British Heart Foundation

A deeper look at the heart

Impact of British Heart Foundation support for cardiovascular MRI research

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This review was led by Sven Plein, BHF Professor of Cardiovascular Imaging at the University of Leeds

Message from our Medical Director

At the British Heart Foundation (BHF), we fund research to save and improve the lives of the millions of people living with or at risk of heart and circulatory diseases, in the UK and worldwide. We focus our efforts on supporting underpinning research and turning discoveries into lifesaving medical advances.

Working with research leaders, we are producing a series of compelling reviews that articulate the impact arising from the support of the BHF in specific fields of research, from the generation of new knowledge all the way to improving patients' lives.

The following pages illustrate the lasting impact of our research funding and some of the key players who made the breakthroughs, leading to better diagnosis, treatment and care of patients with heart and circulatory diseases. None of these achievements could have been realised without the generosity and dedication of our supporters, and the passion and perseverance of our researchers.

I hope they inspire you as much as they inspire me.

Professor Sir Nilesh Samani,
Medical Director, British Heart Foundation

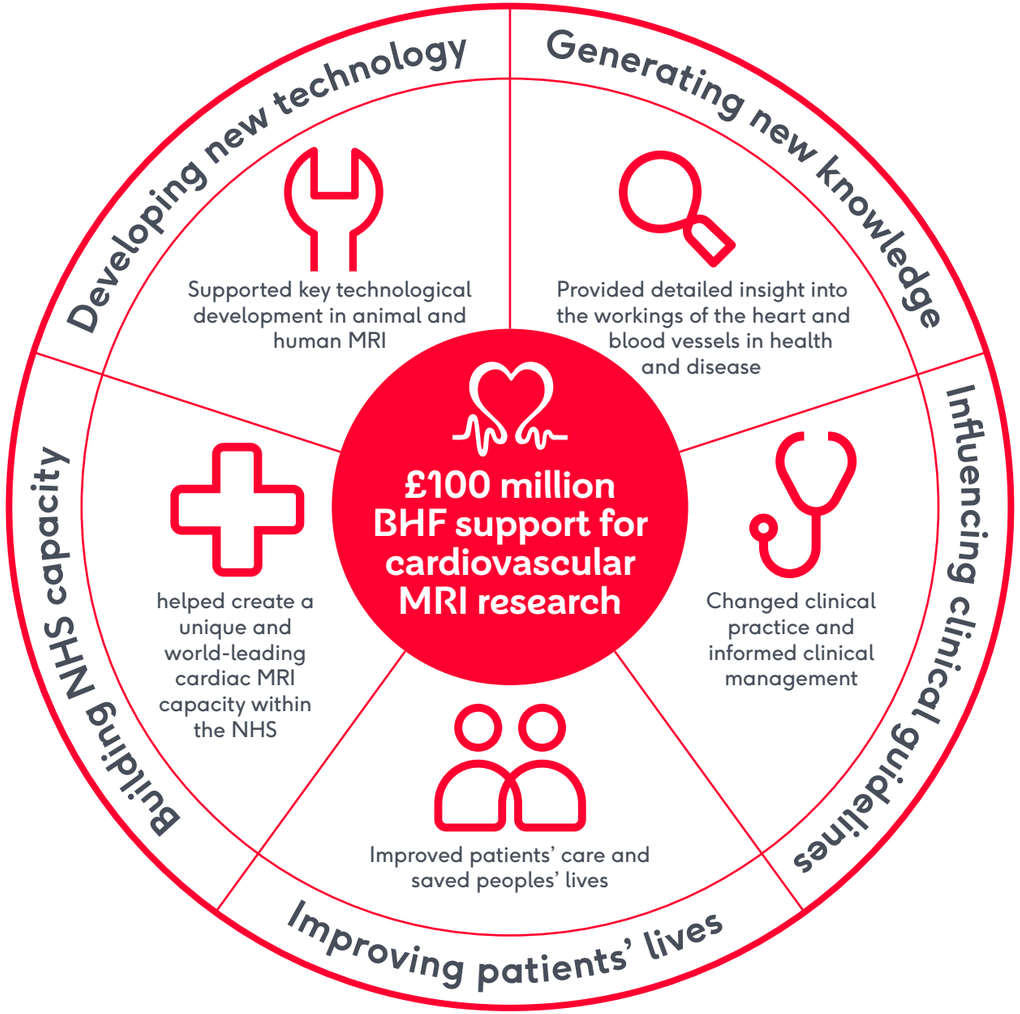
Our support for cardiovascular MRI research

Cardiovascular Magnetic Resonance Imaging, also known as cardiovascular MRI, is a non-invasive imaging technique that provides highly detailed assessment of the structure and function of the heart and blood vessels. The technique has advantages over other imaging tests as it does not expose patients to harmful radiation and allows very detailed assessment of the heart's structure, composition and function.

