French Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes one of the PhD subjects proposed by the French Polytech network. The network is composed of 15 engineering schools/universities. The document also provides information about the supervisor. Please contact the PhD supervisor by email for further information regarding your application.

Supervisor information	
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PhD information	
Title	Biomechanics: Numerical and in vitro analysis of blood flow and perturbations related to the stents. Application: Stent in a coronary, aortic valve.
Main topics regards to CSC list (3 topics at maximum)	III-7 Biomedicalengineering. IV-6. Calculation of materials and simulation for design

Required skills in science and engineering	Skills in numerical modelling (Finite element analysis) and/or in experimentation (development of experimental bench in collaboration with technicians)

Subject description (two pages maximum including biblio)

I. Background:

Coronary stenting is the most common treatment to restore blood flow in atherosclerotic coronary arteries. Despite the high rate of occurrence of this procedure, failures associated with hemodynamic alterations from vascular stenting, including in-stent restenosis and late thrombosis, have yet to be overcome. Improvements in validation techniques for interventional strategies and medical device designs are necessary. The basic principle of angioplasty is to introduce a stent of about 1 mm in diameter and 10 to 30 mm in length in a stenotic coronary in order to recover the blood flow essential for the perfusion of the heart (Cf. Fig. 1).

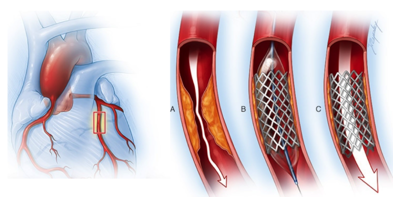

Figure 1. Basic principle of coronary stent deployment.

II. Objective.

The main objective of these project is to provide decision support tools for cardiologists. For that, numerical studies (finite element modeling, Ansys, Fluent) will allow to evaluate the configuration with risks and the most adapted angioplasty solutions [1-4]. This study will be conducted in close collaboration with a cardiologist from the Lyon cardiology hospital. For this, numerical models (FEA) will have to be developed to investigate the blood flow in areas with stents and/or aortic valves (for valves replacement). Complex but usual configurations, such as coronary bifurcations, will be studied. Then parametric studies will be performed to analyze the most appropriate treatments and the situations to avoid. The geometries will be derived from patient data. A review of the different parameters for the evaluation of the risk of thrombosis and re-stenosis will be performed. Then, a multi criteria parameter will be proposed and validated on true cases from patients to quantify the risks of thrombosis and re-stenosis.

Parallel to this numerical study, an experimental bench should be developed. This experimental bench will be an extension of an in vitro experimental platform (developed in our laboratory) [5] to visualize and quantify the flow disturbances induced by prostheses. Figure 2 illustrates the principle of this optical device. It is composed of two parts: the optical part and the image acquisition devices. The objective is to obtain the 3D distribution of the blood flow near stented zone or near aortic valves prothesis.

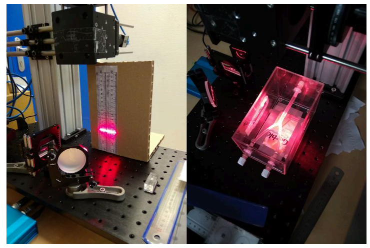

Figure 2. Part of the existing experimental bench with a coronary bifurcation phantom (on the right).

Figure 1. Optical bench A) General assembly and B) Detail of the light plane optics.

III. Conclusion

Numerical and experimental results should provide relevant information and be a decision support tool for surgeons.

Depending on the skills of the PhD student, the experimental or numerical part will be more detailed. The experimental tests will be performed on replicas of coronaries and hearts (aortic valve zone) in order to validate the numerical modelling.

IV. References

[1] M. Malve, G. Finet, M. Lagache, R. Coppel, R. I. Pettigrew, J. Ohayon.
Chapter 11: Hemodynamic disturbance due to serial stenosis in human coronary bifurcations: A computational fluid dynamics study.
Book entitled “Biomechanics of Coronary Atherosclerotic Plaques: From Model to patients”, Elsevier (2020). (https://www.elsevier.com/books/biomechanics-of-coronary-atherosclerotic-plaque/ohayon/978-0-12-817195-0)

[2] Lagache, M.; Coppel, R.; Finet, G.; Derimay, F.; Pettigrew, R.I.; Ohayon, J.; Malvè, M. Impact of Malapposed and Overlapping Stents on Hemodynamics: A 2D Parametric Computational Fluid Dynamics Study. *Mathematics* **2021**, *9*, 795.
https://doi.org/10.3390/math9080795

[3] Lagache M., R Coppel., Finet G., M Malvé., Pettigrew R. I. and Ohayon J. : impact of collateral flow on true FFR prediction for left main coronary stenoses with downstream lesions. Computer Methods in Biomechanics and Biomedical Engineering Volume 22.
https://doi.org/10.1080/10255842.2020.1713465

[4] R. Coppel, J. Ohayon, G. Finet, G. Rioufol, A. Gomez, F. Dérimay, M. Malvé, S.K. Yazdani, R.I. Pettigrew and M. Lagache." Influence of collaterals on true FFR prediction for a left main stenosis with concomitant lesions: An In vitro study", *Ann Biomed Eng* **47,** 1409–1421 (2019). https://doi.org/10.1007/s10439-019-02235-y

[5] R. Coppel, AL. Gomez, G. Finet, M. Mauro, RI. Pettigrew, J. Ohayon & M. Lagache (2017) Experimental Bench for Hemodynamic Study of Coronary Artery with Serial Stenoses: Fractional Flow Reserve Assessment, Computer Methods in Biomechanics and Biomedical Engineering, 20:sup1, 45-46.
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