WELCOME *To the*

2026 SYMPOSIUM

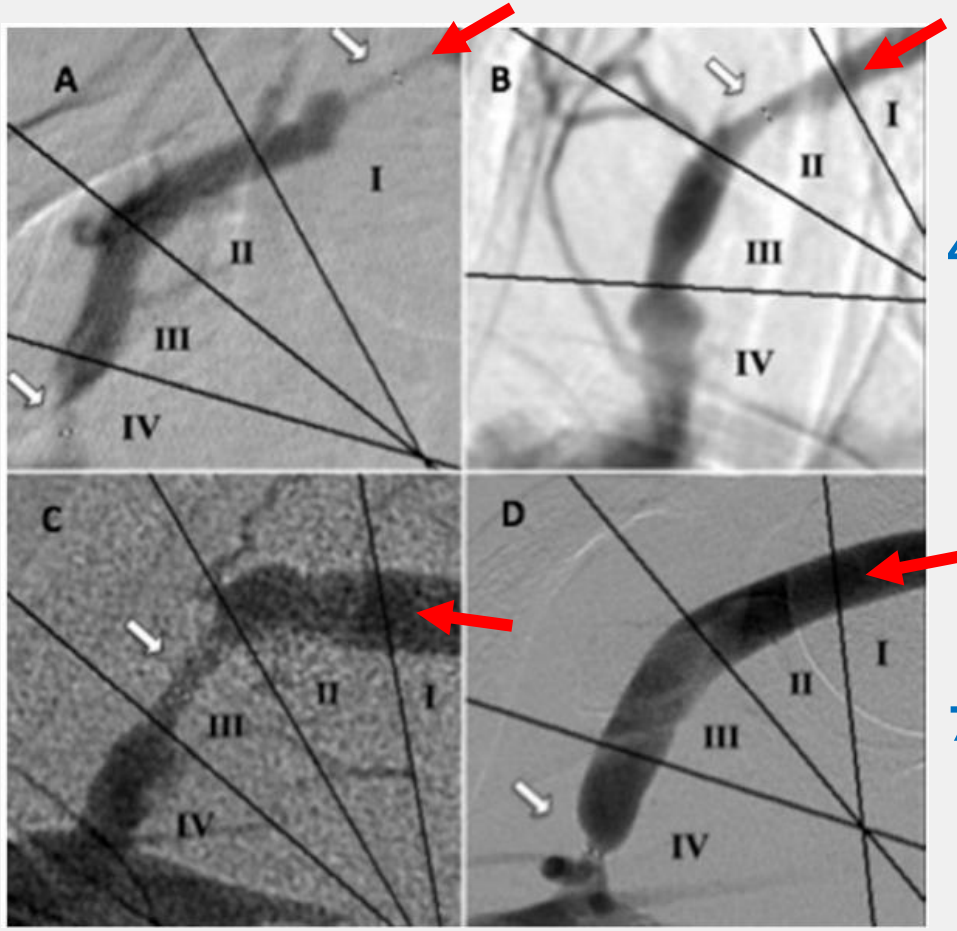
Remodeled cephalic arch geometry promotes disturbed flow at pre-maturation flow rates

