Vascular cross-section, rather than tortuosity, can classify first pass outcome of mechanical thrombectomy for ischemic stroke

S.M.M. Janbeh Sarayi MS[1,2,†], Briana A. Santo BS[1,3,†], Muhammad Waqas MBBS[1,4], Andre Monterio MD[1,4], Sricharan S. Veeturi MS[1,2], TaJania D. Jenkins MA[1,3], Elad I. Levy MD[1,4], Adnan H. Siddiqui MD-PhD[1,4], Vincent M. Tutino PhD[1,2,3,4,*]

† authors contributed equally

[1]Canon Stroke and Vascular Research Center; [2]Department of Mechanical and Aerospace Engineering, [3]Department of Pathology and Anatomical Sciences, [4]Department of Neurosurgery, [5]Department of Biomedical Engineering, University at Buffalo, Buffalo, NY, USA

*** Corresponding Author:**
Vincent M. Tutino, PhD
875 Ellicott Street
Canon Stroke and Vascular Research Center
University at Buffalo
Buffalo, NY 14203, USA
E-mail: vincentt@buffalo.edu
Phone: (716) 829-5400

Running Title: Vessel cross-section features can predict stroke thrombectomy outcome

Keywords: mechanical thrombectomy, geometric morphometrics, acute ischemic stroke, first pass effect, vessel morphology

Abstract

Background: Vascular geometry plays an important role in stroke thrombectomy outcomes, but few studies have examined complex characteristics of vessel morphology. We hypothesized that engineered vessel cross-section features could be used to predict thrombectomy First Pass Effect (FPE).

Methods: We analyzed CTA and non-contrast CT (nCCT) from 50 anterior circulation stroke thrombectomy patients. After segmentation, traditional metrics (vessel tortuosity, and angulation) were calculated from vessel centerlines that were transformed into the same coordinate system and same ROI. Univariate statistical analysis and geometric morphometrics (GMM) were used to explore differences in geometry between cases that did and did not achieve FPE, which these features could not capture. To describe these differences complex cross-section features were engineered and quantified using a semi-automatic pipeline. Machine learning was used to train predictive models of FPE based on significant cross-section features.

Results: Only one local tortuosity metric was significantly different (q=0.019) between FPE and first pass failure cases. The most significant Principal Component score (q=0.012) from GMM highlighted M1 and upper Cavernous ICA variation as morphological indicators of first pass outcome. 15 cross-section features, corresponding to ICA and MCA regions, were significantly different between cases that did and did not achieve FPE. Predictive models exhibited strong prediction of FPE (AUC=0.98±0.05) and outperformed models using traditional tortuosity and angulation features.

Conclusion: Cross-section features are a novel class of powerful and interpretable predictors of FPE, which could assist in treatment decision making.