At the cutting edge of surgery

Impact of British Heart Foundation support for cardiac surgery research

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British Heart Foundation

Contents

This review was led by Gianni Angelini, BHF Professor of Cardiac Surgery at the Bristol Heart Institute; John Dark, Professor of Cardiothoracic Surgery at Newcastle University; and Former BHF Professor Robert Anderson, Newcastle University.

Message from our Medical Director

At British Heart Foundation (BHF), we fund research to save and improve the lives of the millions of people affected by 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 BHF in specific fields of research, in each case assessing impact all the way from generation of new knowledge to improving patients' lives.

The following pages illustrate the lasting impact of our support for cardiovascular surgery research, showcasing some of the key players who made the breakthroughs, leading to better 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

What is cardiac surgery?

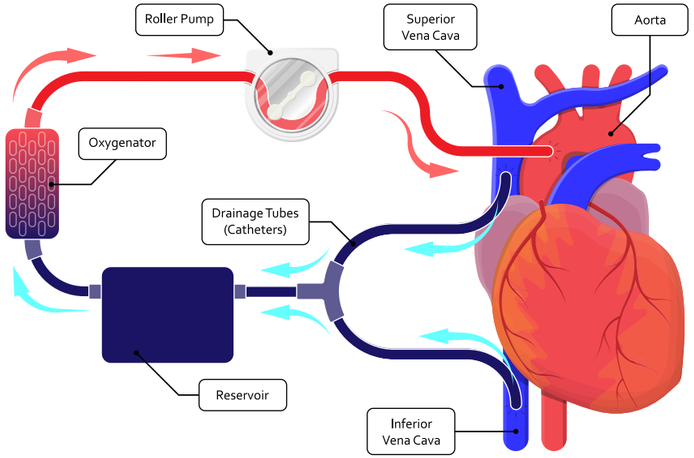
Cardiac surgery includes any surgical operation that involves the heart or the blood vessels in the heart. Cardiac surgery can be planned or performed as part of emergency treatment, for example after a heart attack. As this field is broad, this booklet focusses on specific areas of importance where BHF funding has been sustained and impactful.

Some definitions

Cardiopulmonary bypass (CPB)

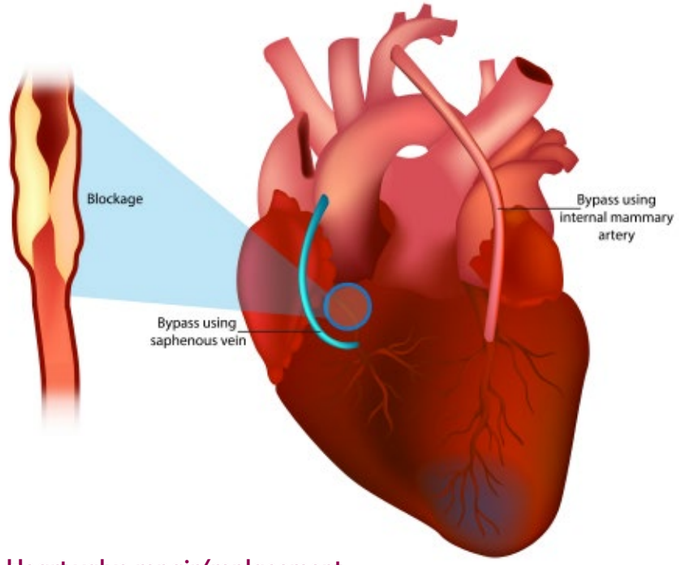
A technique where a machine temporarily takes over the function of the heart and lungs during surgery. Examples of where CPB is used includes coronary artery bypass surgery (CABG), heart transplantation, repair of congenital heart defects and in the surgical replacement of heart valves.

Cardiopulmonary bypass



Coronary artery bypass surgery (CABG)

An operation to treat coronary artery disease, a condition where the blood vessels supplying the heart (coronary arteries) are narrowed or blocked. CABG surgery diverts blood around narrowed or clogged parts of the arteries to improve blood flow and oxygen supply to the heart. CABG is also known as heart bypass surgery.



