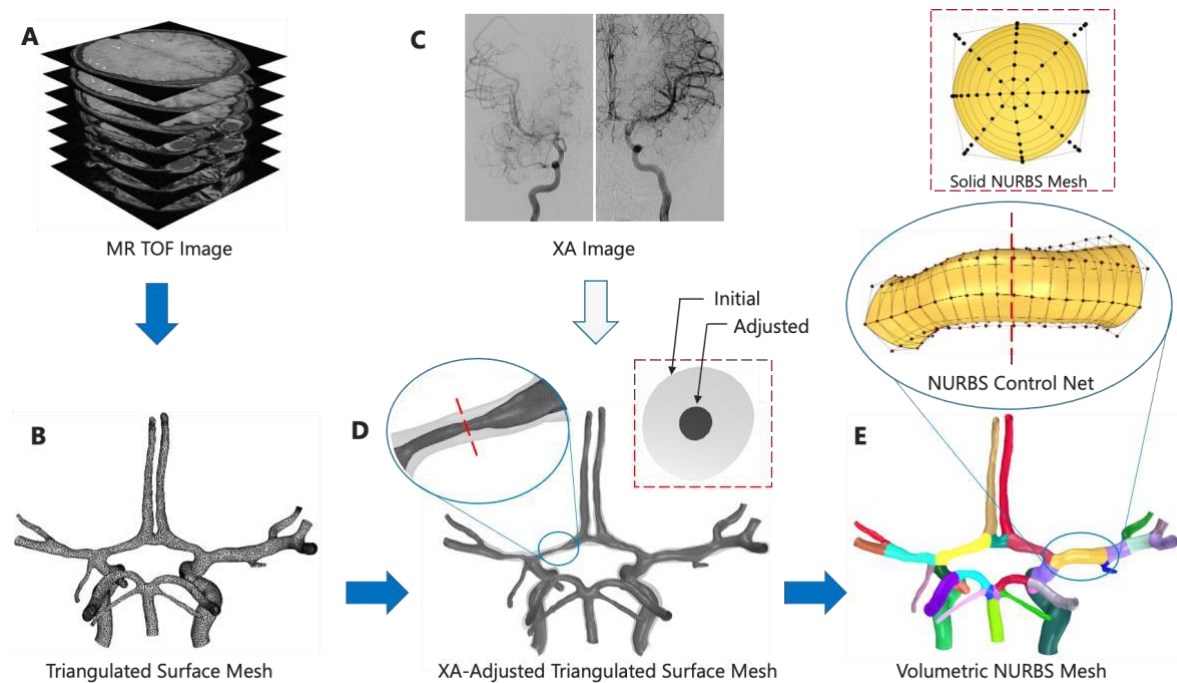
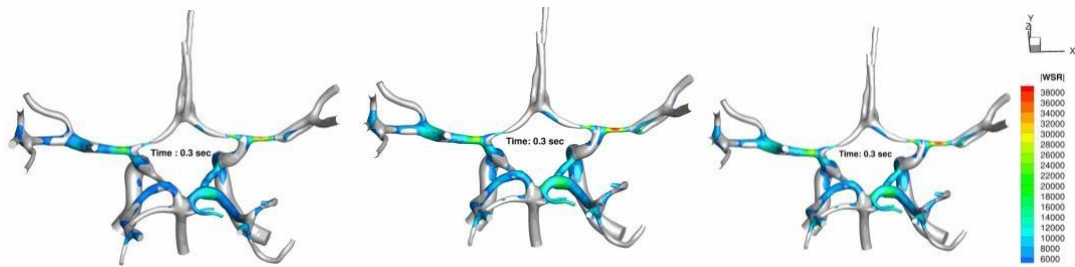


