

Computation of wall shear stress from 3D reconstructions of coronary arteries from optical coherence tomography images

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Introduction

- Wall shear stress (WSS) is the tangential force of blood flow on the lumen wall.
- Areas of high wall shear stress within coronary arteries have been associated with increased plaque vulnerability and greater risk of a cardiac event (Kumar et al., 2018).
- Optical coherence tomography (OCT) is the highest resolution intracoronary imaging technique. This allows for clearer identification of vulnerable plaque.
- Using OCT images to create 3D models of coronary arteries, the aim of this study is to better understand WSS patterns.

Methods

- Angiography and optical coherence tomography (OCT) images from patients (n=63) enrolled in the Shear-Stent study were used to create a 3D reconstruction of coronary arteries.
- Reconstructed vessels (n=63) were meshed using SimVascular and steady flow simulations were performed (n=34). Inflow boundary conditions were determined by the following empirical relationship that accounted for the inlet area.

$$Q = \left(1.43 * \frac{2\sqrt{A/\pi}^{2.55}}{100} \right) * 10^6$$

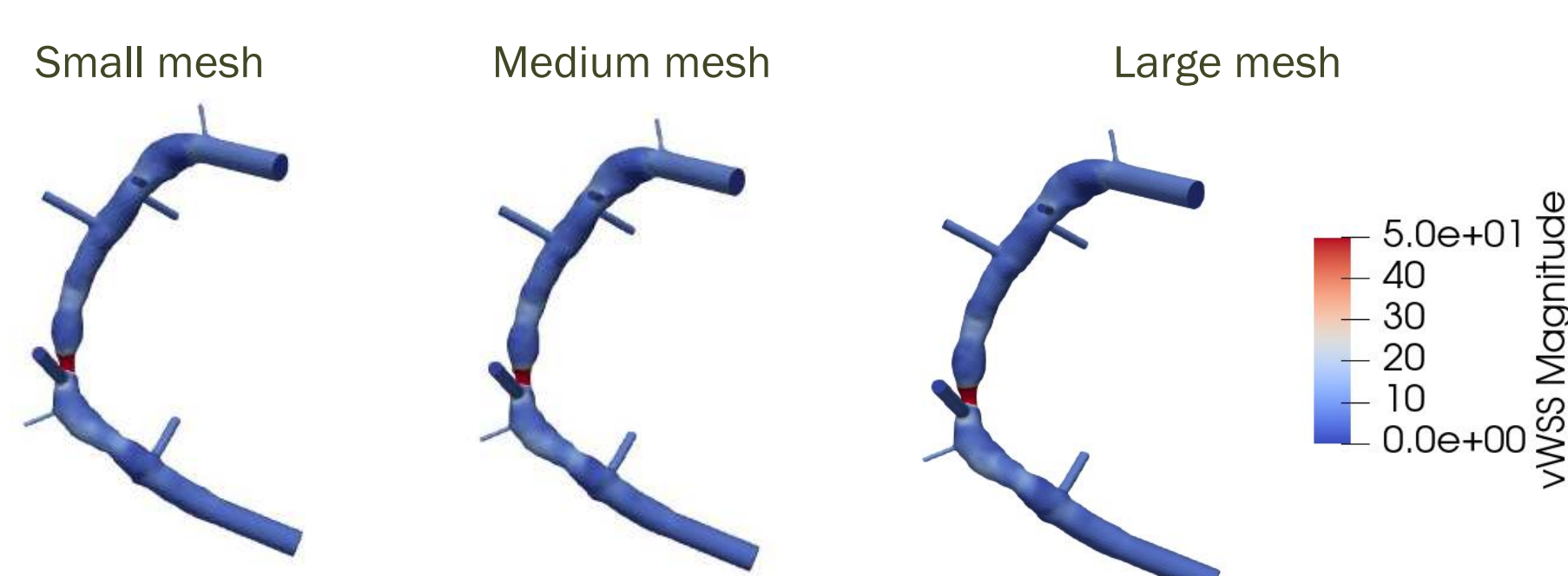
- Outflow resistance boundary conditions were determined by splitting the total resistance between each branch, as shown in the following formula.

