Evaluation of advanced computational tools for the planning of left atrial appendage occluder interventions

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Background:

Advanced computational tools are starting to move from the engineering stage to being integrated into clinical pipelines for training, planning and guidance of complex interventions. Commonly, clinicians make decisions based on the exploration of patient-specific medical images in 2D flat monitors using specialised software. The new generation of technologies such as 3D printing, 3D advanced rendering, Virtual Reality, and in-silico simulations, provide complementary ways to better understand the structure and function of the organs under study and improve and personalise clinical decisions. In left atrial appendage occlusion (LAAO) interventions, clinicians select the type and size of the LAAO device to implant, as well as the location to be deployed. Usually, interventional cardiologists make these decisions after the analysis of patient-specific medical images in 2D flat monitors, before and during the procedure, obtaining manual measurements characterising the cardiac anatomy of the patient to avoid adverse events after the implantation.

Objectives:

In this work we evaluate several advanced computational tools for the planning of LAAO interventions, including web-based 3D imaging visualisation (VIDAA platform), Virtual Reality (VRIDAA platform), computational fluid simulations and 3D printing.

Methods:

Six physicians, including three interventional and three imaging cardiologists, with different levels of experience in LAAO interventions, tested the different technologies in pre-operative data of 5 patients, to identify the usability, friendliness, limitations and requirements for the clinical translation of each technology. The first step involved generating the 3D surface model from the patient-specific medical images of five cases. The resulting 3D model was the base for the setup of all models used in the different technologies, which were tested by the clinicians in an experimental session where they were asked to decide the device type, size and position. Subsequently, the participants answered a System Usability Scale (SUS) questionnaire and a general questionnaire with open questions. The clinical data used in this

work were provided by Hospital Haut-Lévêque (Bordeaux, France), including atrial fibrillation patients that underwent a LAAO intervention.The study was approved by the Institutional Ethics Committee; patients gave the informed consent.

Results:

The obtained results showed that the VIDAA platform provided a complete morphological characterisation and excellent user-interaction to manipulate and test multiple device configurations. Economical 3D printed models, although lacking completely realistic device-LAA interaction, were useful to have a better perception of the 3D LAA anatomy and can easily be integrated in the current clinical workflows. VR technologies were also very helpful for 3D perception, being especially suited for educational or pre-operative planning purposes, but only simple VR headsets would be suitable for daily clinical routine. In-silico fluid simulations with LAAO devices resulted in reducing the risk of leaks and device-related thrombus after the implantation but required more user-friendly interfaces.

Conclusions:

The obtained results demonstrate the potential impact of advanced computational tools to improve the planning of LAAO interventions but also the need of their integration onto a single platform to facilitate their use in a clinical environment.