Selection of patient-specific aortic valve prosthesis by a hybrid technique that integrates CFD simulations, machine learning, and multi-stage validation

The suggested **digital valve methodology** depends on a mix of diagnostic technologies (echo, MRI, CT), sophisticated machine learning models, and complex mathematical frameworks. In modern healthcare, **there is an urgent requirement** to develop a precise virtual approach that can provide further insights into **patient treatment strategies**. This approach aims to reduce the risk associated with selecting valve types and placements mismatched with the patient's anatomy. Consequently, numerical simulations combined with artificial intelligence will **be crucial in reducing patient mortality.** However, medical diagnostics will necessitate substantial innovation to overcome this challenge. Establishing an **initial screening protocol**, supported by validated numerical methods through experimental (lab and retrospective data) studies, will yield **diagnostic insights** not accessible with standard diagnostic tools.

The project aims to develop a more robust, accurate, and significantly faster method to plan the TAVI procedure. This enhanced robustness and precision are achieved by incorporating in the model both mechanical and blood flow phenomena, whereas the traditional approach only models the former. The increased speed of the simulations is due to the application of reduced order methods and Machine Learning (ML) technique The input of the latter will come from the validated results of a set of **in silico** models, retrospective patient data, and in the course of project execution, also current anonymized TAVI patient data. By encompassing a broader range of phenomena, the resulting tool will provide a much deeper understanding of the post-surgery scenario than its standard counterpart.

The core idea of the **mathematical procedure**, of the project, is depicted in Figure 1. **Subsequent procedures** will be **developed** by applying a combination of numerical models (blood flow, deformation of valve leaflets), machine learning (ML) — artificial intelligence (AI) techniques, supported by **in vivo** (ovine model) and **in vitro** experiments. The results will be validated using diagnostic and visualization techniques used in medicine, i.e., echo, MRI, CT, and retrospective patient-specific data.

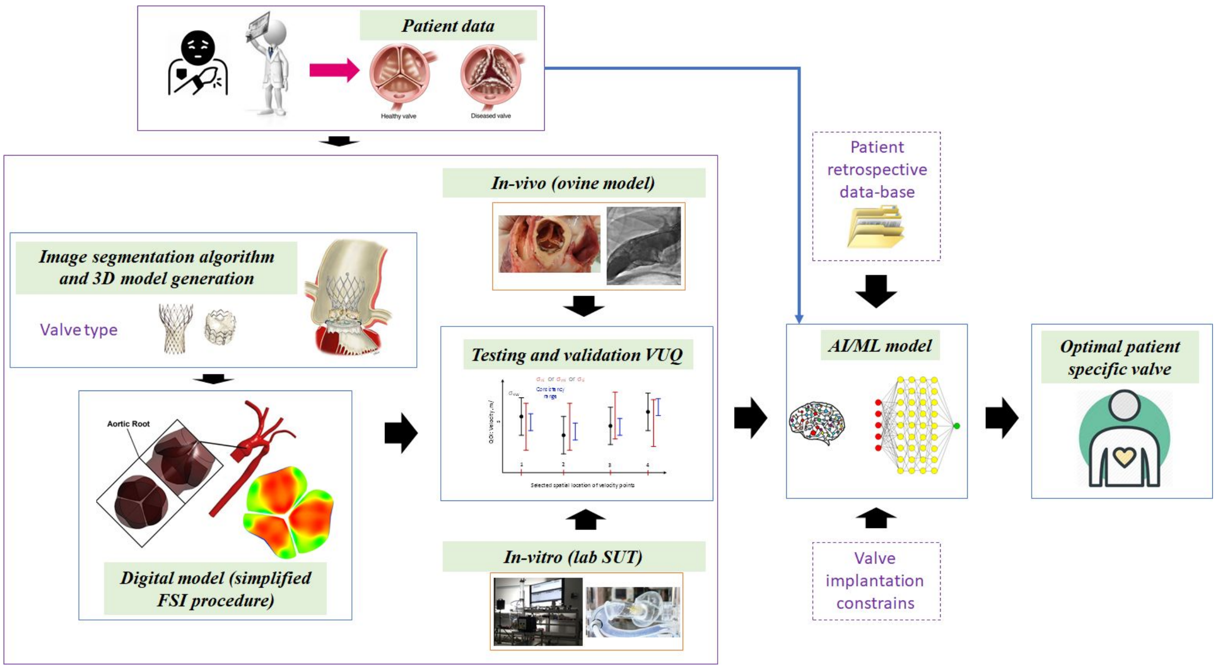

Figure 1: General concept of the **in silico** diagnostic procedure