$$R_i = \frac{\sum_j A_j}{A_i} R_{tot}, \quad R_{tot} = \frac{P}{Q}$$

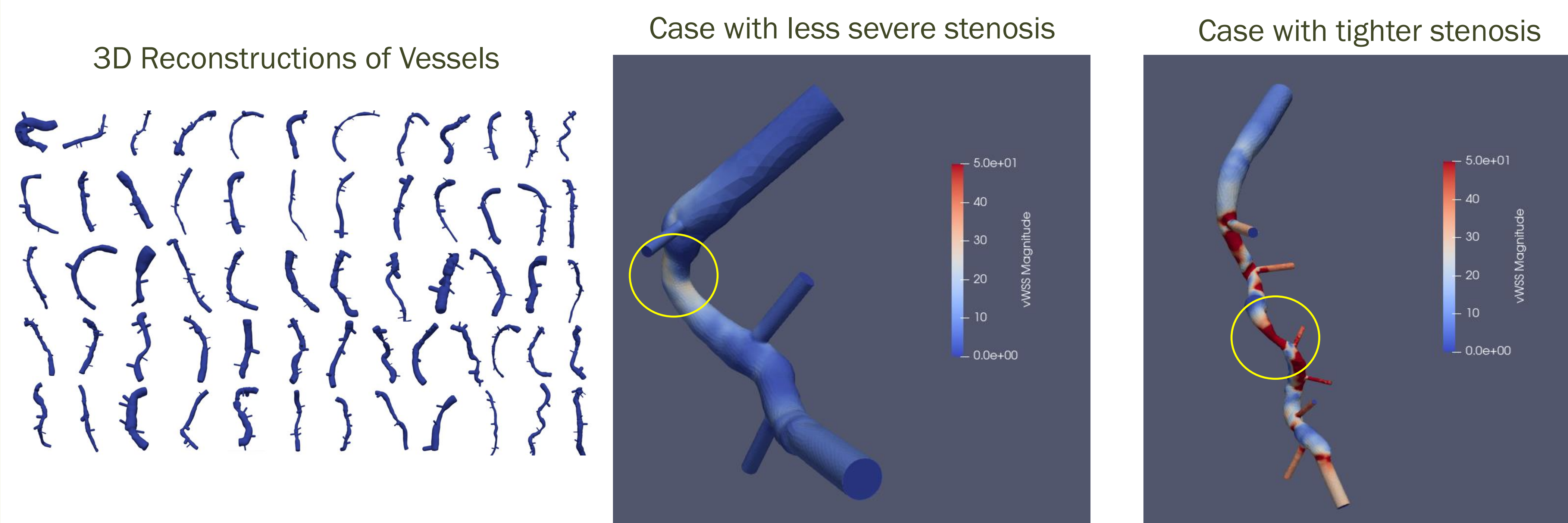
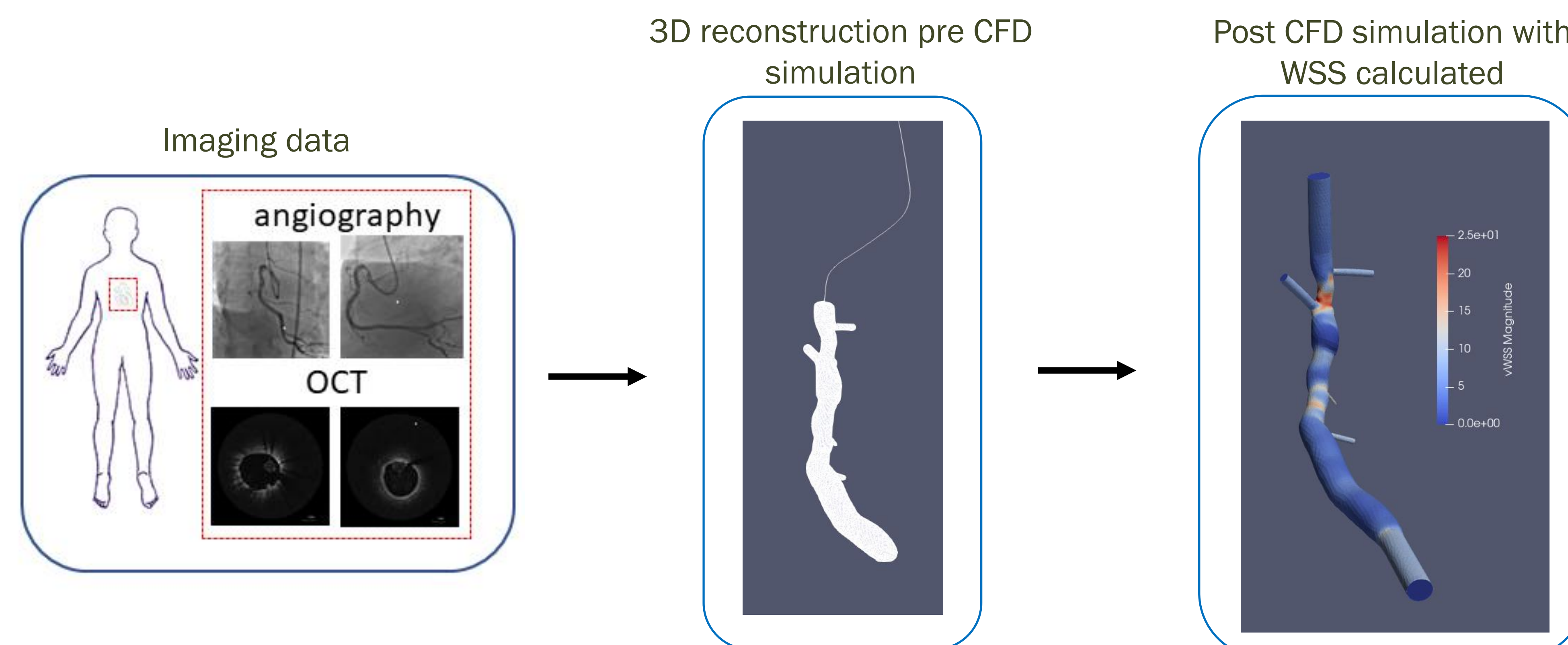
- Mean aortic pressure (P) was assumed to be 93.33 mmHg for all patients.