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Introduction

Cephalic Arch Stenosis (CAS) is the most common cause of access failure in BCFs

17.4%



40.6%

56.0%

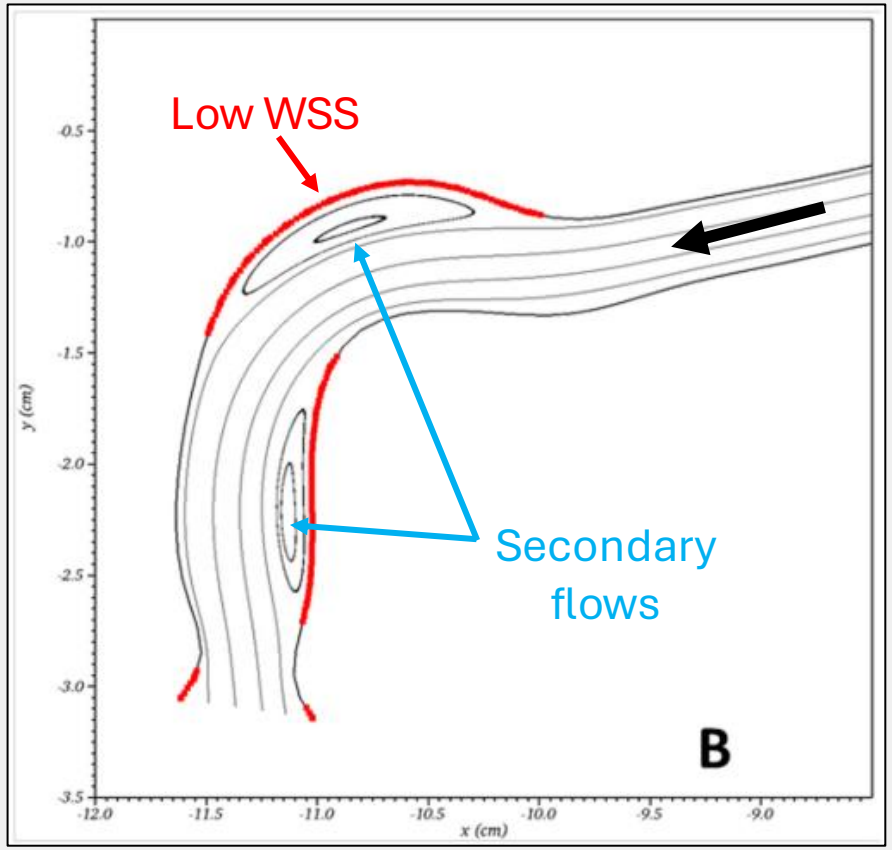
72.5%

- Most CAS instances occur after the bend
- It remains unclear what contributes to CAS in these highly stereotyped locations

(Bennet, *et al.*, 2015)

Cephalic arch geometry may create disturbed hemodynamics

- 2D computational studies have predicted low wall shear stress (WSS) and turbulent flow in the CA (Hammes, 2016)
- High Reynolds number (Re) flow has been calculated in patient CA (Hammes, 2021)
- ***There is a need to confirm the presence of disturbed flows in the CA***

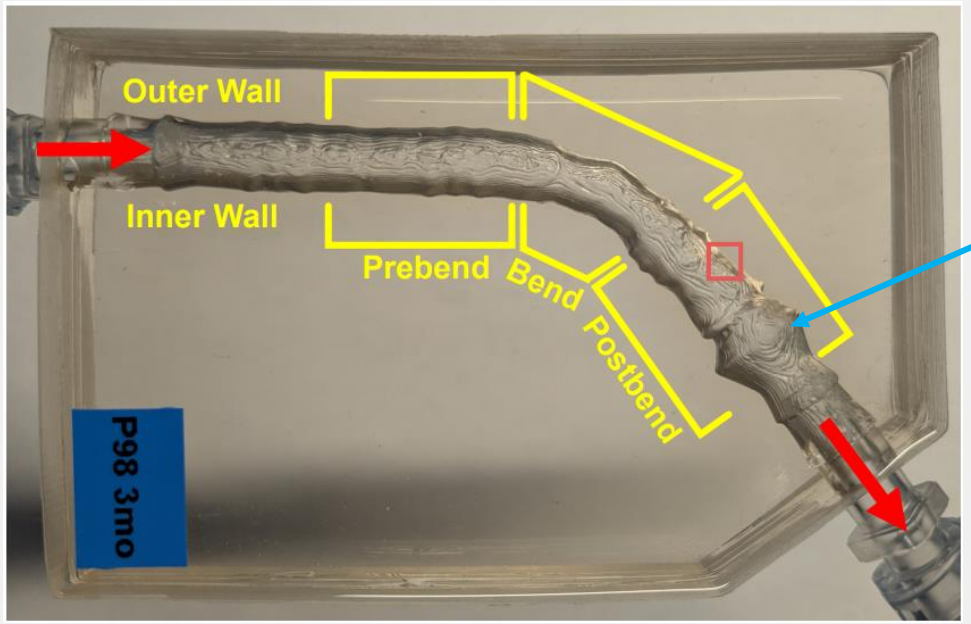


Hypothesis

The inherent curvature and topographically uneven vessel walls of the CA predispose it to disturbed flow.

Methods

Device design & image acquisition



Patient-specific geometry encased in PDMS.



Hemodynamics are visualized via fluorescently-labeled beads suspended in a blood-mimicking fluid (6.3% dextran w/v) that is perfused through the model.

Hemodynamics were characterized systematically from physiologic flow rates (40 mL/min) to elevated ones (>350 mL/min).