Over the past 40 years, cardiovascular MRI has become a mainstream diagnostic test for a range of heart and circulatory diseases, including coronary heart disease, cardiomyopathy, myocarditis, congenital heart disease and peripheral arterial disease (PAD). It is also an important tool that allows researchers to get a better understanding of the diseased heart and blood vessels, enabling the discovery of novel treatments.

The BHF has supported research in cardiovascular MRI since the 1980s and has funded more than 250 research grants at a total value of over £100m. This funding has supported key technological developments in cardiovascular MRI, helping establish it as a reliable clinical tool.

New advances in this area have changed the way we understand the structure and function of the heart in health and disease. The research has spanned a broad spectrum of heart and circulatory diseases and has changed clinical practice and informed clinical management guidelines with direct impact on patients' lives. In addition, BHF support has helped create a unique and world-leading capacity in cardiovascular MRI within the NHS by supporting highly trained specialists in cardiovascular MRI and establishing international hubs for MRI research.



Developing new technology

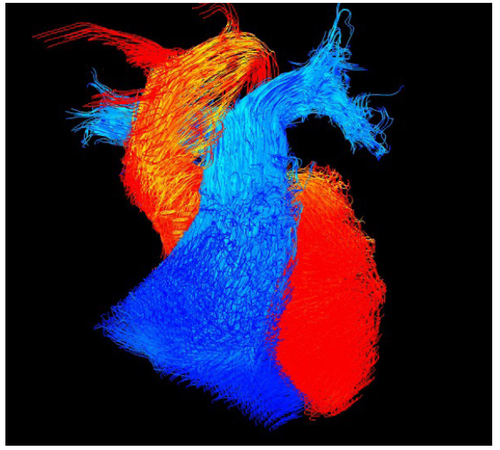
Imaging the heart and blood vessels with MRI technology posed many challenges, mainly because of the rapid motion of the beating heart. This led to the need for major technological innovation. BHF support for cardiovascular magnetic resonance research began in the 1980s and helped the development of techniques including imaging and spectroscopy. Examples include:

- Reducing the time it takes for an image to be retrieved from many minutes to just a few seconds or less. This maximises the number of pictures acquired during a single MRI scan.
- Developing cardiac perfusion MRI, which looks at blood flow to the heart muscle, from its conception to its establishment as a routine clinical tool. This technique helps the management of people with coronary artery disease.
- Establishing Magnetic Resonance (MR) spectroscopy, from its inception through to clinical studies. MR spectroscopy provides insights into the metabolic changes that occur in the diseased heart, for example in heart failure and cardiomyopathies.
- Development of real-time cardiovascular MRI, used for rapid visualization of the function of the heart and blood vessels.
- Small animal MRI in order to help develop and test new treatments for heart and circulatory diseases.

Visualising blood flow in the heart

The coronary arteries deliver oxygen and nutrients to the heart muscle. Restrictions in blood flow through the coronary arteries can result in symptoms of chest pain (angina) and heart attacks (myocardial infarction).

The blood supply to the heart through the coronary arteries can be visualised using a technique called cardiac perfusion MRI. In 1995, the BHF supported Dr James Cullen and colleagues at the University of Leicester to undertake some of the first clinical cardiac perfusion MRI studies in the world. Since then, the BHF has supported research studies across the UK that have made these methods faster and more robust. A number of BHF-funded researchers revealed the potential of this method to improve the management of patients with coronary artery disease. Thanks to BHF funding, this new diagnostic tool, which can help predict patients' risk of having a heart attack, has become a routine test in the NHS following cardiac consultation and appropriate assessment.



More recently, BHF-funded researchers have been using 4D flow MRI which enables precise visualisation and measurement of the complex blood flow patterns within the heart and blood vessels. Its use is being investigated in a range of conditions including coronary heart disease, heart failure, heart valve disease, congenital heart disease and diseases of the aorta.

