Hope for Hearts Fund: End of Project Summary

Project title	Automated MRI Imaging for better patient care
BHF Investment	**£82,521**
Project duration	12 months
NHS Trust	Bart's Heart Centre, Bart's Health
Project Team	PI: Rhodri Davies, Associate Clinical Professor (UCL) Co-PI: James Moon, Professor of Cardiology (UCL) Clinical research fellow: Hunain Shiwani (UCL) With additional contribution from Jessica Artico (Clinical research fellow, UCL)

Overview of the clinical problem the team set out to address:

Measures of cardiac structure and function derived from cardiac imaging drives most clinical decisions in cardiovascular medicine.

Cardiac function is best measured using cardiac magnetic resonance (CMR) imaging, but the examination is time-consuming, taking around 60 minutes for a basic examination, which makes it an expensive investigation. Furthermore, once the images are acquired, they require analysis by a clinical expert. Such experts are rare, expensive, and most importantly, variable – this variability can lead to errors in clinical-decision making, which can have profound effects on patients.

Our aim was to use AI to:

1. **Speed up acquisition of cardiac MRI**. This should lead to reduced waiting lists and costs, more availability at more centres, and a more pleasant exam for patients.
2. **Automate the analysis of CMR** once the images have been acquired. This would reduce the waiting time for the final report, reduce the need for expert clinician time, reduce costs and improve treatment choice for patients.
3. Move towards **patient-specific recommendations**. By making patient-specific reference ranges, we can categorise/diagnose patients with higher precision.

We aimed to take a **patient-centred approach** and a secondary aim was to look at the impact of such an AI system on patients through patient and public engagement activity.

How did you go about delivering the project?

Precision AI development: we built on AI that we had previously developed to automate the analysis of cardiac MRI, improving measurement precision, reducing time to wait for the report and freeing up clinicians.

Protocol optimisation: cardiac MRI protocols are often treated as 'one size fits all'. We set about to tailor acquisition sequence to get rid of unnecessary images.

Clinical delivery: the AI was delivered directly to point of care, by implementing it directly on the MRI scanner so that analysis was performed as the images were being acquired. The analysis was complete by the time that the patient had left the scanning room.

Patient engagement: We formed a focus group to gather patients'/the public perception of AI, their thoughts on using it for image acquisition, and how we should present it. This improved our understanding of patient perception and allowed us to tailor our approach (e.g. terminology we use, patient information leaflets) to patients.

Clinician engagement: We also engaged with the reporting clinicians to see what worked best for them, and to make sure that the clinical workflow was optimised.

Patient-specific reference ranges: We used data from 4500 subjects from the UK biobank and ~2000 additional healthy volunteers to create reference ranges specific to the AI, as well as sex, age, size, and ethnicity.

How did you approach the evaluation of the project?

The evaluation of this project consisted of two key elements:

1. The accuracy of the code in delivering accurate scans and reports. This aspect was carried out in conjunction with clinical imaging experts who reviewed outputs and advised the activity to increase the accuracy.
2. Measures related to measuring patient and clinician satisfaction of the new approach. Additionally speed related measures were captured including increased throughput of patients during available MRI clinic hours and an accompanying reduction in waiting list times.

What outcomes did you achieve?

- **Quicker Scan times:** the scan time is reduced from 36 minutes to 23 minutes.
- **More patients scanned per day:** we reduced the slot times for each patient, meaning that we could scan an **additional 3 patients per day.**
- **Quicker reporting time**: from 21 to 10 minutes per patient
- **Better patient experience**: the speed of the scan and reconstruction algorithms meant that if the patient struggled with their breathing, the scan could still be acquired. Patients in the focus group made it clear that they sometimes found MRIs uncomfortable and would welcome shorter scans.
- **Greater precision:** the increased precision in scan reporting enables clinicians to make better decisions about patient care and prescribe appropriate treatment
- **Generalisability:** the innovation can be used at other centres meaning it can be used to benefit heart failure patients at other centres. The AI has been rolled out to 5 centres in the UK and is also being used in Italy and the USA.

What is novel about this project?

There are several elements that were novel about this project:

1. **Clinical deployment of AI in Cardiac MRI:** The project utilized AI to automate and enhance the precision of cardiac MRI scans. A few papers have been published on the subject, but very few have been applied to actual patients as we have here.

2. **Benchmarking Against Human Precision:** The project established a unique benchmarking process to evaluate the precision of the AI against human precision. This provided a tangible way to measure the success and accuracy of the AI in a clinical setting.

3. **Multi-Pathology Validation:** The AI was validated using a dataset that contained multiple pathologies. This broad-based testing and validation approach ensured that the AI could handle a wide range of cardiac conditions, increasing its potential usefulness in real-world clinical settings.

4. **Clinical validation:** Even as the project leaned heavily into AI automation, it retained a degree of human supervision to validate the scan, slice prescriptions, and reports. This novel hybrid approach ensures patient confidence and maintains a high level of accuracy.

What difference did the Hope for Heart fund make for your project?

The Hope for Heart funding allowed for the following:

1. **Clinical delivery**: most grants encourage us to develop methodologies and technologies. The Hope for Heart Fund allowed us to concentrate on clinical delivery, allowing us to get the technology to the patient.
2. **A holistic approach**: as well as clinical delivery, we got to evaluate its impact on both patients and reporting clinicians.
3. **Train clinical AI scientist**: we recognise the need for multi-disciplinary work and one of our key outputs was training a clinical radiologist (Hunain Shiwani) as an AI data scientist.

What happens next?

We aim to continue this work by:

1. Rolling out to more centres. We currently have 5 UK centres 'on-line' (Barts NHS Foundation, Cheines-Mews, Royal Free, Glenfield, Leicester and Leeds) but we aim to expand this
2. Further reduce scanning time
3. Extend the techniques to other measures of cardiac structure and function
4. Train up more clinical AI scientists

The work has helped enabled other projects at our centre, including faster heart scanning of cancer patients who are receiving chemotherapy, and improved diagnostic criteria for patients with diseases of the heart such as hypertrophic cardiomyopathy.

Some of the work has been presented at national and international conference including the European Association Cardiovascular Imagine/Society for Cardiovascular MR (SCMR) conference in London, British Society Cardiovascular MR Conference 2022, and SCMR conference 2023.