- Post processing was done using VTK.

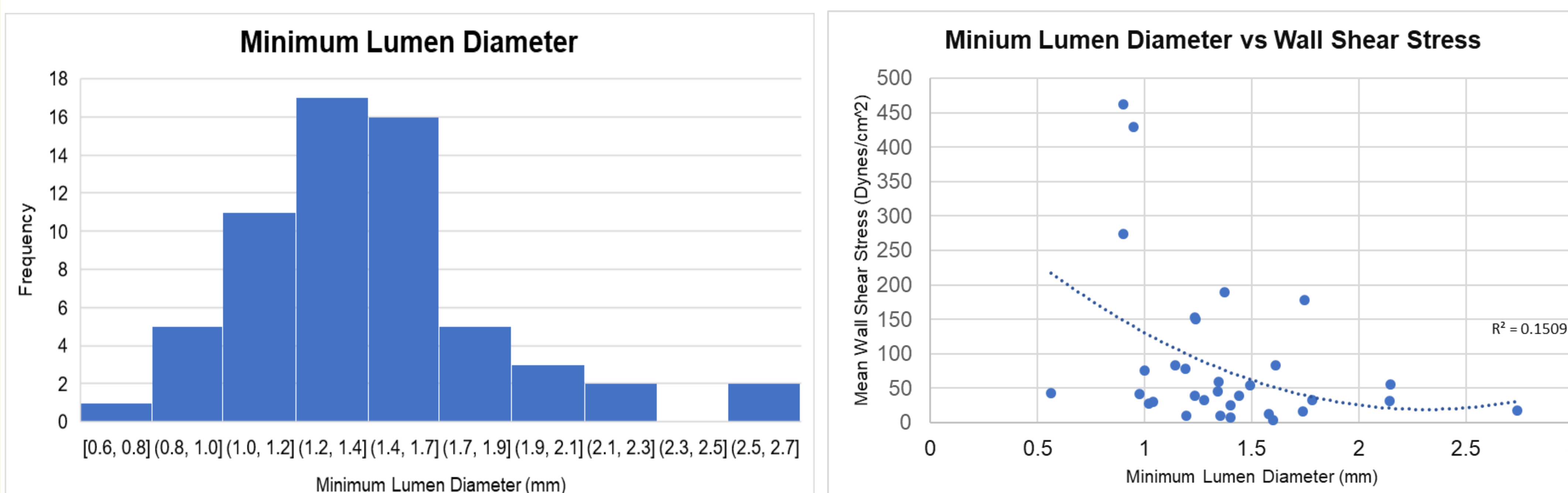
Mesh Independence:



Workflow



Results



Patient Population

| | |
|----------------------------------|------------------------------------|
| Patient sex | 50 male (79.4%), 13 female (20.6%) |
| Mean Patient Age | 63.4 years (± 11.4) |
| Patients with Hypertension | 16 (25.4%) |
| Prior Myocardial Infarction (MI) | 17 (26.9%) |
| Patients with Diabetes | 21 (33.3%) |
| Mean Minimum Lumen Diameter | 1.44 mm (±0.4) |
| Mean Flow Rate | 1.77 mL/s (±3.65) |

Discussion

- Kumar et al., 2018 found that wall shear stress was higher in patients with major adverse cardiovascular events. This study found that the optimal threshold for WSS predicting a myocardial infarction (MI) was 4.71 Pa (47.1 Dynes/cm²).
- The results from this project show that 22% of patients have WSS values greater than 47.1 Dynes/cm² at the location of the minimum lumen diameter within the analyzed vessel.
- Future directions for this project include investigating the relationship between WSS and plaque within the artery.

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