F11 Improving Echocardiographic Assessment of Aortic Valve Disease Using Experimental and Computational Haemodynamics

HOST ORGANISATION

Oslo University Hospital
(OUS), Oslo, Norway

PHD AWARDING INSTITUTION

University of Oslo
(UiO), Norway

Supervisory Team
Lead Supervisor
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Co-Supervisors
- Dr. Alessandra Bavo (FEops/Materialise)
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Project Description
Transcatheter aortic valve implantation (TAVI) has transformed the treatment of aortic valve disease, allowing many patients to receive life-changing therapy without open-heart surgery. However, the growing use of TAVI has also increased the need for accurate methods to assess valve disease, identify patients who will benefit from intervention, determine the optimal timing of treatment, and evaluate outcomes after the procedure. Current echocardiographic measures of valve severity and haemodynamic performance rely on simplified assumptions about valve geometry and blood flow that may not fully reflect the complex flow conditions present in individual patients.

This project aims to improve the assessment of aortic valve disease through the development of patient-specific experimental and computational models. The doctoral candidate will develop three-dimensional printed models of diseased aortic valves and play a central role in the further development and validation of a laboratory-based mock circulation platform capable of reproducing physiological pulsatile flow conditions.

This experimental framework will enable the acquisition of high-fidelity pressure and flow measurements that can be directly compared with echocardiographic assessments.
A central objective of the project is to investigate the accuracy and limitations of current echocardiographic methods for estimating transvalvular pressure gradients and valve severity.
By combining controlled experimental studies with patient-specific valve geometries, the project will identify haemodynamic and anatomical conditions under which commonly

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used echocardiographic assumptions break down and explore how these limitations can be overcome. Emerging ultrasound techniques such as blood speckle tracking (BST) will also be evaluated to determine whether they provide additional haemodynamic information beyond conventional Doppler methods.

To provide mechanistic insight into the experimental findings, computational fluid dynamics (CFD) models, including fluid–structure interaction (FSI) simulations where appropriate, will be developed and validated against experimental measurements. These models will be used to investigate the relationships between valve morphology, flow patterns, pressure recovery, and pressure loss, helping to explain the limitations of simplified Bernoulli-based approaches. The computational framework will also serve as a theoretical framework for the development of improved echocardiographic methods based on clinically obtainable measurements, which will subsequently be evaluated and validated against reference measurements obtained in the mock circulation system.

The candidate will benefit from access to one of Europe's largest TAVI programmes, extensive clinical and experimental datasets, and international secondments with research groups in London and Ghent that have extensive experience in cardiovascular mock circulation systems and experimental haemodynamics. These collaborations will support the development of the experimental platform and provide opportunities for advanced training and knowledge exchange.

The project will be conducted in close collaboration with cardiologists and clinical researchers involved in the assessment and treatment of patients with aortic valve disease. While echocardiographic examinations will be performed by collaborating clinical investigators, the doctoral candidate will play a central role in integrating experimental, computational, and clinical perspectives to improve diagnostic methods and support more informed treatment decisions. Ultimately, the project aims to improve the evaluation of aortic valve disease and TAVI outcomes by developing diagnostic methods that more closely reflect the underlying haemodynamics, enabling more accurate treatment decisions and more personalized patient care.

Planned Secondments

- King's College London, United Kingdom (2 months): training in cardiovascular flow phantoms, computational fluid dynamics and advanced haemodynamic measurements.

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- Ghent University, Belgium (1 month): training in cardiovascular flow phantoms, computational fluid dynamics and experimental flow modelling.
- FEops, Belgium (1 month): exposure to the commercial application of computational modelling for planning structural heart interventions.

Desirable Project-Specific Qualifications and Skills

We seek a motivated, creative, and enthusiastic candidate with a strong interest in interdisciplinary research at the interface of engineering, mathematics, and medicine.

- Applicants should hold a Master's degree (or equivalent) in Mechanical Engineering, Biomedical Engineering, Medical Technology, Engineering Cybernetics, Physics, Applied Mathematics, Informatics, or a related discipline.
- A strong academic record is required, corresponding to a weighted average grade of B or higher.
- Experience with computational fluid dynamics (CFD) simulations is highly desirable. Experience with fluid–structure interaction (FSI) modelling is an additional advantage.
- Experience with scientific programming (e.g., Python, MATLAB, C++, or similar languages) is advantageous.
- Knowledge of fluid mechanics, computational mechanics, mathematical modelling, numerical methods, or medical image analysis is considered an advantage.
- Experience with experimental fluid mechanics, laboratory instrumentation, physical modelling, sensor technology, or experimental validation is advantageous.
- Experience with three-dimensional modelling, computer-aided design (CAD), or additive manufacturing (3D printing) is beneficial.
- Previous research experience, including scientific publications, conference presentations, or participation in research projects, is advantageous.
- Interest in cardiovascular physiology, echocardiography, heart valve disease, medical technology, or computational medicine is desirable.
- Experience with experimental, pre-clinical, or clinical research, including data collection, validation studies, or analysis of biomedical data, is an advantage.
- Excellent written and oral communication skills in English are required.
- The successful candidate should be able to work independently while also contributing effectively within a multidisciplinary and international research team.

Please direct any query regarding this project to:

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Applicants are required to use this website to submit their application for this position: https://2411.webcruiter.no/Main2/Recruit/Public/5167557384