What is the impact of stenting on coronary physiological parameters: a computational study

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Background

Coronary Artery disease (CAD) is one of the leading causes of death globally [1] and the number one cause of death in the developed world. [2] It is caused by the build up of atherosclerotic plaque which causes vessel luminal narrowing and a reduction in blood flow.
Treatment of atherosclerosis typically involves the insertion of stent(s) into the vessel, to restore blood flow to the distal myocardium. Deciding which lesions will benefit from treatment can be challenging. Fractional flow reserve (FFR) is the most widely used method for assessing coronary blood flow and is the gold standard method for determining physiological lesion significance.
However, FFR is only a surrogate of flow, predicting only percentage changes. It cannot assess absolute flow or microvascular resistance.
The development of VIRTU-Q permits the assessment of these parameters alongside FFR during routine pressure-wire assessment. [3] The goal of stenting is to improve absolute coronary flow however this is rarely quantified in clinical practice. Moreover, little is understood about the change in MVR that occurs following stenting and how this relates to flow and FFR.

In this study we sought to determine, using VIRTU Q, the impact of treatment on FFR, flow and MVR in a cohort of patients undergoing stenting for CAD.

Methods

- Data was collected from patients undergoing coronary artery stenting, with FFR assessment at Sheffield Teaching Hospitals NHS Foundation Trust.
- Coronary Angiograms and pre & post PCI pressure readings were obtained prospectively. Cases with a post-PCI FFR>0.95 were excluded due to inaccuracy of VIRTUQ in these cases.
- Coronary arteries were reconstructed in 3D using previously described methods(ref). Virtual stenting was performed to replicate the real-life PCI procedure (figure 2)[4].
- Virtu-Q was applied to compute absolute coronary flow, MVR and stenosis resistance (SR) [3] [4]. This was performed on the baseline vessel (pre-PCI) and on the virtually stented artery (post PCI). An example case is shown in Figure 1.
- FFR, absolute flow, MVR and SR were compared pre and post PCI.

Figure 1 (Left). Pre-PCI vessel segment processed through VIRTU-Q.
Figure 1 (Right). Post-PCI vessel segment processed though VIRTU-Q

Results

- VIRTUQ was successfully performed pre and post PCI in 29 cases. Results are summarised in Table 1.
- PCI resulted in a significant increase in absolute flow (average 35.9%) and FFR (average 32%) and a reduction in stenosis resistance (average 84.5%).
- There was no significant overall change in MVR however results were highly variable (from 354% increase to 74% reduction).

	Parameter	Pre-PCI ± SD	Post-PCI ± SD	P value
Baseline	FFR	0.816 ± 0.121	0.940 ± 0.028	2.5E-05
	Outlet flow (ml/min)	33.462 ± 32.455	50.911 ± 49.714	0.0036
	Microvascular Resistance(MVR)	3.080 ± 1.957	3.030 ± 2.612	0.91117
	Stenosis Resistance (SR)	0.769 ± 0.864	0.167 ± 0.119	0.00108
Hyperaemic	FFR	0.661 ± 0.112	0.874 ± 0.059	4.6E-09
	Outlet flow (ml/min)	52.514 ± 43.963	71.389 ± 49.503	0.00385
	Microvascular Resistance(MVR)	1.456 ± 1.012	1.540 ± 1.251	0.79316
	Stenosis Resistance (SR)	1.294 ± 2.060	0.200 ± 0.145	0.0005

Table 1 (Left). VIRTU-Q processed data averages of coronary parameters for pre and post-PCI cardiac vessel segments.

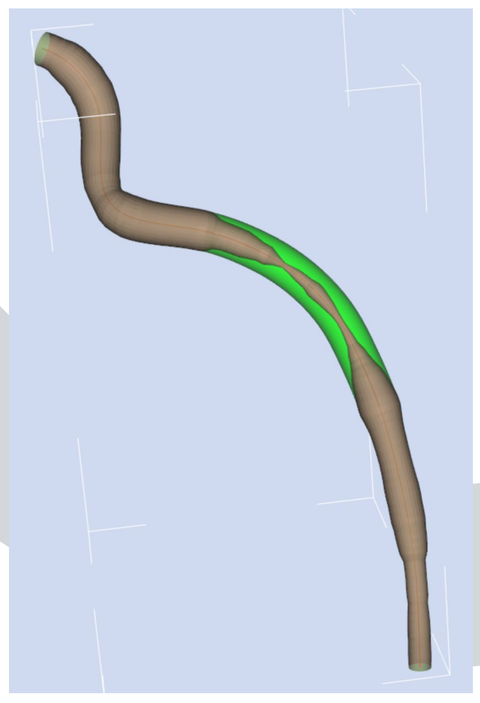

Figure 2. Generated mesh of coronary segment (in grey). Virtually stented vessel mesh (in green)

Conclusions

Overall, improvements in Fractional Flow Reserve, Outlet flow and Stenosis Resistance were shown.

Improvements in FFR are linked with improvements in Outlet flow, however improvements in flow are variable.

The change in MVR isn't significant, however there was a significant variability in response.

Further work is required to understand the response of MVR to stenting given the high variability of response shown.

Improvements in flow cannot be fully predicted until MVR's behaviour is fully understood.

References

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The Insigneo Institute for *in silico* Medicine is a collaborative initiative between the University of Sheffield and Sheffield Teaching Hospitals NHS Foundation Trust.

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