## ELECTRONIC SUPPLEMENTARY MATERIAL

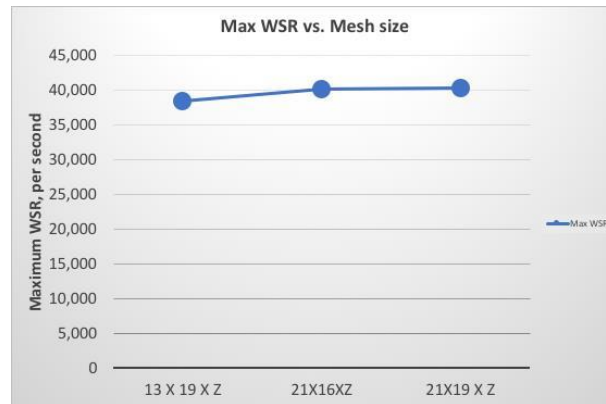


**Supplementary Figure 1:** Creation of circle of Willis (CoW) model from imaging data. The CoW vasculature is segmented from an MR time of flight (TOF) image stack (A) and exported as a triangulated surface mesh (B) using 3D Slicer. The segmented mesh is then registered to (C) X-ray angiography (XA) images by aligning its corresponding 2D projections. The diameters along the mesh are locally adjusted to match the diameters of the XA images. (D) shows the adjustments made across the entire mesh. Inset highlights the adjustments made along the left anterior cerebral artery (ACA) along with a cross section of left ACA where the diameter required a 70% adjustment. Centerlines are extracted from the adjusted surface mesh and used to construct a Nonuniform Rational B-Splines (NURBS) reparameterization (E) of the adjusted triangulated surface mesh. Inset shows a single NURBS patch and its control net along with a cross-section. To construct a volumetric mesh to be used in a computational fluid dynamics analysis, the control points of each axial frame in the NURBS surface control net are extruded in the radial direction to a point on the centerline.

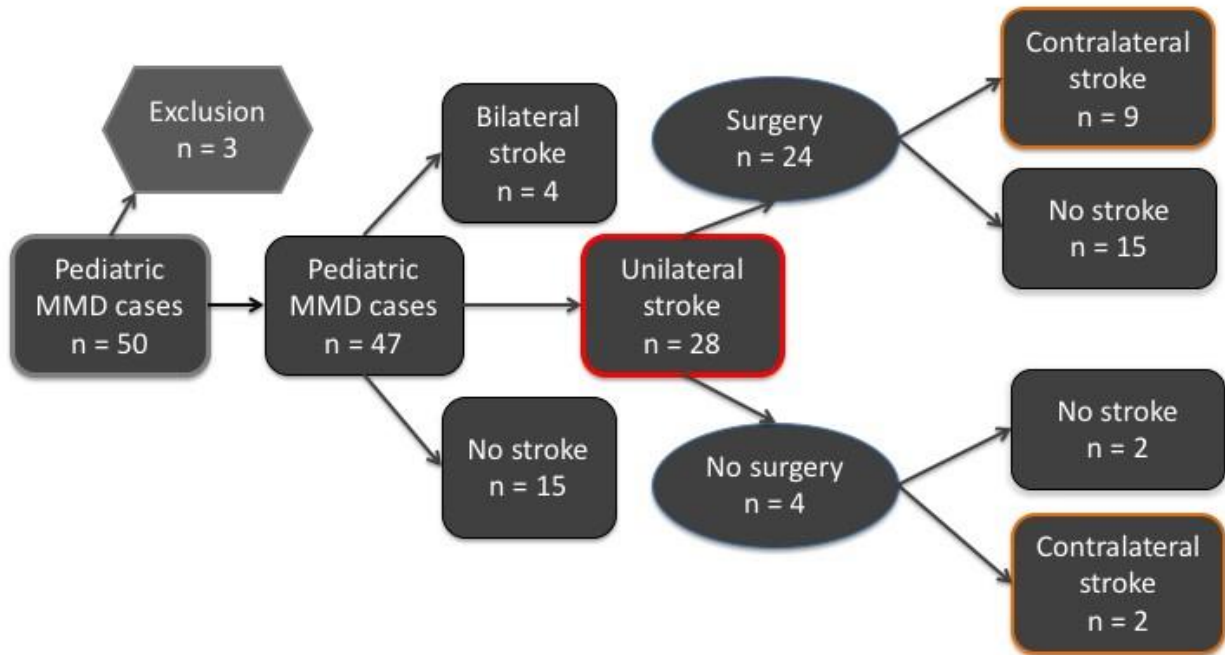
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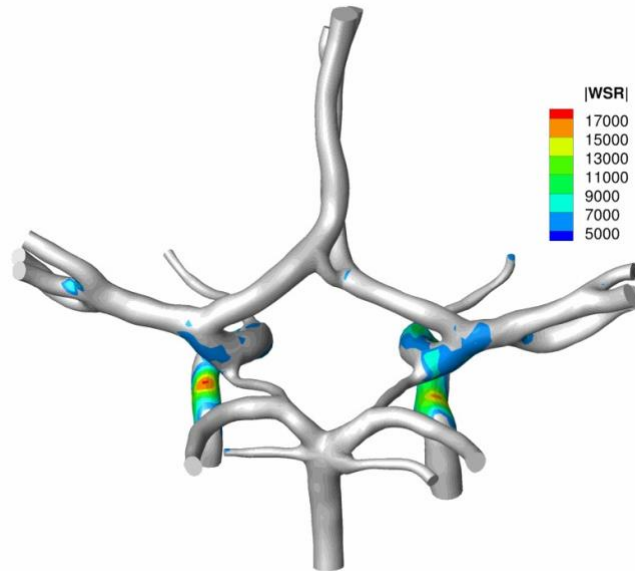
B



