

# Restricted Transport of Charged Macromolecules Across Capillaries in the Kidney

by

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## **Abstract**

Previous experimental studies have revealed that under normal conditions, the glomerular capillary wall restricts the passage of polyanions more than that of neutral macromolecules, and restricts the transport of the latter more than that of polycations. During a variety of conditions, however, the glomerular capillaries apparently lose this selectivity and the capillary wall becomes essentially only size selective.

A theoretical model of the charge-selectivity has been developed based on the following assumptions: (a) all ions (tracer macromolecule and univalent cations and anions) obey a modified Nernst-Planck flux expression, including terms for convection and size-selective retardation; (b) the capillary wall has a homogeneous distribution of fixed negative charges; and (c) Donnan equilibria exist at the surfaces of this "membrane." To allow specific application of the model, the electrophoretic mobilities of bovine serum albumin, different derivatives of horseradish peroxidase (HRP), and narrow fractions of dextran sulfate (DS), and diethylaminoethyl dextran (DEAE) were measured. The values obtained were then used to estimate effective molecular charge.

Based on these measurements and previously reported values for the glomerular filtrate-to-plasma concentration ratio ( $\theta$ ) for the above-mentioned macromolecules, the apparent fixed charge concentration of the capillary wall was obtained. It was found that this membrane fixed charge concentration declines from a value of about 120-170 mEq/liter in normal rats to a value as low as 20 mEq/liter following glomerular injury.

The effect of the hydrodynamic determinants of single nephron glomerular filtration rate (e.g., glomerular plasma flow rate and transmembrane hydraulic pressure difference) on the filtrate-to-plasma concentration ratio of charged macromolecules was also tested. It was found that the filtrate-to-plasma concentration ratio for a negatively charged macromolecule decreases while that for a positively charged macromolecule increases as glomerular plasma flow rate or transmembrane hydraulic pressure difference increases. Furthermore it was found that the percentage change in filtrate-to-plasma concentration ratio is greater for more negative values of molecular charge.

The applicability of an alternative model, based on detailed calculations of the double layer interactions, was also examined. It was found that even though this model provides fairly consistent results for negatively charged macromolecules (repulsive interactions), it does not give satisfactory results for positively charged macromolecules (attractive interactions).

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