COMPUTATIONAL ASSESSMENT OF THE EFFECTS OF BICUSPID AORTIC VALVE MORPHOTYPE ON ASCENDING AORTA HEMODYNAMICS

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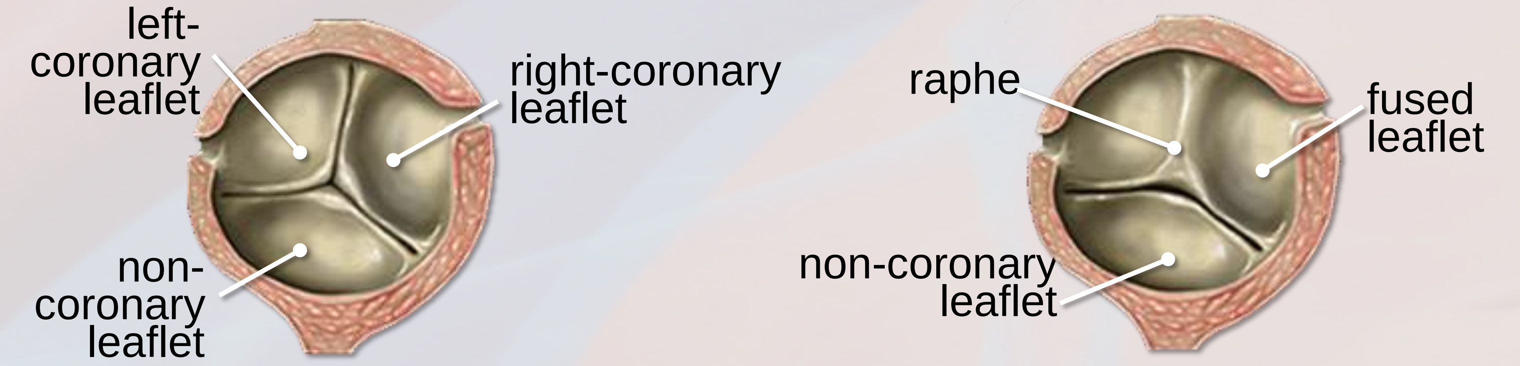
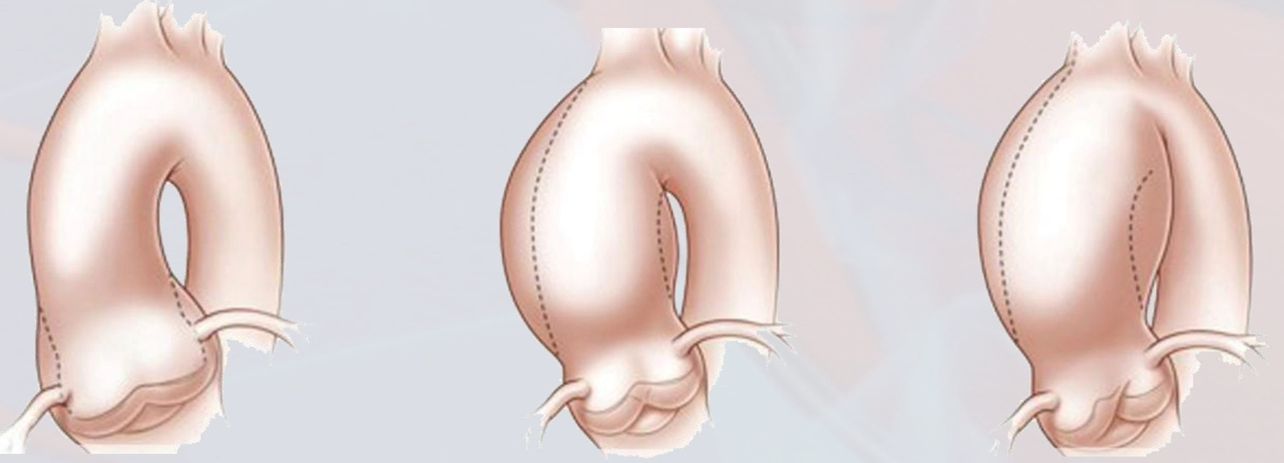
INTRODUCTION

