PATIENT-SPECIFIC MODELS TO SUPPORT INTERVENTIONAL PROCEDURES: A CASE STUDY OF AORTIC COARCTATION

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Introduction
Coarctation of the aorta (CoA) is a narrowing of the aorta typically occurring just distal to the head and neck vessels. Stent therapy is considered an effective alternative to surgery for treatment of CoA [Ringel, 2012]; however, procedural complications are associated with multiple stent implantations such as wall dissection and vessel obstruction [Krasemann, 2011]. Patient-specific models might help reduce these procedural risks by virtually simulating the stenting procedure. In this study, we report the application of such models to aid the decision making process and optimise the treatment strategy for a patient with CoA.

Methods
The patient (19-years-old, male) with native CoA and aberrant right subclavian artery (ARSA) across the narrowing was first stented in 2001. Following a first re-dilatation of the bare stent (14mm), in 2012, follow-up catheter examination showed recurrent obstruction (15mmHg pressure gradient) and the formation of a small aneurysm in the proximal portion of the stent. Insertion of a CP covered stent (Numed, US) was discussed and postponed after further investigations because of the ARSA origin positioned in the distal portion of the bare stent. Computerised tomography and magnetic resonance (MR) scan were used to build patient-specific models – rapid prototyping, finite element (FE) and computational fluid-dynamic (CFD) – of the patient’s aorta and indwelling stent. FE analyses were performed to optimise the deployment diameter of the CP stent. The resulting stented anatomies were inputted into CFD simulations to assess obstruction relief across CoA and post-operative flow to the ARSA. Pre-procedural flows from MR were used to set the boundary conditions. Post-procedural data were retrospectively employed to validate the computational models.

Results
The rapid prototyping model allowed clinicians to explore the patient’s implantation site and understand the relative positions of aneurysm, bare stent and ARSA (fig. A). FE simulations determined size selection for the CP stent, with maximum expansion to 18mm (fig. B). In this scenario, CFD analyses predicted decreased pressure drop across CoA and satisfactory flow distribution to the ARSA (fig. C). Following the models’ indications, the implantation of a 16mm CP covered stent was successfully performed resulting in relief of the obstruction with no residual gradient and no compromise flow to the ARSA (fig. D).

Discussion
In the presented case, patient-specific models helped select a successful strategy for re-stenting of CoA. This work showed the benefits of integrating modelling techniques into patient conventional clinical assessment to optimise treatment in complex cases.

References