4D flow MRI shows blood flow through the heart's major chambers and vessels.

Generating new knowledge

BHF-funded research has led to new understanding of many disease processes by utilising the unique information MRI can provide about the workings of the heart and blood vessels. Some examples are:

- Changes in how the heart handles different energy sources.
- The role of scar tissue in the heart, also called fibrosis, in late complications for people with heart valve disease or born with congenital heart disease.
- Detecting 'heart muscle bleeding' (myocardial haemorrhage) in people who have suffered a heart attack.
- Tracking the blood supply in the lower limb which could help people suffering with or at risk of PAD.
- In clinical trials, measuring the effect of new treatments for people with cardiomyopathies and heart failure.
- Accessing the UK Biobank to combine MRI scans with health data such as genetic factors in order to establish imaging biomarkers of cardiovascular risk.

Analysing MRI scans of UK Biobank participants

The BHF is one of a group of research funders who provide funding to support the collection of data for UK Biobank, which contains anonymised health and lifestyle data and biological samples from 500,000 volunteers that are being followed for at least 30 years.

The BHF has awarded £3m for cardiac MRI scanning of 100,000 UK Biobank participants. This large-scale database links MRI scans with a range of health data including genetic factors and health outcomes, providing a unique opportunity to establish imaging biomarkers of cardiovascular risk. It is also a great platform for developing artificial intelligence and machine learning based techniques.

In 2020, a collaboration between Professor Steffen Petersen at Queen Mary University London and Professor Stefan Neubauer in Oxford analysed cardiac MRI scans from 5,000 participants. They found that differences in the shape and texture of men and women's hearts could potentially explain why their risk of heart disease differs.

In 2020, UK Biobank began carrying out MRI scans of at least 3,000 of its volunteers who have or have not suffered COVID-19 infection. These images will be compared to the images of the same people taken before the pandemic to look for changes post-infection. This will further our understanding of the medium and long-term effects of Covid-19 on individuals and across populations.

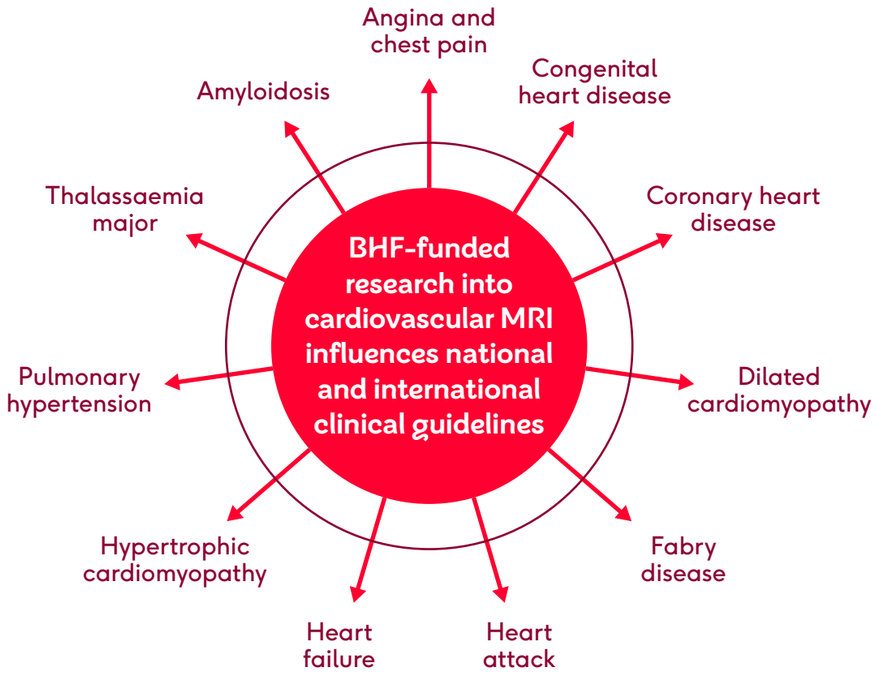
Influencing clinical guidelines

The UK is leading the world not only in cardiovascular MRI research, but also in adopting this technology into routine clinical practice enabling better diagnosis, better treatment and better outcomes for people with heart and circulatory diseases. The impact of BHF-funded cardiovascular MRI research is reflected in the clinical practice guidelines, which summarise the available evidence for tests and treatments, guiding physicians in their daily care of patients. Some examples include:

