PIMS / AMI Seminar

Wednesday, May 21, 2014
3:30 p.m. in CAB 365

"A mathematical model for fluid-glucose-albumin transport in peritoneal dialysis"

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Abstract

Peritoneal dialysis is a life saving treatment for chronic patients with end stage renal disease. The peritoneal cavity, an empty space that separates bowels, abdominal muscles and other organs in the abdominal cavity, is applied as a container for dialysis fluid, which is infused there through a permanent catheter and left in the cavity for a few hours. During this time small metabolites (urea, creatinine) and other uremic toxins diffuse from blood that perfuses the tissue layers close to the peritoneal cavity to the dialysis fluid, and finally are removed together with the drained fluid. The treatment cycle (infusion, dwell, drainage) is repeated several times every day. The peritoneal transport occurs between dialysis fluid in the peritoneal cavity and blood passing down the capillaries in tissue surrounding the peritoneal cavity.

An important objective of peritoneal dialysis is to remove excess water from the patient. Typical values of the water ultrafiltration measured during peritoneal dialysis are 10 - 20 mL/min. This is achieved by inducing osmotic pressure in the dialysis fluid by adding a solute (called osmotic agent) in high concentration. The most frequently used osmotic agent is glucose. This medical application of high osmotic pressure is unique for peritoneal dialysis. The flow of water from blood across the tissue to the dialysis fluid in the peritoneal cavity carries solutes of different size, including large macromolecules (e.g., albumin), and adds a convective component to their diffusive transport.

Mathematical description of fluid and solute transport between blood and dialysis fluid in the peritoneal cavity has not yet been fully formulated, in spite of the well-known basic physical laws for such transport. We have constructed a mathematical model for fluid and solute transport in peritoneal dialysis. The model is based on a three-component nonlinear system of two-dimensional partial differential equations for fluid, glucose and albumin transport with the relevant boundary and initial conditions. Our aim is to model ultrafiltration of water combined with inflow of glucose to the tissue and removal of albumin from the body during dialysis, by finding the spatial distributions of glucose and albumin concentrations and hydrostatic pressure. The model is developed in one spatial dimension approximation and a governing equation for each of the variables is derived from physical principles. Under some assumptions the model can be simplified to obtain exact formulae for spatially non-uniform steady-state solutions. As the result, the exact formulae for the fluid fluxes from blood to tissue and across the tissue are constructed together with two linear autonomous ordinary differential equations for glucose and albumin concentrations in the tissue. The obtained analytical results are checked for their applicability for the description of fluid-glucose-albumin transport during peritoneal dialysis.
The talk will be based on the results obtained in [1]—[3] and some unpublished results.

[1] R. Cherniha, J. Stachowska-Pietka, and J. Waniewski. arXiv:1310.5876v1 22 Oct 2013.
[2] Cherniha R, Dutka V, Stachowska-Pietka J and Waniewski J In: Mathematical Modeling of Biological Systems, Vol.I. Ed. by A.Deutsch et al., Birkhaeuser, pp.291-298 (2007)
[3] Waniewski J, Dutka V, Stachowska-Pietka J, Cherniha R: Distributed modeling of glucose-induced osmotic flow. Adv Perit Dial 2007;23:2-6.

Refreshments will be served in CAB 649 at 3:00 p.m.