PHD THESIS SUMMARY

Research on the role of 3D printing technologies based on imaging models in guiding complex cardiovascular procedures

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Introduction: Cardiovascular disease is currently known as the leading cause of death globally and one of the most prominent public health problems. Currently, the diagnostic and therapeutic system is focused on the paradigm that most patients benefit from the same diagnostic and therapeutic strategy, being partially absent the specific distinction between patients. Thus, in recent years the theory of patient investigation and treatment has taken precedence in an individualized approach. In cardiology, the potential of personalized and precision medicine applies at all stages of disease diagnosis and includes risk assessment, the establishment of preventive measures, and the establishment of the therapeutic approach. Among the innovative technologies, 3D printing is a technology with potential for implementing the personalized medicine strategy.

General objectives: The purpose of study was to assess the feasibility of rapid-3D prototyping technologies based on data from multimodal imaging in guiding intervention procedures in patients with complex cardiovascular pathology, such as severe aortic valvulopathy, carotid vascular disease, respectively coronary ischemic disease and congenital heart disease in the adult patients.

General methodology: This paper included patients with complex cardiovascular pathology, such as: valvular diseases, congenital structural diseases or peripheral vascular diseases. Patients enrolled in this study were divided into 2 main studies, of which: in the first study was studied the importance of 3D models in aortic valvular pathology and TAVI; in the second study was analyzed the usefulness of three-dimensional printing in myocardial ischemic pathology, in congenital adult pathology and in peripheral vascular pathology.

Study 1: This was a transverse observational study that included 20 patients with severe aortic stenosis who underwent pre-procedural planning for implanting aortic valve by the TAVI method. Patients were enrolled from January 2020 to December 2022. The purpose of this study was to investigate: (a) accuracy of 3D printing of aortic valves derived from images from CT angiography, measured by two methods of accuracy quantification and (b) potential utility of the printed valves in the preparation of valvular replacement interventions by TAVI. Planimetric and photogrammetric method were used.

Conclusions of study 1: The results obtained have shown, in accordance with recent studies, that high-precision three-dimensional models can be achieved. There were no significant differences between the two types of measurements, and the correlations regarding the intra-class coefficients between the two methods had a very good result.

Study 2: It was a study that evaluated the cardiac and vascular pathology. A multimodal imaging evaluation, respectively cardiac CT, post-processing CT, post-processing specialized 3D and 3D printing was performed. The aim of this study was to investigate the accuracy of 3D printing of cardiac structures with congenital and vascular disorders reconstructed based on images from CT angiography and to study the potential utility in simulation and preoperative preparation for surgical correction.

Conclusions of study 2: The study highlighted the usefulness of three-dimensional models for anatomy understanding and therapeutic planning in patients with complex congenital heart disease. This technique has the potential to be included in the use in medical practice in selected cases to improve spatial orientation, simulation of interventions or doctor-patient communication.

General conclusions: In this study, the role of three-dimensional models derived from CT imaging was evaluated, concluding that 3D printing is: a) an innovative imaging technology with potential for the implementation of the personalized medicine strategy, which brings benefits in terms of improving the understanding of the therapeutic strategy within the interventional procedures of the structural anomalies, valvular or vascular; b) modern method of rendering anatomical structures to guide interventional planning in patients with complex cardiovascular pathology, such as severe aortic valvulopathy, congenital diseases, structural heart disease, peripheral vascular disease, carotid vascular disease and coronary ischemic disease and its complications; c) a diagnostic and useful tool in therapeutic guidance in aortic valvular pathology, these models being reliable in terms of 1: 1 reproduction of aortic and periaortic valvular structures; d) an excellent tool for improving doctor-patient communication; e) a complementary diagnostic method that can provide 1: 1 reproduction of congenital diseases in adults such as ventricular septal defect and venous sinus atrial septal defect; f) a reliable anatomical orientation technique in the preparation of endarterectomy interventions in peripheral arterial disease, especially in carotid stenoses.