Models used in this study

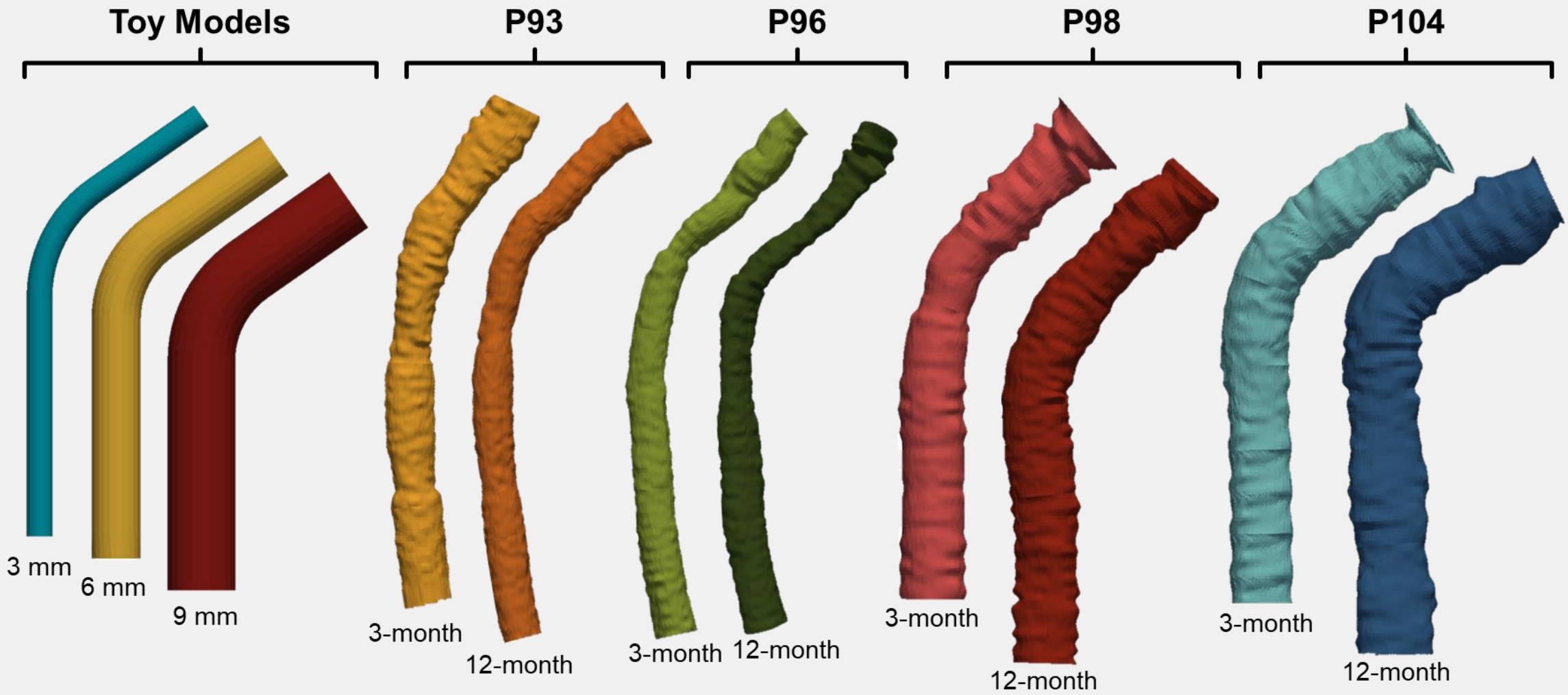