THE AORTIC VALVE



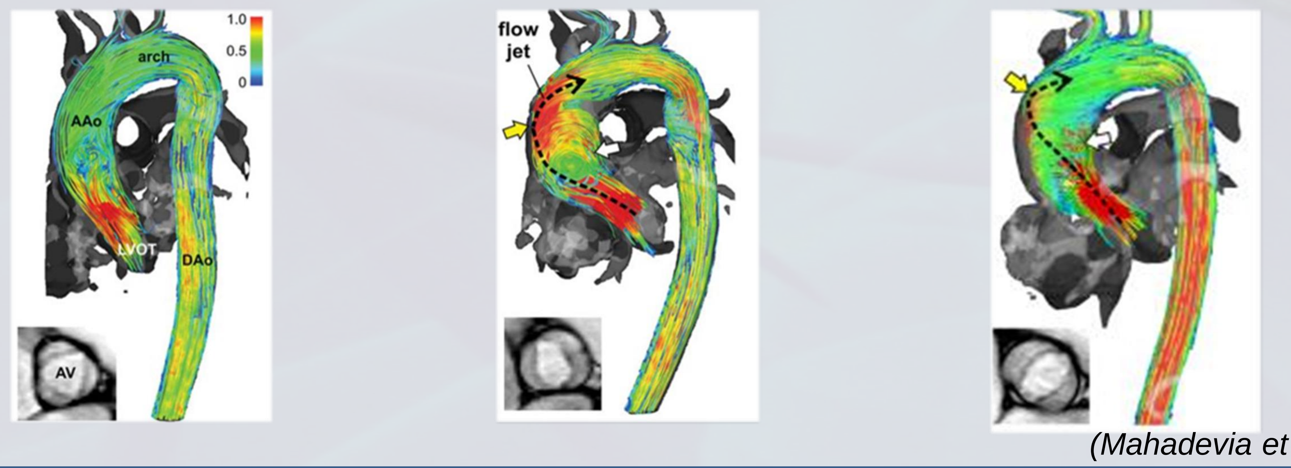
TYPE-I BAV CLASSIFICATION

AORTIC DILATION CLASSIFICATION



(Verma & Siu, 2014)

AORTA FLOW PATTERNS



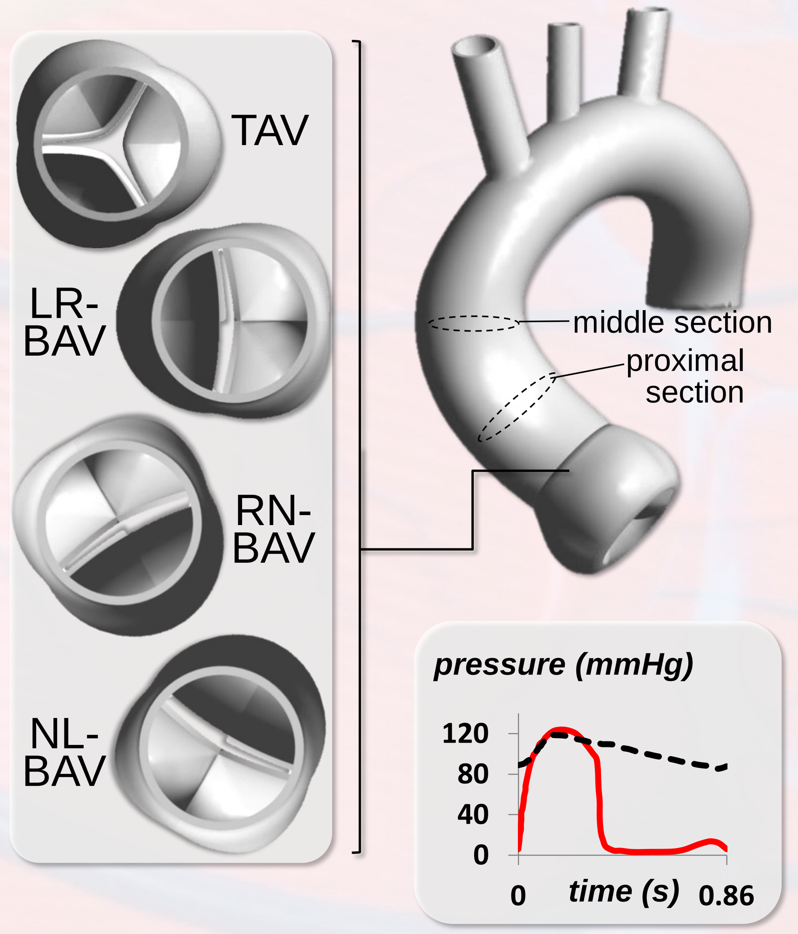
(Mahadevia et al, 2014)

HYPOTHESIS

Among all standard flow parameters, wall shear stress (WSS) abnormalities are the most reliable predictors of BAV aortopathy prior to dilation