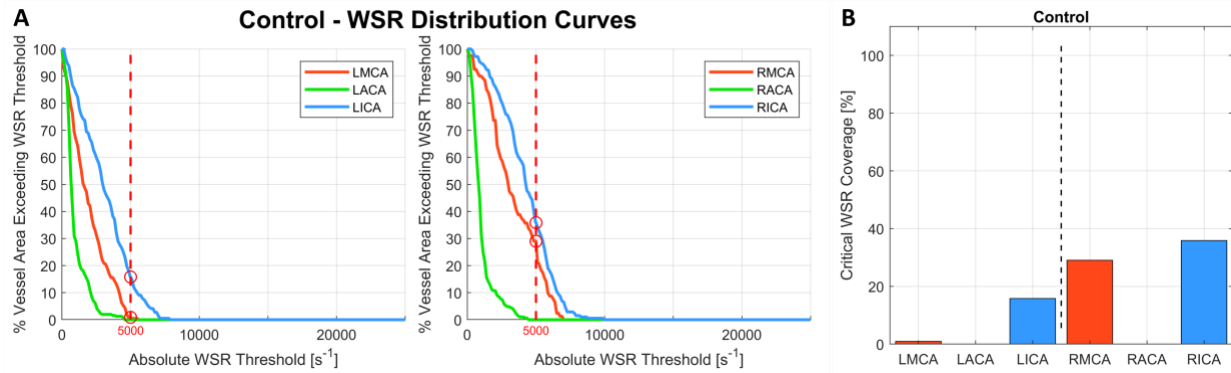
**Supplementary Figure 2:** Mesh independence study. (a) Wall shear rate (WSR) distribution in the CoW model of patient MMD3 for Refinement Mesh 1 ( $13 \times 13 \times Z$ ), Refinement Mesh 2 ( $21 \times 16 \times Z$ ), and Refinement Mesh 3 ( $21 \times 19 \times Z$ ), from left to right. (b) Maximum WSR value in the right middle cerebral artery at peak systole for Refinement Meshes 1, 2, and 3 (left to right).