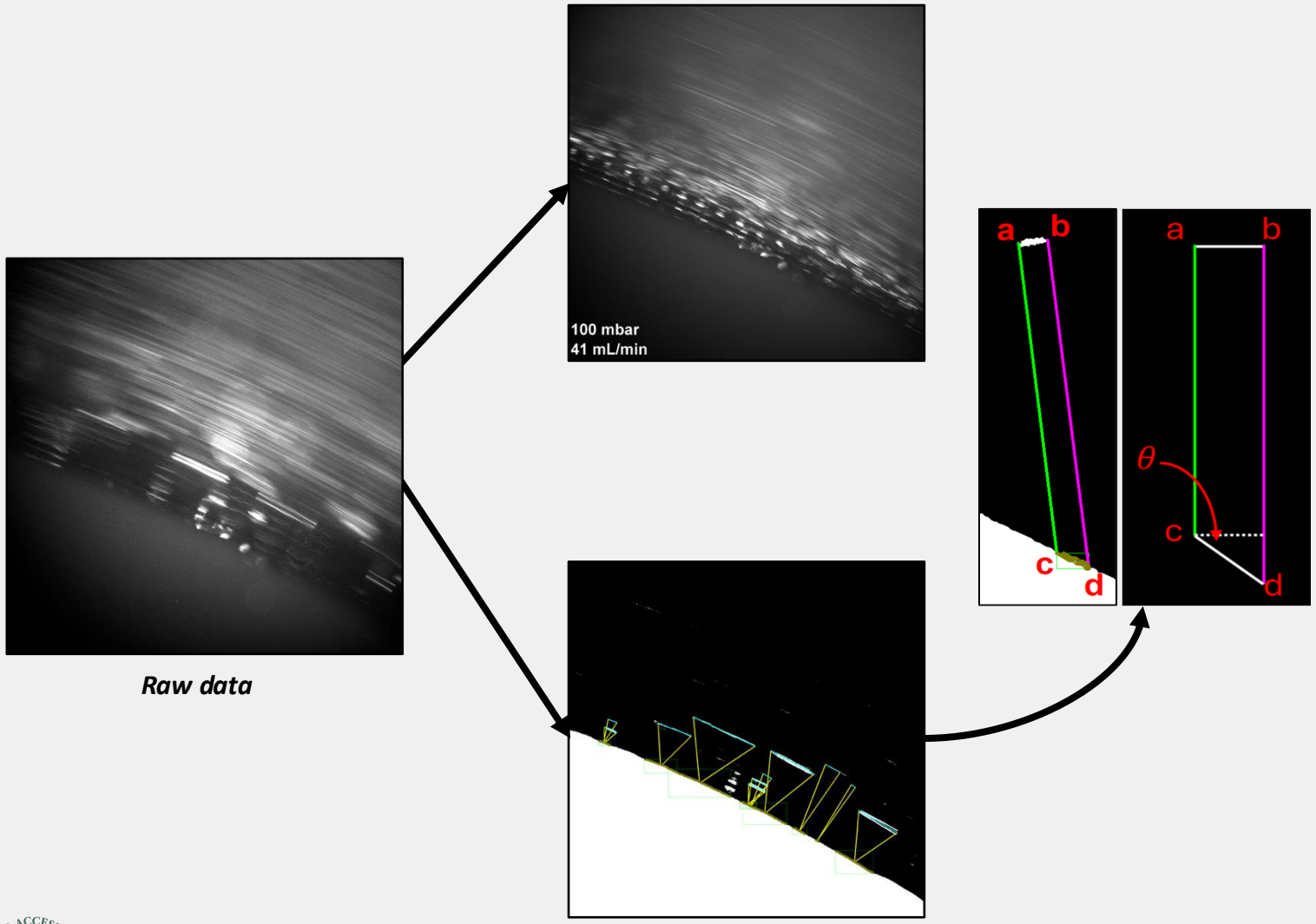