METHODS

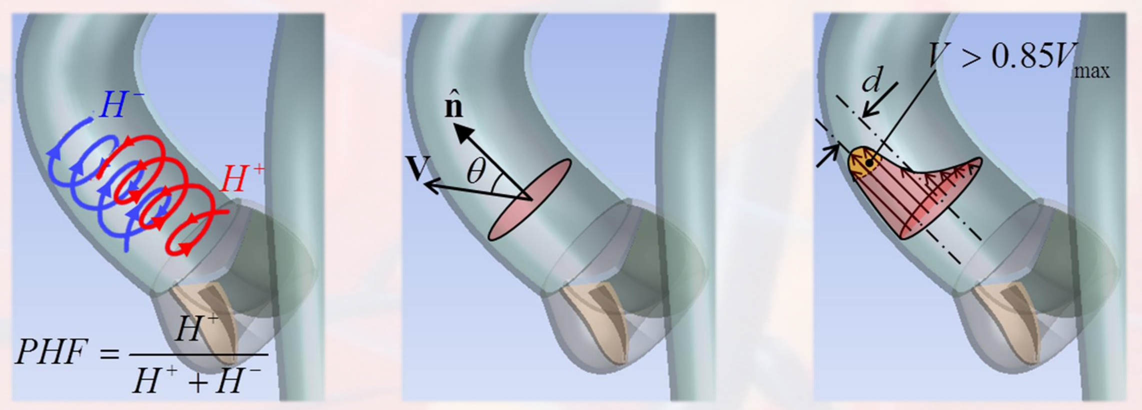
GEOMETRY & BOUNDARY CONDITIONS



CONSTITUTIVE MODELS

blood	Newtonian, incompressible fluid
leaflets	Isotropic, homogeneous, hyperelastic material
aortic wall	Isotropic, homogeneous, linear elastic material

FLOW METRICS



$$PHF = \frac{H^+}{H^+ + H^-}$$

WSS METRICS

$$TSM = \frac{1}{T}\int_0^T |\tau|\, dt$$

$$TSG = \frac{1}{T}\int_0^T \left|\frac{\partial \tau}{\partial t}\right| dt$$

$$OSI = \frac{1}{2}\left[1-\left(\left|\int_0^T \tau\, dt\right| \Big/ \int_0^T |\tau|\, dt\right)\right]$$

DISCUSSION

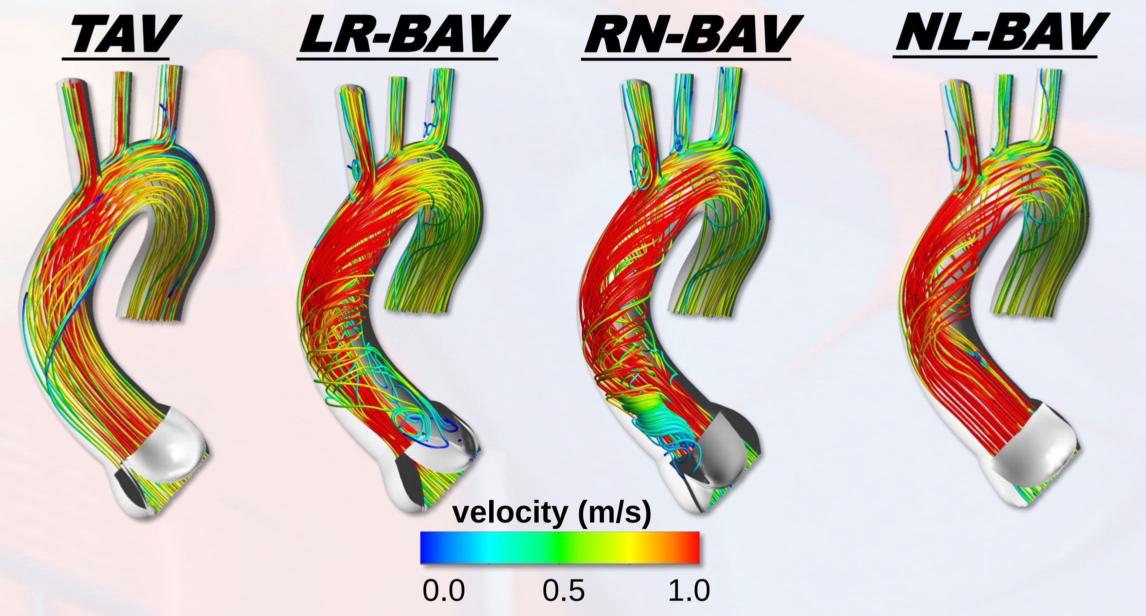
- The BAV generates abnormal aorta hemodynamics and disturbed regional WSS, which are strongly dependent on the leaflet fusion
- Global flow metrics (i.e., PHF, flow angle, flow displacement) may not be sensitive enough to identify BAV aortopathy types and predict disease progression prior to dilation
- WSS metrics seem to exhibit superior predictive capabilities and to be better risk assessment markers for BAV aortopathy

