta has been estimated to lie between $15x10^{-8}$ and $16\ x10^{-8}$ ml/s. Plasma protein concentration at the same position has been estimated to lie between 4.75 and 5.35 g/dl. Sodium permeability of the descending vasa recta has been estimated to lie within a range of $26x10^{-5}$ $42x10^{-5}$ cm/s. Hydraulic permeability of the descending vasa recta has been estimated to lie within a range of $23x10^{-8}$ to $120\ x10^{-8}$ cm $s^{-1}mmHg^{-1}$. Hydraulic permeability of the ascending vasa recta has been estimated to lie within a range of either $30x10^{-8}$ to $50\ x10^{-8}$ cm $s^{-1}mmHg^{-1}$ or within a range of 675 $x10^{-8}$ to $1075\ x10^{-8}$ cm $s^{-1}mmHg^{-1}$, depending on sources of data used.

Predictions of the model are consistent with information from several sources. Predictions of initial descending vasa recta blood flow rates and protein concentrations are consistent with features of glomerular dynamics. Descending vasa recta sodium permeability predictions are consistent with values measured in the hamster. Predicted hydraulic permeabilities are physiologically reasonable by comparison to values in other renal capillary systems. Prediction of system behavior is consistent with the need to remove sodium chloride and water from the inner medullary interstitium without causing excessive washout of urea.

It is concluded that the model and underlying assumptions provide an accurate representation of vasa recta participation in the concentrating mechanism.

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