Image processing & calculations



Raw data

1) Maximum intensity projection to show “average” flow (ImageJ)
2) Calculate wall shear stress (WSS), a major predictor of thrombosis (Python)

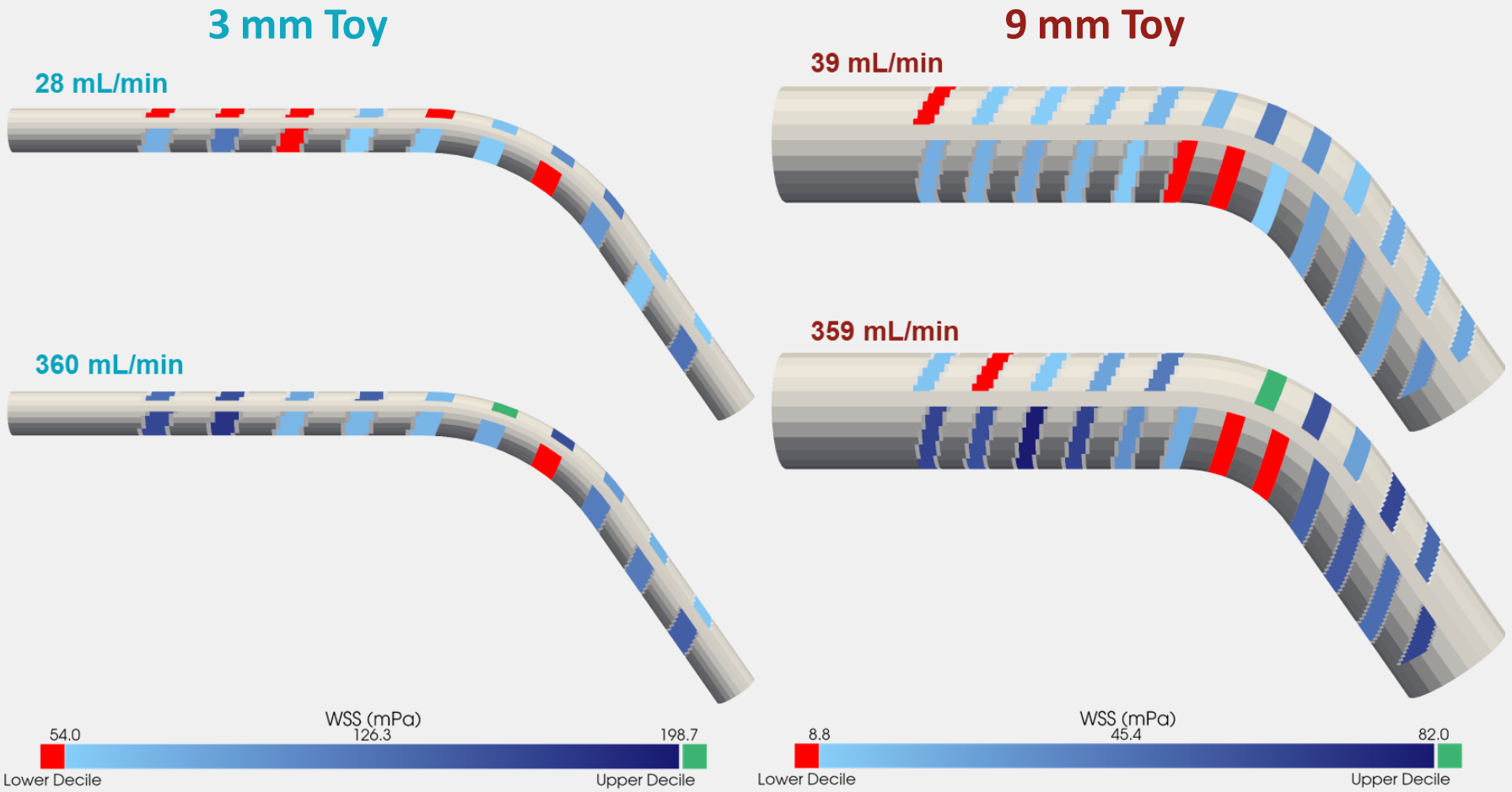
$$\tau = \eta \frac{v}{h}$$

η = viscosity
v = velocity
h = streamline distance

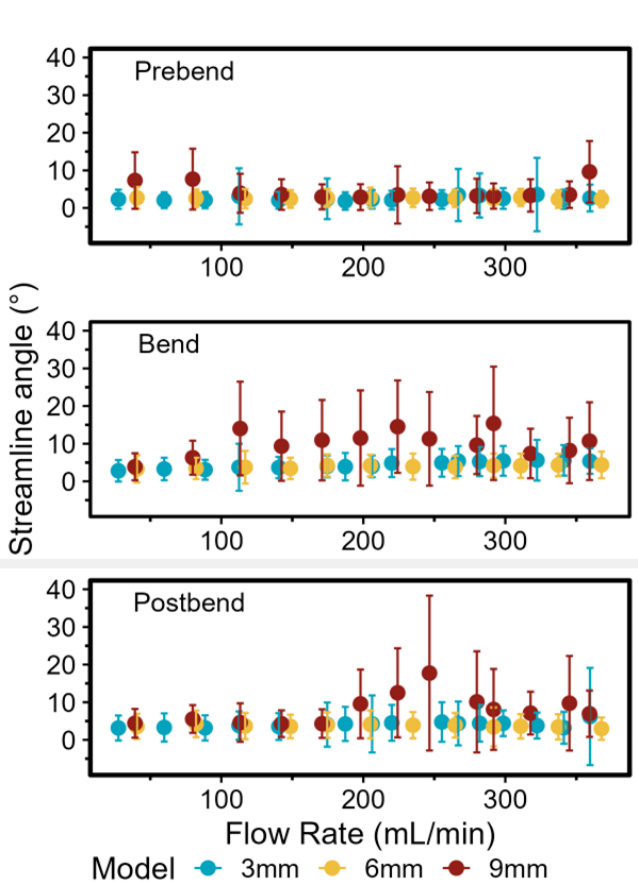
3) Calculate streamline angle as a measure of flow disturbance (Python)

