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**Author:** Marcin Nowak Msc

**Title:,, Development of numerical model for modeling artificial heart valves for performing virtual therapies."**

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### **Project background**

The subject of doctoral thesis is consistent with the title and covers research of numerical model of blood flow through the artificial aortic valve. Main aim of the study was to develop complex numerical model to create virtual twin of blood flow through mechanical aortic valve. To develop mathematic mock- up Author used experimental model and Fluid Structure Interaction Technique. It is worth to mention that Author did not limit the study to theoretical model but also used in doctoral thesis experimental model created in laboratory. Moreover, Author has validated his work in laboratory setting.

Subject of doctoral thesis is hot topic in medical translational science which is focused on supporting highly specialistic procedures by virtual twins. That lead to more patient oriented and personalized medical procedures. In introduction Author quote epidemiological data and clinical problems and connect it with numerical modeling. Utilization of virtual twin for risk optimalization and predicting long term outcomes are next step for improving outcomes by personalize medicine. Development of this kind solutions is highly demanding and require not only engineering skills but also awareness of problems in medical field.

### **General description of thesis**

Doctoral thesis is divided into 6 chapters, and it is written in English. It begins with table of contents and list of abbreviation. Dissertation has typical design and it is subordinate to the main aim. Author cite 169 manuscripts which most of the were published no longer that 10 years ago. Cites are numerically segregate. The cites allude to subject of dissertation. This doctoral thesis has QR codes which lead to online movies

describing results of this project. The dissertation is well written in easy-to-read English. Moreover, the results, figures and table are nicely done and very readable.

In introduction Author describe epidemiology of cardiovascular diseases highlighting severe aortic stenosis, design of artificial mechanical valves and computer modeling of blood flow through the heart valves. It is worth to mention that Author described types of mechanical implantable valves and attached figures with them. The motivation for development of virtual twin in medicine was nicely justified. The is lack of description of virtual twin as next step for personalized medicine.

The aim of project was to create numerical model of blood flow through the artificial mechanical valve implanted in aortic position. The aim is clearly defined and well-motivated.

Author approachable described physics of blood flow through aortic valve. In the subsequent chapters the mathematical model development and validation were described. Nonetheless, the model of mechanical valve used for this project is not mentioned. It is important due to fact that each producer applies different technological solutions.

This project gives huge impact in the cardiosurgery as well as in the interventional cardiology. The results acquired in this project could be further use in basic science as well as in clinical applications. Dissertation was written very well. The high quality of designee of experiment and analysis of the results should be highlighted. The aim of the study was achieved. Despite the critics as a clinician I would recommend this dissertation for distinction due to innovative nature and highly applicable character of the project. Moreover, this work follows worldwide trends for personalized medicine and utilization of numerical models in clinical medicine.

## **Conclusion**

The dissertation of prepared by Marcin Nowak fulfill criteria to be defended according to w art.187 ustawy z dnia 20 lipca 2018 r - Prawo o Szkolnictwie Wyższym i Nauce (j.t.Dz.U. z 2020 r. poz. 85 z późn.zm)

I would recommend this dissertation for distinction



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