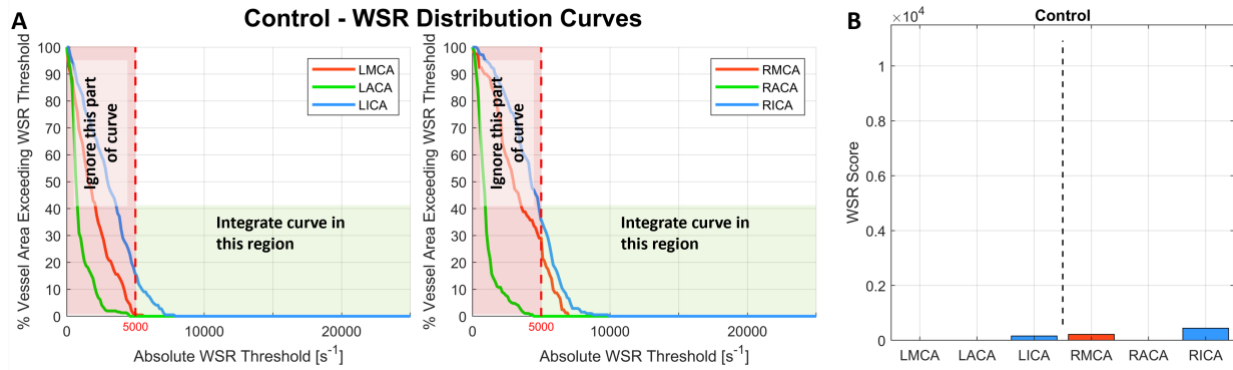
**Supplementary Figure 3.** A retrospective study of 50 pediatric MMD cases with known stroke history who were followed up longitudinally  $2.79 \pm 2.15$  years on average. Forty-four percent of these patients were female (mean age  $9.82 \pm 5.63$  years), while 56% were male (mean age  $10.30 \pm 5.0$  years). Three cases were eliminated due to lack of adequate patient data. Among the remaining patients ( $n = 47$ ), 15 (30.9%) did not have a stroke, 4 (8.5%) had bilateral stroke (stroke on both sides) and 28 (60%) suffered a unilateral stroke. 24 (85.7%) of the unilateral stroke patients underwent post-stroke dural inversion surgery. However, 11 (39.2%) of these unilateral stroke patients, 9 of whom underwent dural inversion surgery, suffered a subsequent contralateral stroke. Three (27%) of the contralateral stroke patients underwent another revascularization surgery. Among the remaining 8 (73%) contralateral stroke patients who did not undergo a second post-stroke surgery, two (25%) suffered recurrent strokes, either contralateral, or ipsilateral. These observations suggest the possibility that treatment by dural inversion can be followed by a contralateral stroke (Hossain et al., 2021).



**Supplementary Figure 4.** Critical WSR ( $> 5000 \text{ s}^{-1}$ ) distribution at peak systole ( $t = 0.3 \text{ s}$ ) in the CoW of a control subject. While a global maximum WSR of approximately  $17,000 \text{ s}^{-1}$  was predicted, the WSR does not exceed  $11,000 \text{ s}^{-1}$  in the vessels under consideration: terminal internal carotid artery (ICA), proximal middle cerebral artery (MCA), and proximal ACA. Further details can be found in (Hossain et al., 2021).



**Supplementary Figure 5.** Computation of the critical WSR coverage (CWSRC) for the vessels of the control subject. This metric is percentage of a vessels surface area with WSR values exceeding the coagulation threshold ( $5000 \text{ s}^{-1}$ ) and evaluation the WSR distribution curve for each vessel (A) at a WSR threshold of  $5000 \text{ s}^{-1}$  yields the critical WSR coverage values shown in (B) for the vessels of the control model.



**Supplementary Figure 6.** Wall shear rate (WSR) score computation. (A) The WSR distribution curves generated for each vessel are integrated in the domain where WSR threshold is above 5000  $s^{-1}$  (the green area under the curve). The portion of the curve with WSR threshold value less than 5000  $s^{-1}$  (in red) is ignored. (b) WSR score for the left and right ICA, MCA and ACAs of the control subject are shown.

#### References:

Hossain, S.S., Starosolski, Z., Sanders, T., Johnson, M.J., Wu, M.C.H., Hsu, M.-C., Milewicz, D.M., and Annapragada, A. (2021). Image-based patient-specific flow simulations are consistent with stroke in pediatric cerebrovascular disease. *Biomechanics and Modeling in Mechanobiology*. 20, 2071-2084.