S05

Towards predicting aneurysm rupture with patient characteristics and aneurysm location, morphology and hemodynamics

F. Detmer[1], B. J. Chung[1], F. Mut[1], M. Slawski[2], F. Hamzei-Sichani[3], C. Putman[4], C. Jimenez[5] J. Cebral[1]

[1]George Mason University, Bioengineering, Fairfax, Virginia, United States
[2]George Mason University, Statistics, Fairfax, Virginia, United States
[3]University of Massachusetts, Neurological Surgery, Worcester, Massachusetts, United States
[4]Inova Fairfax Hospital, Interventional Neuroradiology Unit, Fairfax, Virginia, United States
[5]University of Antioquia, Neurosurgery, Medellin, Colombia

Introduction: Incidental cerebral aneurysms pose a dilemma for physicians who need to weigh the risk of a devastating subarachnoid hemorrhage against the risk of surgery or endovascular treatment and their complications when deciding on a treatment strategy. The aim of this study was the development of a probability model for aneurysm rupture to guide such treatment decisions.

Material and Methods: Computational fluid dynamics (CFD) and automated shape characterization of 1,631 aneurysms were used to compute 47 hemodynamic and geometric parameters. Logistic group lasso regression was applied for variable selection and model fitting using this hemodynamic and morphological information, patient gender and age, and aneurysm location. Since applying such a model for a new case requires CFD simulations, a second simpler model was fitted using 12 parameters that can be obtained from angiographic images and patient data without much effort. The models" discrimination, calibration, and clinical usefulness were internally validated based on the area under the curve (AUC) of the receiver operating characteristic (ROC), calibration plots, and clinical decision curves.

Results: The final model retained 11 hemodynamic and 12 morphological variables, aneurysm location, and patient age and gender. Internal validation indicated a clinical usefulness of the model (AUC = 0.86). Based on the model"s coefficients, aneurysms with a higher rupture risk had a more complex shape, an adverse hemodynamic environment characterized by a higher maximum oscillatory shear index, higher kinetic energy and smaller low shear area, and were harbored by younger, male patients. For the "simple model" (SM), all 12 parameters were retained in the process of model fitting. Its AUC was 0.84. When fitting linear regression models using the variables of the SM to predict the predictors in the final "complex model" (CM), the 10 most influential variables in the CM could be explained by variables of the SM. This indicates why the SM"s discrimination was only slightly reduced compared to the CM.

Conclusion: Internal validation of the developed probability model for aneurysm rupture indicated the potential for its application in clinical decision making. If hemodynamic or morphological information is not available, a simplified model can be used to identify rupture-prone aneurysms with an only slightly reduced predictive performance.