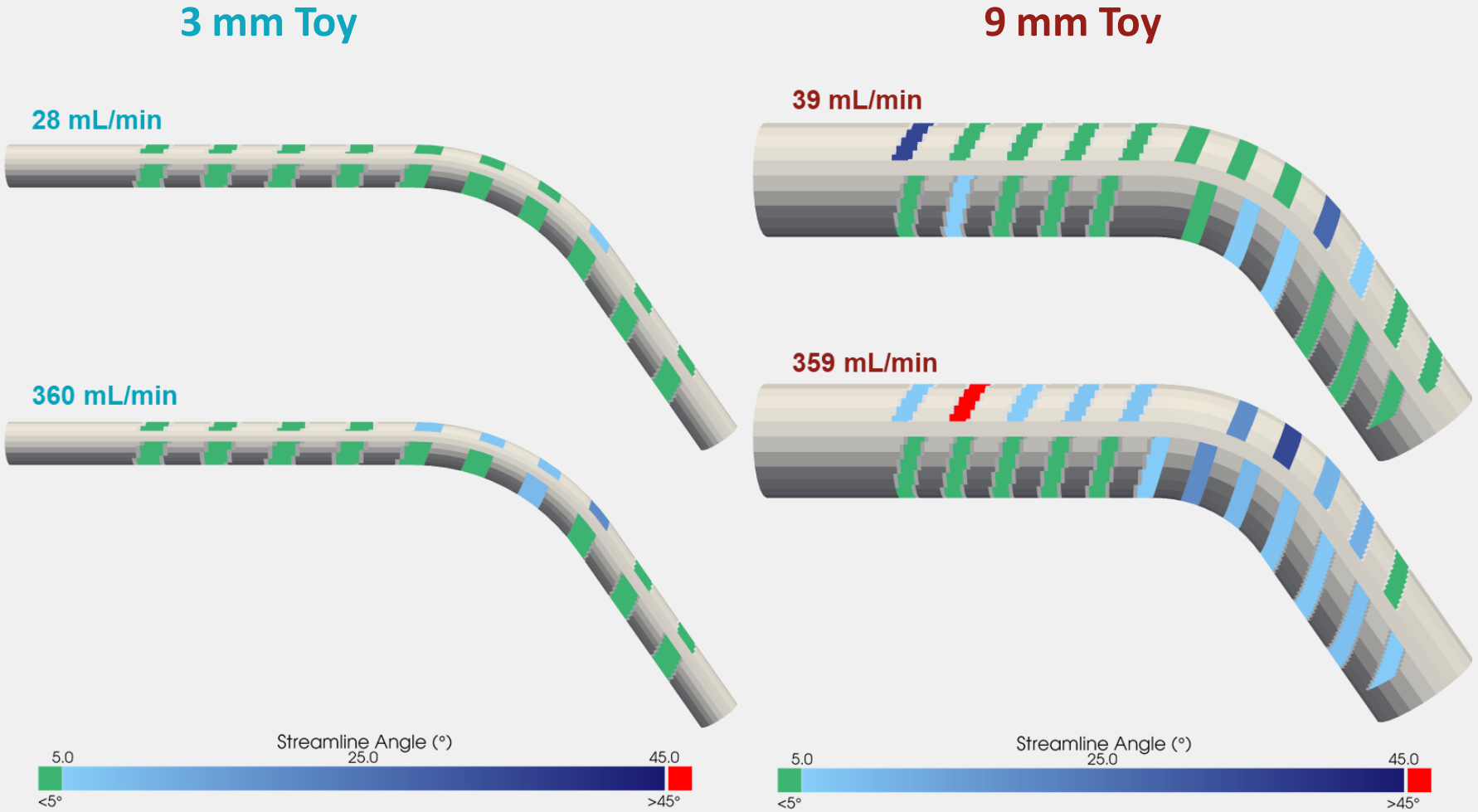
Results

Vessel curvature creates systematically low WSS zones in toy models

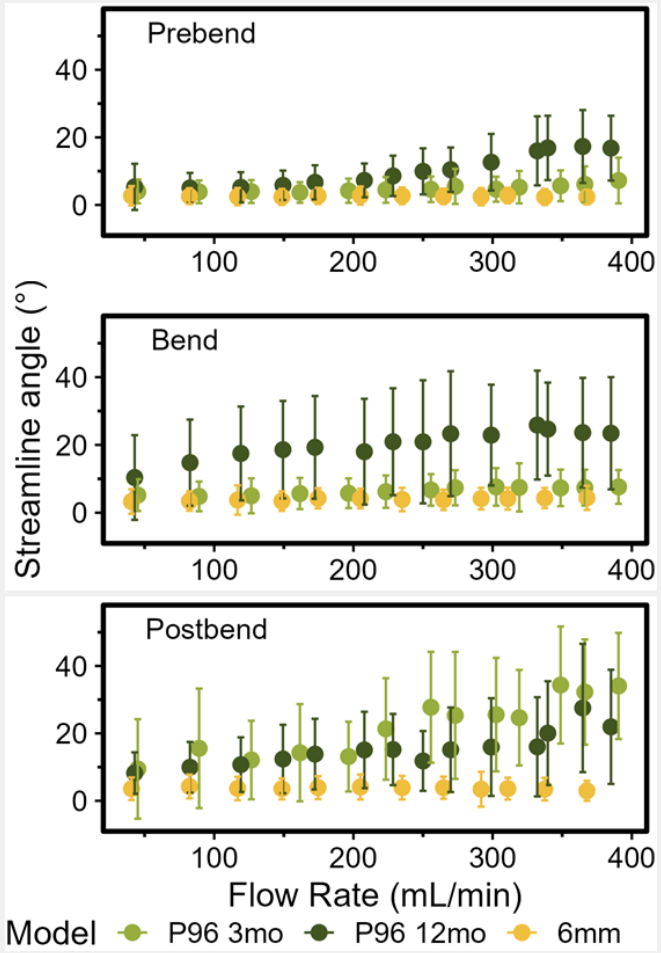


