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Modern trends in personalized hemodynamics

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Motivation and Aim: Vascular diseases hold the leading place in deaths as a result of diseases (according to WHO [1]). Cerebral aneurysms or abdominal aortic aneurysms are common diseases and occur in 2–5 % of the population depending on gender and race [2]. The most promising approach in the treatment of such pathologies is the approach that includes the use of personalized patient data or personalized preoperative modeling. However, such modeling in some cases faces both computational and expert challenges, and therefore requires a versatile approach – from numerical experiments with idealized formulations to formulations taking into account nonlinear models of vessel wall elasticity. The paper presents various approaches to preoperative modeling of hemodynamics, signs of development or stabilization of pathologies and, as a result, allowing medical decisions to be made.
Methods and Algorithms: A numerical decision on the installation of a vascular anastomosis was considered both in the model [3] and in the patient-specific case; the model problem of the growth of an abdominal aortic aneurysm [4], the problem of correct endothelization of flow-redirecting devices in the treatment of cerebral aneurysms [5], and the problem of embolization of a model configuration of arteriovenous malformation according to experimental data on the rheology of real embolisates. All calculations were performed using the ANSYS 17.2–20.2 software packages.
Results: Based on the results of the work, an optimal kgol anastomosis was found, the parameters of normal endothelialization of the flow-redirecting device were calculated for the first time, and an increase in pressure proximal to the abdominal aortic aneurysm was proved, which is confirmed in clinical practice.
Conclusion: The results of the work make a significant contribution to the solution of various problems of cerebral and abdominal hemodynamics and can significantly increase the understanding of hemodynamics by real users of such models – practicing surgeons.
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