MODELLING OF THE HUMAN ARTERIAL NETWORK FOR AN EXPERT SYSTEM FOR PREOPERATIVE PREDICTIONS

W. Bornatowicz, K. Kaser, J. Krocza, M. Suda
Austrian Research Center Seibersdorf
A-2444 Seibersdorf

Ch. Almeder, F. Breitenecker, S. Wassertheurer
Technical University, Vienna
Wiedner Hauptstraße 8-10, A-1040 Wien

The aims of this project are the extension and preparation of a mathematical model that describes the relationship of morphology and hydraulics in human arterial networks and the development of an expert system connected with the model [1]. Both parts will be combined in a graphic oriented software package. With this system mean flow velocity, mean flux, flow direction and blood pressure at any point of a vessel network can be calculated. By changing the topology of a network the hydraulic effects of stenoses and bypasses are simulated. The results of these simulations may help physicians in their decisions, if an operation is necessary and which kind of operation has the best chance of success.

In the mathematical model the vessel networks are simplified to hydraulic pipe networks [2]. The input parameters are the length and the diameter of each vessel and the network topology. For easier and faster working, several preconfigured standard networks (e.g.: leg arteries, cerebral arteries, etc.) are included in the package. But the physiology can be quite different, therefore those standard models have to be changed into specific patient models by adapting them on data from ultrasonic Doppler measurements and X-ray pictures. It is planned to automate this process of adjustment using an expert system. When the patient model is configured a physician can simulate different operation methods on the screen (changing the place or dimensions of bypasses, widen closed vessels, etc.). Immediately the effects of these operations relating to the blood flow are shown on the screen.

Some assumptions and simplifications were necessary to get a compact mathematical model that can be handled. During the adaptation of the standard model on the patient data the whole model calculation has to be carried out several times. Therefore these calculations must not be too time-consuming. The fact, that in most cases only few patient data are available for the adaptation, requires a small model, so that its parameters can be identified with the measured data. Nevertheless tests have shown a mean difference of only up to 10% between calculated and measured flow velocity depending on the amount and quality of data available. This inaccuracy is insignificant, because for the decisions on the kind of operation only fundamental statements of the flow velocity, flow direction and blood pressure are necessary, that means that no exact values are needed, but ranges. A more complicated aspect is the adaptation of standard models on the data received from different measurements and diagnoses of the physicians. Much experience and knowledge of the mathematical model are necessary to do this adjustment by hand, and even then it takes some hours. To automate this time-consuming work an expert system will be constructed and implemented between the user interface and the model interface.

In summary, the project should lead to a user-friendly software package for physicians that can be used as an advisor in vessel surgery and maybe as a training tool for medicine students.

References

1. M. Suda, O. J. Eder, B. Kunsch , D. Magometschnigg, H. Magometschnigg, *Preoperative assessment and prediction of postoperative results in artificial arterial network using computer simulation*. Computer Methods and Programs in Biomedicine, 41 (1993), 77-87.
2. R. Epp and A. G. Fowler, *Efficient code for steady-state flows in networks*, J. Hydr. Div., 96 (1970), 43-56