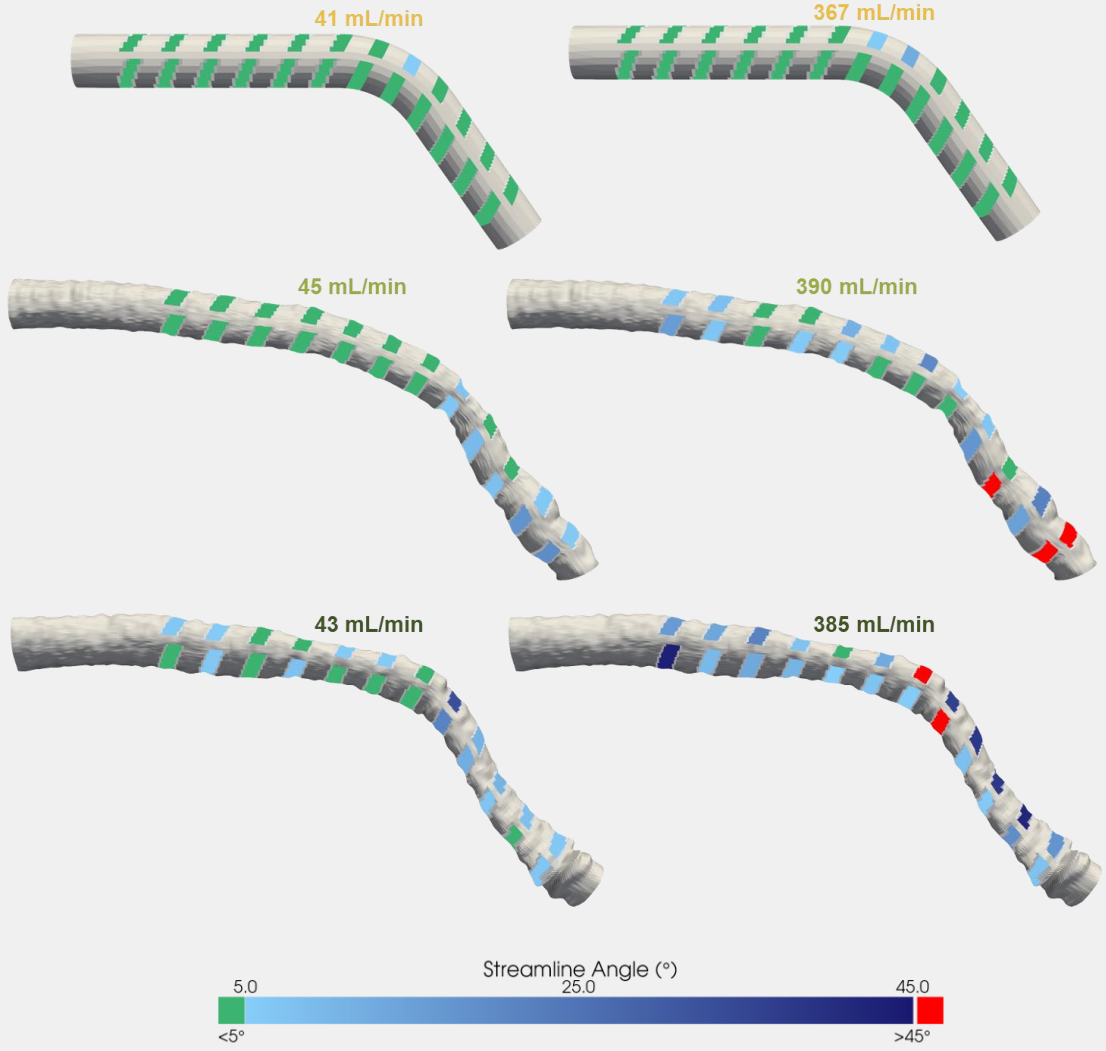
Vessel curvature leads to increased streamline angle at elevated flow rates



