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Compartmental modeling and adequacy of dialysis

In compartmental modeling the patient body may be considered as a single compartment, two compartments (intracellular and extracellular or perfused and non-perfused) or more compartments, as appropriate to the kinetics of investigated solute. Then the analysis of solute kinetics can be used for the description of dialysis and provide support for the assessment of its efficiency. Two compartment variable volume urea kinetic model, based on ordinary differential equations, was used to simulate numerically different dialysis modalities: 1) conventional hemodialysis (HD) with three dialysis sessions per week, 2) daily HD with 6 short sessions per week, 3) nocturnal HD with 6 long sessions per week, 4) continuous ambulatory peritoneal dialysis (PD) with four exchanges of dialysis fluid per day and 5) bimodal dialysis, i.e., a combination of 5 days on PD and two HD sessions. The volumes of extracellular (Ve) and intracellular (Vi) compartments were related to total body volume V as Ve(t) = 1/3V(t) and Vi(t) = 2/3V(t), respectively. The obtained urea concentration, mass and distribution volume profiles in patient body and solute concentration, mass and dialysate volume profiles allow to calculate the following dialysis adequacy indices, DAI: 1) fractional solute removal, FSR; and 2) equivalent continuous clearance, ECC. FSR is defined as total solute mass removed from the body normalized by solute mass in the body. ECC is defined as solute removal rate over solute concentration in the extracellular compartment of patient body. In general, there are four variants of DAI linked to the variability of solute concentration, mass and fluid volume during intermittent dialysis treatment with different time intervals between treatments. FSR and ECC are related to 1) peak, 2) peak average, 3) time average and 4) treatment time average reference values of mass and concentration, respectively. The system of DAI was applied 1) to compare conventional, daily and nocturnal HD and continuous ambulatory PD, i.e., treatments with different dialysis dose and time schedules, 2) to calculate the efficiency of bimodal dialysis, 3) to assess the contribution of residual renal function and dialysis into the overall efficiency of the treatment, and 4) to determine the dialysis dose in metabolically unstable patients. The results of this investigation are important for practical applications of dialysis. Using compartmental models and solute kinetic analysis we were able to evaluate dialysis adequacy, FSR and ECC, for simulated dialysis modalities in anuric and non-anuric patients taking into account their metabolic state.