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AN ATLAS OF COMPUTED FFR IN COMMON PATTERNS OF CORONARY ARTERY DISEASE

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Introduction

Fractional flow reserve (FFR) is the gold standard method for assessing the physiological significance of coronary artery lesions. A 'virtual' FFR can be computed from angiographic images, using computational fluid dynamics, avoiding the need for a pressure wire. FFR is influenced by several factors including; stenosis severity, length of stenosis, size of vessel and myocardial resistance. However, how each of these contribute to the overall FFR is not fully understood. We sought to create a range of 3D geometries, with varying characteristics and determine their corresponding vFFRs, to inform clinicians about the impact upon blood flow caused by commonly encountered disease patterns.

Methods

Geometries were created using ANSYS Design Modeler™ that included stenoses of different shape, severity, number and length, within straight and branched models using variations on a basic standard vessel size (a rigid tubular 3.5mm diameter main vessel, 50mm long, with branches obeying Huo-Kassab's law). vFFR values were calculated using our in-house VIRTUheart™ workflow. Results were displayed in easy-to-understand pictorial form.

Results

187 geometries were created. The total reduction in cross sectional area had the greatest effect on FFR. All 80% concentric stenoses studied had an FFR of < 0.80, regardless of shape, length or number of lesions. However, when geometries with the same stenosis severity were compared, multiple lesions, increased lesion length, smaller vessel diameter

and lower myocardial resistance were associated with lower FFR values. Using different diameter laws for our branched geometries, resulted in minimal difference to FFR values. Table 1 shows some examples of key FFR results derived from single vessel geometries

Conclusions

vFFR is most affected by stenosis severity. However, changes to lesion shape, length, number and vessel diameter also impact vFFR. These data place these variables into perspective for clinicians when judging the significance of lesions in a diseased vessel.

Table 1: Example of some key FFR results obtained from our straight vessel geometries

Lesion	Diameter Reduction in X and Y direction (%)		Rounded/ Rectangular lesion	Number of lesions (separated by 10mm)	FFR (at outlet)
5mm concentric	X = 70	Y = 70	Rectangular	1	0.80
5mm eccentric	X = 0	Y = 80	Rounded	1	0.93
15mm concentric	X = 70	Y = 70	Rounded	1	0.88
15mm concentric*	X = 70	Y = 70	Rounded	1	0.83
5mm concentric	X = 70	Y = 70	Rounded	2	0.82
5mm concentric*	X = 70	Y = 70	Rounded	2	0.76
5mm concentric†	X = 70	Y = 70	Rounded	2	0.74
5mm eccentric	X = 0	Y = 80	Rounded	3	0.83

* = Indicates Microvascular Resistance was set to 6.721E9, 2E9 lower than the standard 8.721E9 value used.

† = Indicates vessel Diameter was set to 3.0mm rather than standard 3.5mm diameter used.