- In coronary artery disease, current European and US guidelines include the highest level of recommendations for the use of cardiac MRI, based in part on BHF-funded clinical trials.
- Heart perfusion MRI, which has been developed with the support of several BHF grants, has been included in guidelines published by international cardiology societies for the care of patients with suspected cardiac chest pain and has become a routine test in the NHS.
- In heart failure, cardiovascular MRI is now a mainstream option when diagnosing and managing heart failure.
- Latest European guidelines recommend the use of MRI in all patients with hypertrophic cardiomyopathy and indicates its use in Amyloidosis and Fabry's disease, with reference to several BHF supported studies.
- Today, MRI is a routine test for all children and adults born with congenital heart disease, with clear international guideline indications for frequency of repeat imaging tests, based in part on BHF-funded studies.

Influencing cardiovascular care in the UK and around the world

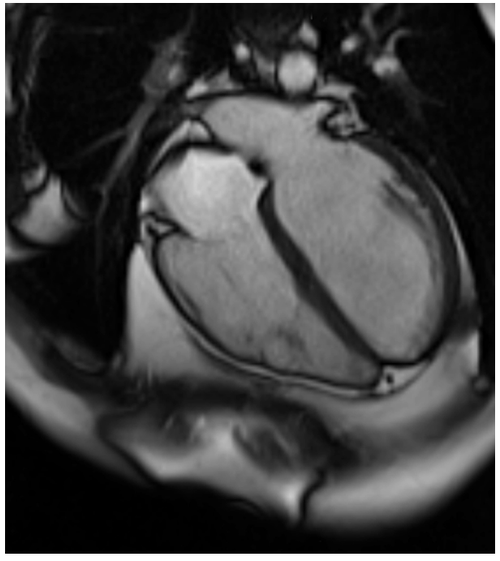
National and international clinical practice guidelines now define the role of cardiac MRI in diagnosis and treatment of people with heart disease, many of which were informed by BHF-funded research.



Improving patients' lives

Major improvements in patient care require the support of multiple funding bodies and are achieved through international research efforts. BHF-funded research into cardiovascular MRI contributed to improve the lives of patients with a wide range of illnesses. These include:

- The development and nationwide introduction of MRI to measure iron in thalassaemia major patients with iron overload disease, which has reduced their risk of premature death from heart failure.
- BHF-funded studies using detailed MRI scanning to guide treatment contribute to the ongoing improvements in the care of heart attack patients. This results in more patients surviving heart attacks and fewer patients suffering the long-term consequences of a heart attack such as heart failure.
- The development of a new MRI technology which has already revolutionized cardiovascular MRI in children with congenital heart disease. This enables rapid imaging of the entire heart (<10 minutes total scan time) without sedation in children as young as six months old.

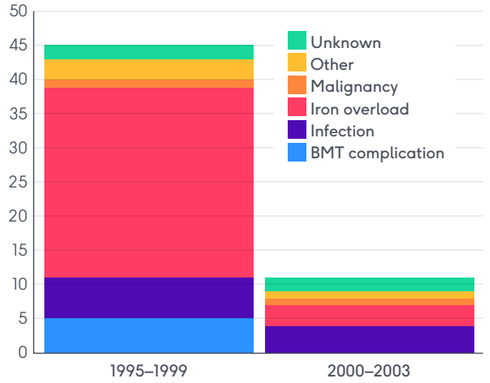


MRI scan showing the four chambers of the heart.

Stopping deaths from an inherited blood disorder

Thalassaemia major is an inherited blood disorder that means the body produces too little haemoglobin, the molecule that carries oxygen in the blood. To survive, most people with thalassaemia major need blood transfusions from a very young age and throughout their lives. However, the iron from transfused blood that accumulates in the body, including in the heart, can lead to heart failure.

The development of drugs to remove iron from the body helped with this problem. But for a long time, there was no safe way to measure the iron overload in the heart, and it was hard to know whether the drugs to remove iron were needed or had been successful.



The number of deaths of patients with thalassaemia major in the UK from heart iron overload has dramatically reduced

That changed in the late 1990s when Professor Dudley Pennell and BHF-funded fellow Dr Lisa Anderson at the Royal Brompton Hospital in London developed a new MRI technique called T2* MRI. This technique can measure how much iron is in the heart muscle and monitor how successful the treatment to remove it is.

