Hemodynamic

Hemodynamics (AmE) or hæmodynamics (BrE), meaning literally “blood flow, motion and equilibrium under the action of external forces”, is the study of blood flow or the circulation. It explains the physical laws that govern the flow of blood in the blood vessels.

Hemodynamic patterns have been associated with cerebral aneurysm instability. For patient-specific computational fluid dynamics (CFD) simulations, the inflow rates of a patient are typically not known. The aim of this study was to analyze the influence of inter- and intra-patient variations of cerebral blood flow on the computed hemodynamics through CFD simulations and to incorporate these variations into statistical models for aneurysm rupture prediction.

Image data of 1820 aneurysms were used for patient-specific steady CFD simulations with nine different inflow rates per case, capturing inter- and intra-patient flow variations. Based on the computed flow fields, 17 hemodynamic parameters were calculated and compared for the different flow conditions. Next, statistical models for aneurysm rupture were trained in 1571 of the aneurysms including hemodynamic parameters capturing the flow variations either by defining hemodynamic “response variables” (model A) or repeatedly randomly selecting flow conditions by patients (model B) as well as morphological and patient-specific variables. Both models were evaluated in the remaining 249 cases.

All hemodynamic parameters were significantly different for the varying flow conditions ($p < 0.001$). Both the flow-independent “response” model A and the flow-dependent model B performed well with areas under the receiver operating characteristic curve of 0.8182 and 0.8174 ± 0.0045, respectively.

The influence of inter- and intra-patient flow variations on computed hemodynamics can be taken into account in multivariate aneurysm rupture prediction models achieving good predictive performance. Such models can be applied to CFD data independent of the specific inflow boundary conditions [1)].

1)
Detmer FJ, Mut F, Slawski M, Hirsch S, Bijlenga P, Cebral JR. Incorporating variability of patient inflow conditions into statistical models for aneurysm rupture assessment. Acta Neurochir (Wien). 2020 Feb 1. doi: 10.1007/s00701-020-04234-8. [Epub ahead of print] PubMed PMID: 32008209.