OBJECTIVES

Assess computationally the prognosis value of proposed hemodynamic predictors of BAV aortopathy in non-dilated TAV and BAV AAs using fluid-structure interaction (FSI) modeling.

RESULTS

PEAK-SYSTOLIC STREAMLINES

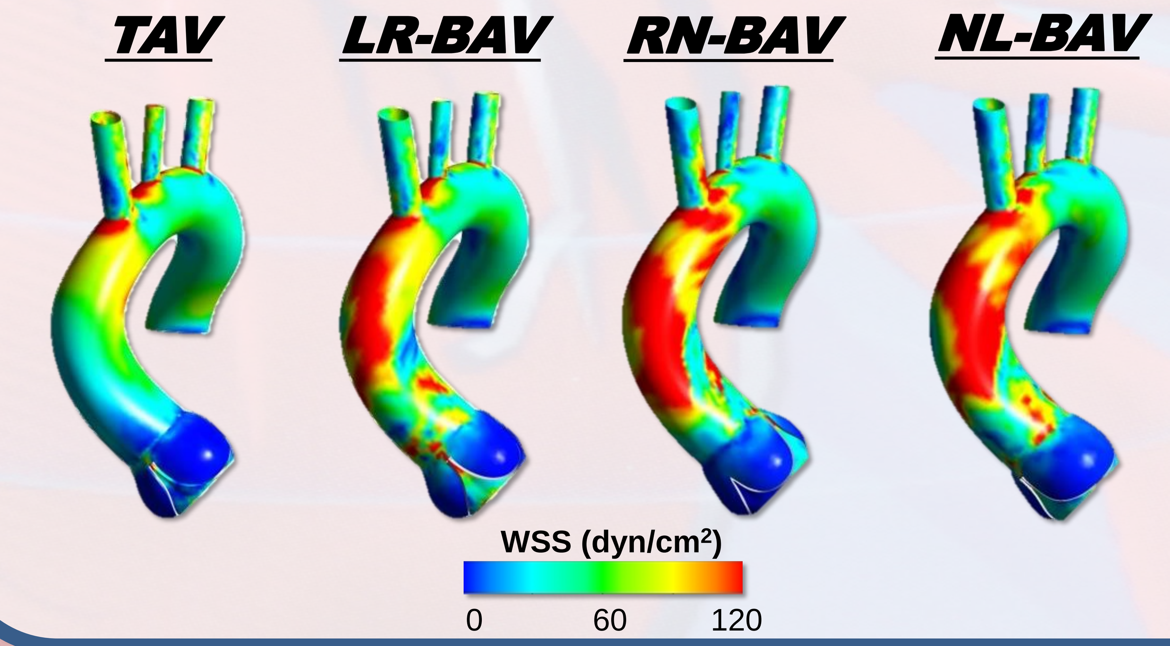


FLOW METRICS

	Proximal aorta			Middle aorta		
	PHF	θ	d	PHF	θ	d
TAV	0.50	4.6°	1.3	0.51	5.5°	3.3
LR-BAV	0.50	11.2°	6.9	0.68	12.1°	8.0
RN-BAV	0.52	12.4°	5.1	0.71	13.4°	8.5
NL-BAV	0.51	13.8°	4.9	0.72	13.6°	6.8

$[PHF] = s^{-1}$ $[d] = mm$

PEAK-SYSTOLIC WSS



WSS METRICS

	Proximal aorta			Middle aorta		
	TSM	TSG	OSI	TSM	TSG	OSI
TAV	15.4	304	0.37	18.9	244	0.17
LR-BAV	19.9	468	0.15	16.8	305	0.24
RN-BAV	15.3	423	0.19	19.5	328	0.13
NL-BAV	19.3	478	0.18	17.4	285	0.13

$[TSM] = dyn/cm^2$ $[TSG] = dyn/(s.cm^2)$

ACKNOWLEDGEMENTS

NSF

American Heart Association. Learn and Live