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MODELING OF OSMOTIC FLUID FLOW AND SMALL-SOLUTE TRANSPORT IN PERITONEAL DIALYSIS: SPATIALLY DISTRIBUTED APPROACH

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ABSTRACT

In peritoneal dialysis, infusion of fluid into the peritoneal cavity creates high hydrostatic and osmotic pressure, which together with the concentration difference, induce fluid and solutes flow between dialysate and blood through the adjacent tissue. Since the goal of the treatment is to remove waste metabolic products as well as the excess water, the understanding of the observed fluid and solute kinetics is of a key importance. Moreover, although the solute and fluid exchange occur locally in the tissue, only the final outcome in the peritoneal cavity and blood can be clinically measured.

A distributed model, that takes into account spatial property of the tissue, was formulated based on our previous models of osmotic fluid and solute flow [2,3]. It took into account combined description of volume and solute mass balances in the peritoneal cavity and flows across the tissue and blood capillary wall with the local tissue parameters which depends on the local tissue hydration and solute concentration [1]. As a result, a system of five, partial, highly nonlinear, differential equations was obtained for the description of the transport through the tissue. In addition, changes in the fluid volume and solute concentration in the peritoneal cavity were described by the system of the ordinary differential equations. These equations defined the boundary conditions for the dynamic processes in the tissue, and in the same time depended on the fluid and solute exchange between the peritoneal cavity and the adjacent tissue layers.

Both, ordinary and partial differential equations, that composed a coupled system, were used to simulate the single peritoneal dialysis session. The average volume and solute concentration profiles were fitted to the clinical data from dwell studies in 40 clinically stable patients on chronic ambulatory peritoneal dialysis using a 3.86% glucose dialysis solution.

The model was able to describe the clinical data with high accuracy. It provided precise description of the relationship between changes in the peritoneal tissue and intraperitoneal dialysate volume and solute concentration kinetics. Computer simulations suggested that only a thin layer of the tissue within 2-3 mm from the peritoneal surface participates in the exchange of fluid and small solutes between intraperitoneal dialysate and blood [1].

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