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Methods for modeling the kinetics of radiopharmaceuticals with iodine isotopes in nuclear medicine problems

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Abstract

The paper considers modeling methods and develops a unified approach to the construction of mathematical models of the kinetics of radiopharmaceuticals with iodine isotopes in the human body during diagnostic and therapeutic procedures of nuclear medicine. Based on this approach, three- and four-compartment pharmacokinetic models were developed and corresponding calculation programs were created in the C++ programming language for processing and evaluating the results of radionuclide diagnostics and therapy. Various methods for identifying model parameters based on quantitative data from radionuclide studies of the functional state of vital organs are proposed. The results of pharmacokinetic modeling for radionuclide diagnostics of the liver, kidney, and thyroid using iodine-containing radiopharmaceuticals are presented and analyzed.

Using clinical and diagnostic data, individual pharmacokinetic parameters of transport of different radiopharmaceuticals in the body (transport constants, half-life periods, maximum activity in the organ and the time of its achievement) were determined. It is shown that the pharmacokinetic characteristics for each patient are strictly individual and cannot be described by averaged kinetic parameters.

Within the framework of three pharmacokinetic models, "Activity-time" relationships were obtained and analyzed for different organs and tissues, including for tissues in which the activity of a radiopharmaceutical is impossible or difficult to measure by clinical methods. Also discussed are the features and the results of simulation and dosimetric planning of radioiodine therapy of the thyroid gland. It is shown that the values of absorbed radiation doses are very sensitive to the kinetic parameters of the compartment model. Therefore, special attention should be paid to obtaining accurate quantitative data from ultrasound and thyroid radiometry and identifying simulation parameters based on them.

The work is based on the principles and methods of pharmacokinetics. For the numerical solution of systems of differential equations of the pharmacokinetic models we used Runge-Kutta methods and Rosenbrock method. The Hooke-Jeeves method was used to find the minimum of a function of several variables when identifying modeling parameters.

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