Heart valve repair/replacement

An operation to repair or replace a faulty heart valve with either a mechanical (artificial) valve or tissue valve (from donor or animal). The heart has four valves which keep blood flowing in the right direction. This operation is performed when heart valves are damaged or diseased.

Paediatric cardiac surgery

Heart surgery in children to treat congenital heart disease, a condition that is present at birth and can affect the structure and function of the heart.

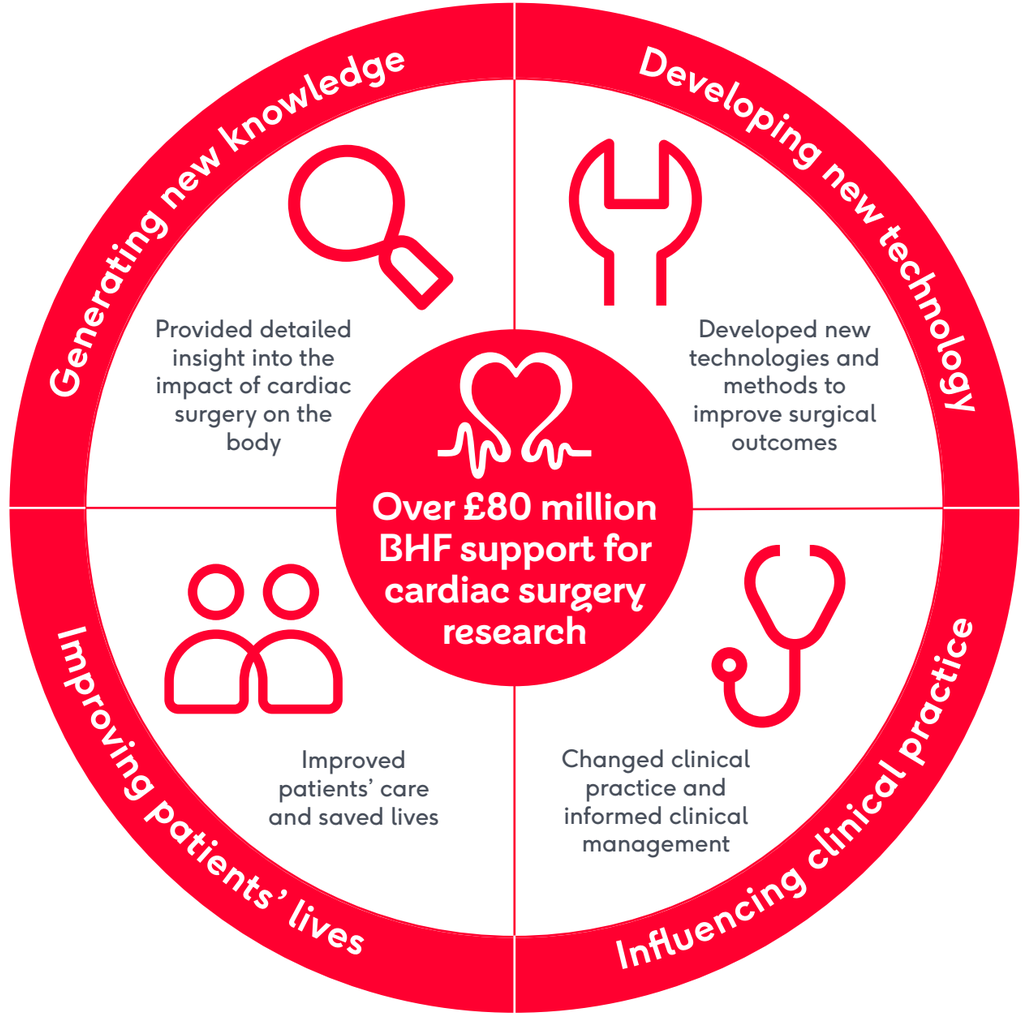
Our support for cardiac surgery research

Cardiac surgery has developed hugely over the last 60 years in terms of being able to treat a wide range of conditions, as well as advancing surgical techniques to improve survival and reduce in-hospital complications. More recently there have been efforts to develop less invasive procedures, which involve small incisions and reduced trauma to the body.

