ORAL PRESENTATIONS

Abnormal jugular valves are not the sole explanation of an impaired outflow from the cranial cavity through the internal jugular veins: Results of *in silico* studies

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Background

Currently, pathological jugular valves are thought to be the main cause of altered hemodynamics in the internal jugular veins, the so-called chronic cerebrospinal venous insufficiency. The alternative interpretation of flow disturbances in these veins is that the main source of abnormal outflow are nozzle-like strictures in their upper parts, at the level or just below the jugular foramen, for example, caused by an enlarged transverse process of the atlas and/or styloid process of the temporal bone.[1] These in silico studies were aimed at validation of this hypothesis.

Methods

With the use of computational fluid mechanics software: the Flowsquare+ and the COMSOL multiphysics, we simulated blood flow in the models of internal jugular veins that exhibited different morphologies (Figure 1). With the Flowsquare+ software, we performed 3-dimensional simulations for the assessment of relevance of the strictures at the level of jugular foramen, while the COMSOL multiphysics software, which was used in 2-dimensional mode, gave us more detailed insight into the behavior of the jugular valve.

Results

*T*here was a normal unidirectional flow, with the centrally positioned centerline velocity and no flow separation in modeled veins, which were not narrowed or presented with gradual narrowings. On the contrary, in a majority of models with nozzle-like strictures located at the beginning of the studied veins, abnormal flow patterns were revealed, with significant flow separation and regions with reversed flow. The most severe flow abnormalities were not seen in the models with nozzles of a small cross-sectional area, but rather in those positioned asymmetrically. Abnormal valves (with reversed or asymmetrical leaflets) further impaired the flow in models with symmetrically positioned nozzles, but had no significant impact on the flow in a case of an already altered flow evoked by the asymmetric nozzles.[1] Importantly, simulations performed with the COMSOL multiphysics revealed that flow disturbances evoked by significant stenosis in the upper part of the internal jugular vein distort leaflets of the jugular valve. This was not seen as a case of a minor stenosis.

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Conclusions

We demonstrated that our working hypothesis is credible and that impaired outflow from the brain through the internal jugular veins is likely to be primarily caused by pathological strictures in the upper parts of these veins, instead of pathological jugular valves that, as of yet, were the main target of clinical research. In addition, pathology of the jugular valves may be secondary to the strictures in the upper segments of the internal jugular veins.

Reference

1. Simka M, Latacz P. Numerical modeling of blood flow in the internal jugular vein with the use of computational fluid mechanics software. Phlebology 2021;36:541-8.

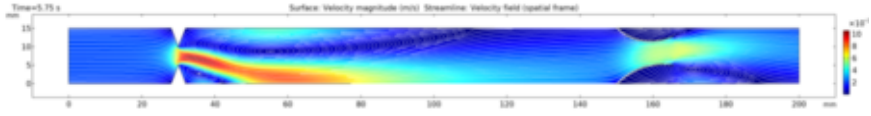

Figure 1. Simulation of blood flow in the model of internal jugular vein exhibiting a stricture at its beginning and a flexible valve downstream with the COMSOL multiphysics software.