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Computer modeling of endovascular devices can enable outcome prediction of endovascularly-treated intracranial aneurysms

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Endovascular flow diversion and coil embolization are minimally invasive therapies for treatment of intracranial aneurysms (IAs), which intend to obliterate the disease through aneurysmal thrombosis. Although generally effective, these therapies are not always successful, as IAs are routinely retreated for incomplete occlusion or recanalization. Incompletely occluded and recanalized IAs expose the patients at sustained risk of IA rupture and risk of complications associated with retreatment. Currently, treatment decisions are based on clinical data, and the risk of adverse outcomes is unknown prior to the treatment. However, if clinicians could credibly asses the risk of adverse outcomes before treatment, they could make better treatment decisions and improve IA outcomes. Since endovascular devices act by modifying aneurysmal flow, our central hypothesis is that IA treatment outcomes are primarily determined by postprocedural hemodynamics. Unfortunately, IA hemodynamics cannot currently be assessed *in vivo*, and testing specific treatment strategies *in vitro* for each patient"s case would be intractable. Our research focuses on developing state-of-the-art computational tools that can simulate IA treatments and hemodynamics *in silico*. These device-modeling tools, along with predictive models, could be used to help clinicians predict IA treatment outcomes *a priori* and improve the disease prognosis from initial treatment planning to final treatment outcome. To that end, we are developing large-scale, statistics-based studies to investigate correlations between postprocedural hemodynamics and treatment outcomes by utilizing the large databank of IAs at our high-volume treatment hospital. We have developed efficient virtual stenting and finite-element based coiling algorithms, which capture the essential and accurate details of these devices. To validate our virtual intervention methods, we developed an experimental workflow in which we deploy real endovascular devices in optically transparent, patient-specific flow phantoms. These efficient virtual intervention tools will enable us to simulate a large number of IA treatment cases retrospectively (100+), simulate their post-treatment hemodynamics, and develop statistical models for treatment outcome prediction. Such modeling tools will address the critical need of individualized treatment planning in the procedure room, improved treatment success rates, and potentially lowered healthcare costs.