

# Artery-to-artery embolism and stroke risks in intracranial atherosclerotic stenosis: high wall shear stress and turbulent flow

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## BACKGROUND & Purouse

Cerebral hemodynamics may be related to artery-to-artery embolism (AAE) in symptomatic intracranial atherosclerotic stenosis (sICAS). We aimed to associate hemodynamics across a sICAS lesion with the presence of AAE and stroke risks.

## METHODS

Patients with 50-99% atherosclerotic stenosis of M1 middle cerebral artery on CT angiography (CTA) were included. Probable stroke mechanism at baseline was assessed in diffusion-weighted MR imaging. Relative WSS (rWSS) across the sICAS lesion was quantified on CTA-based computational fluid dynamics (CFD) models, adjusted by mean WSS measured at proximally normal vessel. Shear stress score of high WSS ( $SSS_{high}$ ) was calculated respectively in the upstream and downstream plaque segments (divided at the stenotic throat), as the mean rWSS multiplied by the relative area with  $rWSS > 3.0$ . The severity of flow disturbance, quantified by vorticity ratio (VR) on CFD models, was also assessed.  $SSS_{high}$  and  $VR \geq 4$ th quartile were respectively defined as high  $SSS_{high}$  and high VR. All patients received guideline-recommended medical treatment. We associated hemodynamic metrics with AAE at baseline and recurrent ischemic stroke in the same territory (SIT) within 3 months and 1 year.

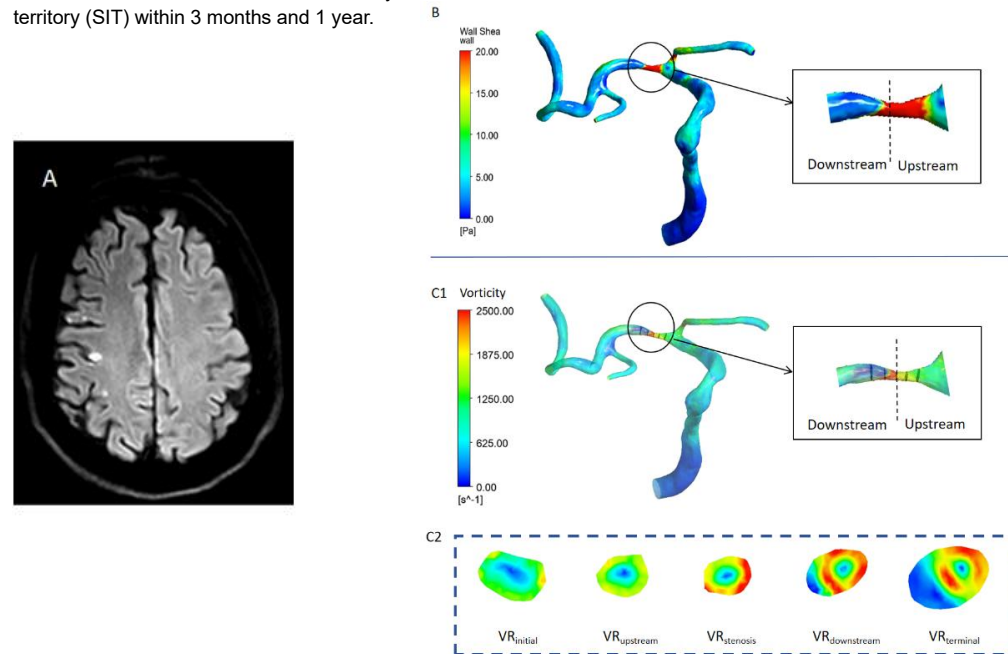


Figure 1. Hemodynamics features in a patient with the probable mechanisms of artery-to-artery embolism at baseline. (A) scattered infarcts in the cortex in diffusion-weighted imaging; (B) elevated WSS mainly cumulated in the plaque upstream; (C1) high vorticity distributed in the plaque downstream; (C2) flow patterns on each cross-section.

## RESULTS

Among 102 patients (median age 62 [interquartile range, 54-70] years, 73 [71.6%] males), 40 (39.2%) had AAE as a stroke mechanism at baseline. High  $SSS_{high-upstream}$  + high  $VR_{downstream}$  (adjusted odds ratio, 4.92, 95% confidential interval, 1.12-21.57;  $p=0.035$ ) was independently associated with baseline AAE in multivariate logistic regression. Moreover, among patients with medical treatment during follow-up, a higher risk of 1-year recurrent SIT was found in those with high  $SSS_{high-upstream}$  (18.2% versus 4.4%; log-rank  $p=0.034$ ) compared with those with normal  $SSS_{high-upstream}$ , which, however, was not significantly different within 3 month.

## CONCLUSIONS

In sICAS patients, high WSS upstream, together with flow disturbance downstream, was associated with AAE as a stroke mechanism at baseline.  $SSS_{high}$  might be a promising indicator for recurrent, same-territory ischemic stroke within 1 year, in medically treated sICAS patients.

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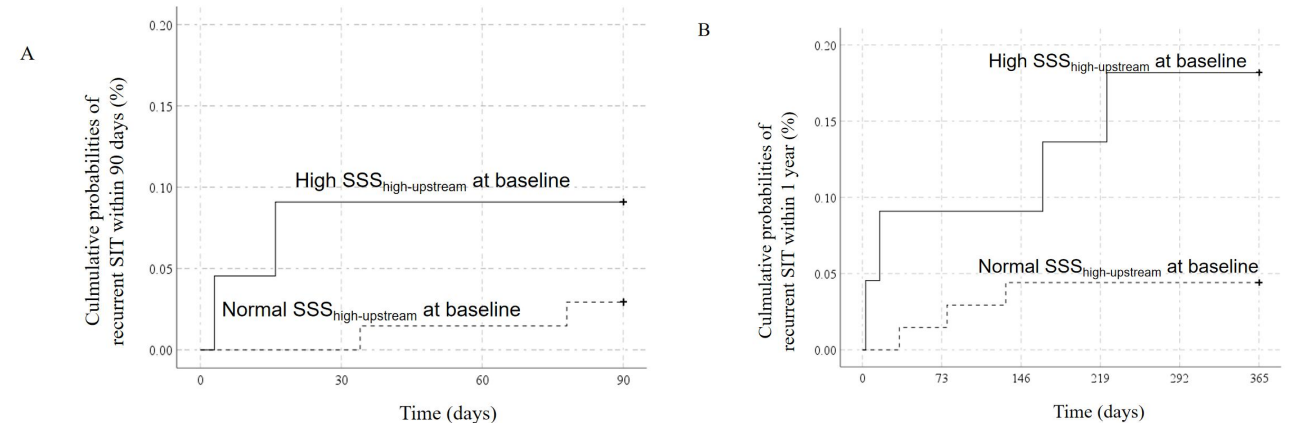


Figure 2: Cumulative probabilities of recurrent ischemic stroke in the same territory (SIT) within 90 days (A) and 1 year (B) in patients with high or normal upstream shear stress score of high wall shear stress ( $SSS_{high}$ ).

A. The risks of recurrent SIT within 90 days were not significantly different between patients with high or normal upstream  $SSS_{high}$  (9.1% versus 2.9%; log-rank  $p=0.210$ ).

B. Significant difference in the risks of recurrent SIT within 1 year in patients with high or normal upstream  $SSS_{high}$  (18.2% versus 4.4%; log-rank  $p=0.034$ ).