Heart failure used to be the most common cause of death for people with thalassaemia major. But since the introduction of iron removal therapy and T2* MRI monitoring, the number of people dying from thalassaemia major in the UK and around the world has dramatically reduced.

Building NHS capacity

The UK today has the highest density of experts in cardiovascular MRI and hospitals that offer cardiovascular MRI in the world. The development of this infrastructure has been enabled in part by more than three decades of BHF support.

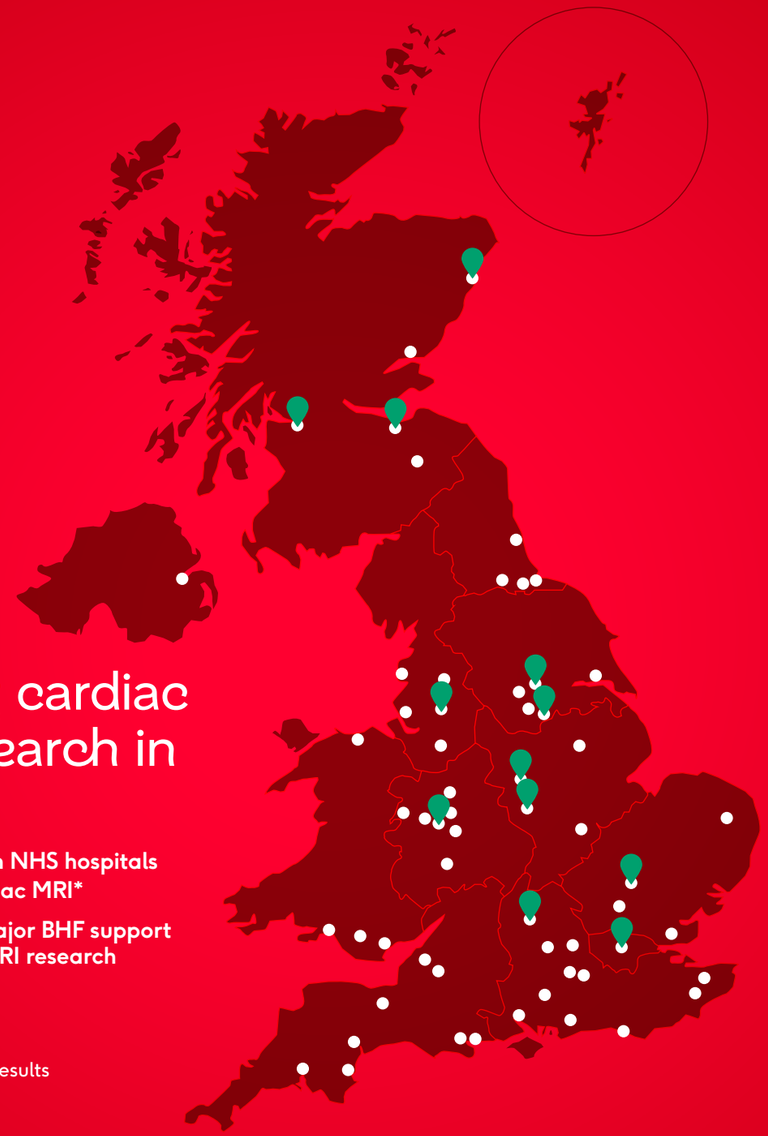
Over 100 BHF-funded fellows have been trained in clinical cardiovascular MRI

Over 80 NHS hospitals offer cardiovascular MRI with over 100,000 scans performed every year in the UK*

All UK congenital heart disease centres have cardiovascular MRI facilities

*BSCMR 2019 survey results

Funding cardiac MRI research in the UK



- locations with NHS hospitals offering cardiac MRI*
- Cities with major BHF support for cardiac MRI research

*BSCMR 2019 survey results

Looking to the future

Cardiovascular MRI remains a highly active, rapidly developing field, and many more research projects are underway that will build on the successes of previous BHF-funded MRI research, with more ground-breaking science and technical advances expected in coming years.

In particular, artificial intelligence (AI) and machine learning are rapidly developing areas of research in all imaging techniques, including cardiovascular MRI. These methods are changing the way images are acquired and analysed and promise to improve the detection and monitoring of diseases, the screening of potential therapeutic targets and the simulation of interventional procedures.

For references, supplementary information and more on the impact of BHF-funded research into cardiovascular MRI research please visit **bhf.org.uk/impactofMRI**

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bhf.org.uk