



**INTER-ANALYST STUDY OF GEOMETRY AND HEMODYNAMICS IN PORCINE  
ARTERIOVENOUS FISTULA**

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Chronic kidney disease (CKD) is a condition characterized by the gradual loss of kidney function over the course of time, affecting approximately 37 million people in the United States [1]. During the end-stage of CKD, CKD patients' kidneys become completely dysfunctional and require treatment such as a kidney transplant or hemodialysis treatment [1,2]. Hemodialysis is the more prevalent approach due to the significant organ shortage for transplants [3,4], and arteriovenous fistulas (AVFs) are the preferred vascular access type due to their better long-term reliability and lower infections among all vascular access types [3]. However, approximately 60% of newly created AVFs fail to mature to become functional due to insufficient outward remodeling or excessive inward remodeling caused by neointimal hyperplasia [3]. The resulting lumen geometry after AVF creation has been shown to increase oscillatory blood flow that damages the vessel walls, which leads to neointimal hyperplasia [3,5]. Understanding the role of hemodynamics in the pathophysiology of neointimal hyperplasia within the AVF vessels is important since neointimal hyperplasia within the AVF vessels has been shown to inhibit the high blood flow rate required for successful hemodialysis treatment [3,5]. To investigate the effects of hemodynamics, this research used a porcine model of AVFs to investigate how the hemodynamics of AVF blood flow affect AVF vessel remodeling. The first step of this investigation is to quantitatively characterize AVF hemodynamics. The Shiu lab uses MRI-based computational fluid dynamics (CFD) simulations for this purpose. CFD simulations require a structural domain (which is the AVF lumen in this clinical problem) and its boundary conditions (which are the blood velocity and/or pressure at the openings of the AVF lumen). The structural domains were established from the 3-D reconstruction of porcine AVF lumens from black-blood MR images using Amira software and flow extensions to the 3-D reconstructed AVF lumen were computationally added using VMTK 1.4.0. The velocity boundary conditions were obtained from cine phase-contrast MR images using Medviso Segment. The data obtained is used to perform meshing in ICEM CFD 2019 R2, and CFD simulations were performed in ANSYS Fluent. Some of the techniques in this project rely on an analyst's judgment. Therefore, the 3-D reconstructions and velocity extractions performed in this research were not completely identical to another independent analyst's results, who also performed these techniques using the same porcine AVFs. In the future, the data obtained from ANSYS Fluent will be processed in Tecplot 360 to calculate the cross-sectional area, wall shear stress, oscillatory index, velocity, and vorticity of AVFs. Currently, a graduate student in the Shiu lab is also performing MRI-based CFD to characterize the hemodynamics of porcine AVFs. The findings from this research will be compared with the graduate student's results to determine whether the CFD simulations will have high degrees of agreement or not.

## REFERENCES

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