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COMPUTATIONAL MODELLING OF FRACTIONAL FLOW RESERVE FROM CORONARY ANGIOGRAPHY: EXPERT TRAINING REQUIRED

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Introduction

Visual estimation of the physiological significance of coronary artery disease (CAD) is inaccurate. Fractional flow reserve (FFR) is better but is under-used. A less invasive alternative is 'virtual' FFR (vFFR) calculated from computational fluid dynamics (CFD) modelling from angiographic images. The aim of this study was to quality assess the vFFRs analysed by non-expert operators by comparing their results to those of fully trained experts.

Methods

Two expert operators re-processed vFFRs from patients with CAD that had previously been processed by seven non-experts. The vFFRs were computed using the VIRTUheart™ tool (University of Sheffield). Figure 1 shows an example from the workflow. The vFFR results of the expert and non-expert analysed were compared on the basis of the recommendation for percutaneous coronary intervention vs medical therapy and the reason for the differences were documented. Inter- and intra-expert differences and the impact of the expert decisions upon potential clinical management were also assessed.

Results

The angiograms from 1098 patients with CAD were screened, from which 316 cases for vFFR analysis were identified as being suitable for processing. From these, one expert selected 264 consecutive cases for re-processing at random, of which 214 were successfully re-processed. Reasons for unsuccessful segmentation included inadequate images, poor opacification, overlap of vessels and unworkable geometry. The expert mean vFFR was 0.76 and the non-expert was 0.75 (mean per case difference 0.11, SD 0.12), with 73% agreement and 27% disagreement about treatment strategy (see figure 2). Of those, 18% would have been incorrectly revascularised and 9% incorrectly managed conservatively. The mean inter-observer (1st vs 2nd expert) and intra-observer (1st vs 1st expert) differences were 0.06 and

0.09 respectively, and agreement in management interpretations 89% and 90% respectively ($p < 0.0001$). The management interpretation, based upon expert vFFR analysis vs the original cardiologist's decision based upon the angiogram alone, revealed 37% disagreement, with 23% incorrectly revascularised and 14% incorrectly managed conservatively.

Conclusions

There is a large difference in vFFR modelling between expert and less expert modellers. The differences are due to errors in 3-D vessel construction. There is little inter- or intra-observer variation between expert modellers. However good the modelling system, training is required to produce accurate vFFR results. Expert vFFR can improve the clinical management of patients with CAD, altering revascularisation decision in 37% cases.

Figure 1: vFFR simulation result using VIRTUheart™

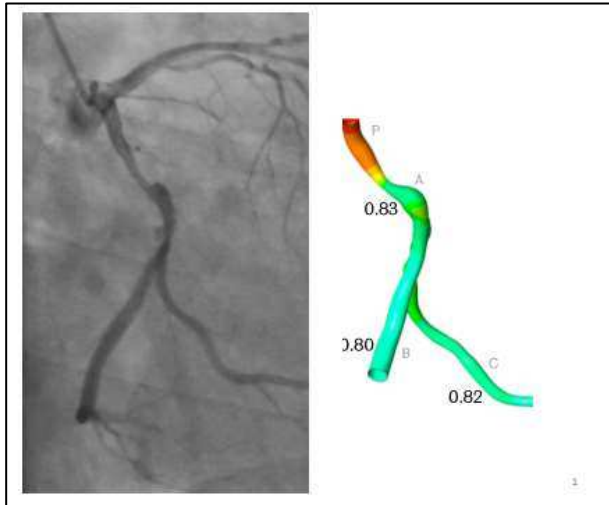


Figure 2: Expert vFFR (X axis) vs non-expert vFFRs (Y axis)

