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Mathematical modelling of cerebral arteriovenous malformations

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Vascular deceases of the brain are one the main causes of human death and disabling. Arteriovenous malformations (AVM) are widespread cerebrovascular anomalies. AVM is an abnormal connection between arteries and veins — a direct connection in the form of chaotic vessel tangle bypassing capillaries. These anomalies degrade normal blood circulation of the brain areas, change blood flow regimes and very often lead to cerebral haemorrhage.

During recent years medical equipment and technologies were greatly advanced. Endovascular embolization procedure was developed to treat AVMs. At the same time, preoperative mathematical modelling of haemodynamic changes within the anomaly and its surrounding brain area during the embolization is a topical problem.

In this work a mathematical model of the AVM is constructed. It is based on 1D hyperbolic system of differential equations on an unordered graph with edges of different lengths and diameters. The embolization process is simulated via variation of the vessel resistance parameters.

To estimate postoperative complications we introduce a haemodynamic parameter — a specific hydrodynamic load on the AVM nidus. It is shown that this parameter is in conformity with neurosurgical approach to embolization amount in staged treatment of the AVMs.

Our research is based on the clinical data obtained during examinations and endovascular surgery in Novosibirsk Research Institute of Circulation Pathology.