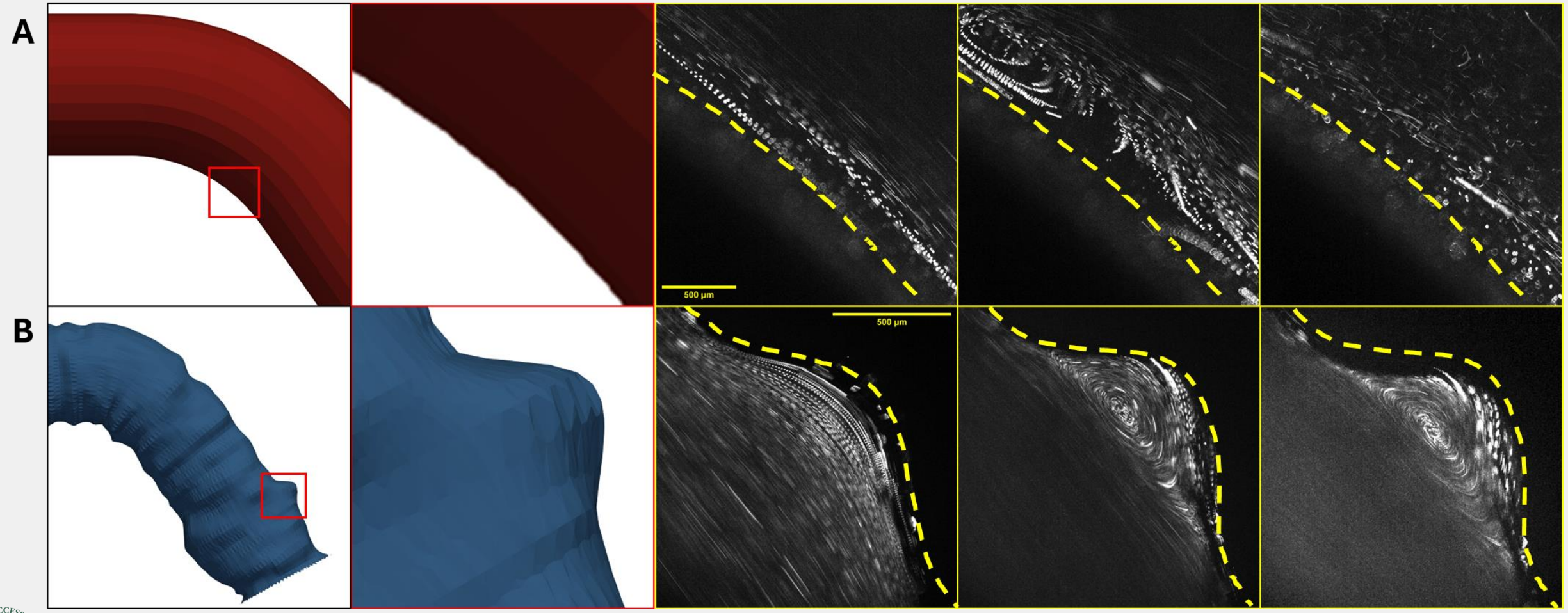


Disturbed flow in patient models is created by remodeled vessel topography

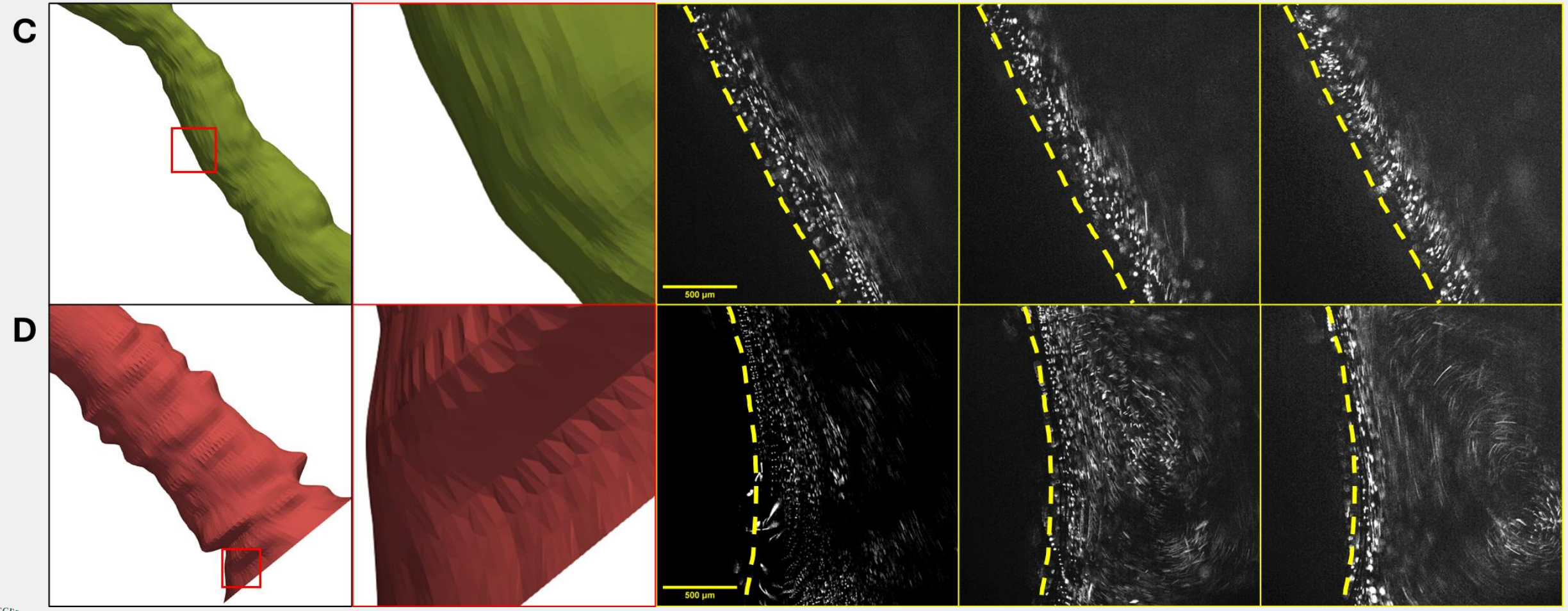




Large- and small-scale geometric features influence disturbed flow development (1)



Large- and small-scale geometric features influence disturbed flow development (2)



Conclusions

- Vessel geometry creates regions along the vessel that experience ***systematically low WSS***
- The occurrence of disturbed flow in the CA depends on both ***flow rate*** and ***vessel geometry***
- Both bulk CA ***curvature*** and ***vessel topography*** contribute to disturbed flow in patient vessels
- Disturbed flow occurs at flow rates much lower than those needed to support hemodialysis
  - Thus, disturbed flow likely develops in these vessels before hemodialysis begins

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