OPTIMAL BRANCHING ANGLES IN CARDIOVASCULAR SYSTEMS

S. Tokarzewski, T. Kowalewski, R. Wojnar

Institute of Fundamental Technological Research,Warsaw, Poland

A dominant feature of the cardiovascular system is its highly branched structure. This structure involves a large number of blood vessel junctions. In the cardiovascular system of human being, the number of such junctions is of the order of billions It has long been

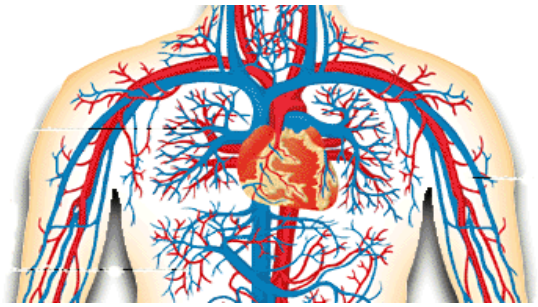

Fig. 1: The cardiovascular system as a highly branched structure

suspected that the branching angles of blood arteries are based on well defined physiological principles. The cardiovascular system being basically a fluid-conducting system, these physiological principles are generally sought in the context of fluid mechanics. Several principles have so far been examined Two of these principles propose that the branching angles are such that the lumen surface or lumen volume of the vessels involved in an arterial junction is minimum. Another two principles propose that the branching angles are such that the pumping power required to drive the flow or the drag force on the endothelial surface is minimum. All four principles mentioned above are valid for arterial bifurcations, cf. [1], [2],[3]. The purpose of the present study is to extend validity of optimum principle based on optimization of pumping power to arbitrary multifurcations. The application of optimality principles to nonsymmetrical multifurcations exposes the principles to a much larger ground on which they can be tested in order to establish the degree of validity of these principles in a cardiovascular system. This knowledge is important to our understanding of the physiological basis of cardiovascular system and its anomalies. A comparison of the theoretical angles with natural angles exposed on X-ray photograph has been made.

References

[1] K. Cieślicki, Hydrodynamiczne uwarunkowania krążenia mózgowego, Problemy współczenej nauki, AOW, Warszawa 2001.

[2] Kamila A., Togawa T.: Optimal branching structure of the vascular tree. Bull. Math. Bioph., 1972, 34, 431-438..

[3] Zamir M., Sinclair P.: Roots and calibers of the human coronary arteries. A. J. Anal, 1988, 183, 226-234.