First Supervisor	Dr Reshma Chauhan
School/Department	School of Medical Sciences/ Division of Cardiovascular Sciences
Email	Rac51@le.ac.uk

Second Supervisor	Dr Xin Li
School/Department	School of Engineering
Email	Xin.li@le.ac.uk

Additional Supervisor	Prof Andre Ng

Section 2 – *Project Information*

Project Title	Understanding Why Failing Hearts Become Electrically Unstable: 3D Optical Mapping and AI Approaches

Project Summary

Sudden cardiac death (SCD) is one of the biggest unresolved problems in cardiovascular medicine, causing around 100,000 deaths each year in the UK. Many of these deaths are caused by dangerous heart rhythm disturbances, but we still struggle to identify which patients are at highest risk and why these arrhythmias develop. One of the major contributors is heart failure, a condition in which both the structure and the nerve supply of the heart remodel in harmful ways. These changes can make different regions of the heart behave unpredictably, creating "electrical hotspots'' that can trigger life-threatening arrhythmias.

This PhD project aims to uncover where and why these unstable regions develop using cutting-edge panoramic (360°) optical mapping — a powerful imaging technique that captures electrical activity across the entire heart in real time. Working with a unique innervated rabbit heart model [1], you will record how the heart responds during normal conditions and during stimulation of its sympathetic nerves (the "fight-or-flight'' system), which are known to become dysregulated in heart failure [2,3].

You will work closely with biomedical engineers to transform these recordings into detailed 3D maps of the heart, combining structural, electrical, and nerve-related information. Using AI-based analytical tools, you will identify patterns of instability, pinpoint arrhythmia-prone regions, and determine how nerve remodelling contributes to sudden cardiac death risk.

This is an interdisciplinary project combining physiology, engineering, and data science, offering training across wet-lab experimentation, high-speed imaging, computational modelling, and machine learning. The findings could ultimately help improve how patients with heart failure are assessed and support the development of targeted treatments that stabilise the heart's electrical activity.

This project would suit a motivated student from bioscience, engineering, physics, or computing who is excited by interdisciplinary research and wants to make a real-world impact in cardiovascular medicine.

Training Opportunities

You will receive full training in advanced cardiac electrophysiology, optical mapping, and the use of an innervated whole-heart model. You will learn experimental skills including heart preparation, electrophysiological recording, pacing protocols, and data acquisition. Computational training will be provided in Python/MATLAB, 3D model reconstruction, AI-assisted analysis, and use of novel electrophysiology data analysis software. You will work within a supportive multidisciplinary team and engage with collaborators in engineering and data science. Additional training includes statistics, scientific writing, presentation skills, and opportunities to present at national/international cardiovascular meetings.

References

1. Ng, G.A., K.E. Brack, and J.H. Coote, *Effects of direct sympathetic and vagus nerve stimulation on the physiology of the whole heart--a novel model of isolated Langendorff perfused rabbit heart with intact dual autonomic innervation.* Experimental physiology, 2001. 86(3): p. 319-329.
2. Chauhan, R.A., et al., *Functional selectivity of cardiac preganglionic sympathetic neurones in the rabbit heart.* Int J Cardiol, 2018.
3. Chin SH, Allen E, Brack KE, Ng GA. Autonomic neuro-cardiac profile of electrical, structural and neuronal remodelling in myocardial infarction-induced heart failure. *J Mol Cell Cardiol Plus*. 2023;5(4):100044.