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PATIENT-SPECIFIC CFD OF AORTIC HAEMODYNAMICS: BRINGING CARDIOVASCULAR VIRTUAL REALITY TO CLINICAL BEDSIDE PRACTICE

L. Antiga[1], F. Auricchio[2], M.Conti[2], C. Trentin[2], A. Lefieux[2], S. Morganti[3], A. Reali[2], F. Secchi[3], S. Trimarchi[3], A. Veneziani[4]

[1]Orobix s.r.l., Bergamo, Italy
[2]Department of Civil Engineering and Architecture, University of Pavia, Italy.
[3]Department of Electrical, Computer and Biomedical Engineering, University of Pavia, Italy.
[4]Thoracic Aortic Research Center, IRCCS Policlinico San Donato, Milan, Italy.
[5]Department of Mathematics and Computer Science, Emory University, Atlanta, GA, USA.

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Realistic computer-based simulation tools are widely studied and developed in the field of cardiovascular biomechanics with the aim of optimizing possible therapeutic approaches thanks to their capability of assessing virtual scenarios during the pre-operative planning. Unfortunately, such simulations are currently adopted to approach only a small number of real-life case studies and are still limited to research, whereas their actual translation to clinical practice has to face different challenges ranging from the assimilation and managing of clinical data to the integration of the required multidisciplinary skills.

This study aims at presenting a recent project identified as *iCardioCloud*, which, grounding its motivation on the above-mentioned issues, aims at actually bringing patient-specific CFD analysis of aortic haemodynamics, before and after endovascular surgery, into the clinical practice. The research team is composed by engineers and physicians (surgeons and radiologists) in order to cover all the required skills to realize the ideal workflow depicted in figure 1-a. In brief, the basic idea is that clinical data in anonymized form are sent from the clinical institution to an engineering platform which performs the simulation and sends back the outcome embedding clinically-relevant information. In particular, starting from medical images such as computed-tomography angiography (see, e.g., figure 1-b), routinely performed in the diagnostic stage, a CFD-suitable mesh of the aortic lumen is generated in a semi-automatic way, through a pipeline of operations (cropping, segmentation, meshing, etc.) performed via the Vascular Modeling Toolkit (`www.vmtk.org`). Such a mesh is coupled with patient-specific flow boundary conditions derived from phase-contrast MRI, which allows to measure non-invasively in-vivo flows at pre-selected arterial cross-sections. Simulations are then preformed using the open-source C++ library LifeV (`www.lifev.org`), developed by some of the authors within a collaborative project including EPF Lausanne, Politecnico di Milano, INRIA Paris, and Emory University. As a trade-off between accuracy and computational costs, we use mixed $P1^{+}$-P1 elements, providing a piecewise continuos linear interpolation, enriched by a cubic bubble, for the velocity, and a piecewise continuos linear approximation for the pressure. The post-processed large amount of numerical outcomes is finally summarized in a report complemented by few animations, providing physicians with clinically-relevant information, such as pressure distribution, localisation of flow disturbance, etc. (see, e.g., figure 1-c). Some preliminary results along these lines can be found in [1].

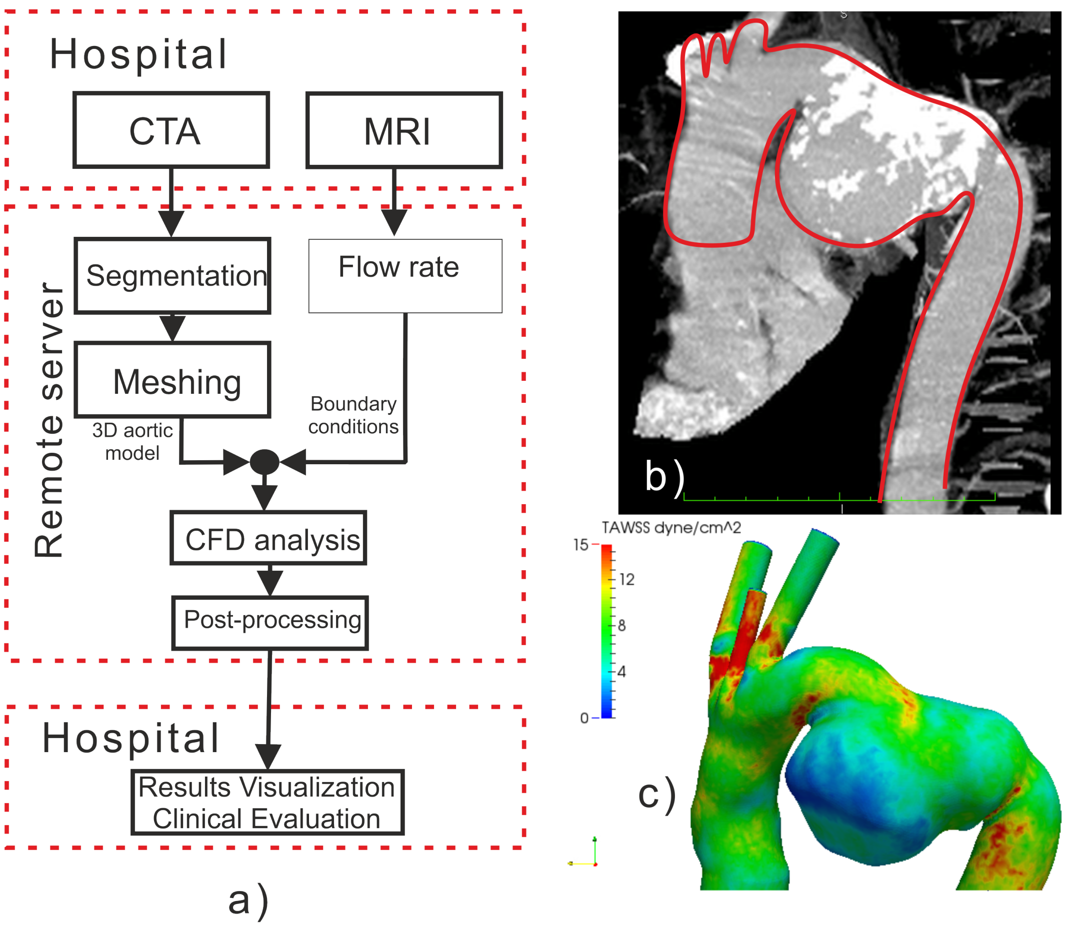

Figure 1: a) iCardioCloud workflow; b) CTA of thoracic aneurism; c) computed time-averaged wall shear stress of the case illustrated in b).

REFERENCES

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