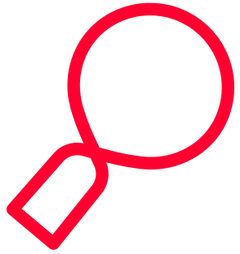
Since its creation in 1961, BHF has supported wide ranging research initiatives across the cardiac surgical spectrum that have been invaluable in transforming modern cardiac surgery into the routine and safe procedures that are undertaken today.

Over 500 grants worth more than £80M

Supporting the training of >30 PhD students and the career development of >40 fellows and 10 BHF Professors who have contributed to advancing the field of cardiac surgery.



Generating new knowledge



Over the last 60 years our understanding of how to treat heart patients with surgical procedures has drastically improved. BHF has funded ground-breaking discoveries, including:

CPB

- Understanding the neurological and neuropsychological impacts of CPB.
- Identifying causes that lead to complications during CPB including the role of the body's inflammatory response, opening up new therapeutic avenues to prevent complications.

CABG

- Identifying new ways to improve vein graft harvesting, where a healthy blood vessel is taken from the leg, arm, or chest and is connected to other arteries in the heart.
- Identifying the importance of proteins called matrix metalloproteinases (MMPs), which have been shown to be implicated in vein graft failure. Inhibitors of these proteins are now being investigated for therapeutic benefit.

Heart transplantation

- Understanding why the body rejects the donor heart during transplantation and developing ways to stop the immune system attacking the transplanted heart.

Congenital heart disease surgery

- Mapping the anatomy of different heart defects and showing how these affect the heart's electrical system to better inform the planning of cardiac surgery.

A drug to reduce blood loss and inflammation during surgery

Bleeding is a significant complication during cardiac surgery, therefore there have been huge research efforts to discover blood conservation strategies.

In the 1980s, BHF Professor Ken Taylor and colleagues made the discovery that the drug aprotinin, also known as Trasylol, reduces blood loss after heart surgery that uses cardiopulmonary bypass (CPB). Aprotinin slows down fibrinolysis, the process that leads to the breakdown of blood clots. By inhibiting fibrinolysis, aprotinin helps maintain the integrity of blood clots, reducing the risk of excessive bleeding during and after surgery.

The use of this drug made a major difference to blood and blood product usage and overall mortality at the time of a repeat operation for the same condition.

15 years later, BHF Professors Dorian Haskard and Ken Taylor discovered that this same drug could also have a role in reducing inflammation caused by CPB, another significant complication associated with surgery.

Though aprotinin is still used in cardiac surgery to control bleeding, tranexamic acid, an alternative anti-fibrinolytic agent that also reduces inflammation, is now more commonly used to minimize bleeding and limit inflammation induced by CPB.

reduction in total postoperative blood loss in patients treated with aprotinin.

20% of patients who received aprotinin needed a blood transfusion compared to 95% of patients who were given a placebo.

Developing new technology

BHF-funded research has supported the development of new technologies and methods that have improved the outcomes of surgery, helped surgeons prepare for surgery, and more. Examples of where BHF-funded research has led to the creation of new technology and methods include:

- Developing a fluid called St. Thomas' Hospital cardioplegic solution originally used to preserve heart function during surgery, and later adopted for the preservation of donor hearts during transplantation.
- Developing a stabiliser to keep the heart beating during off pump coronary artery bypass surgery.
- Studying how 3D printed hearts can help doctors get a better understanding of an individual's heart and help surgeons prepare for surgery.
- Developing a virtual reality system to help doctors better understand congenital heart disease and plan procedures.
- Demonstrating how a blood filtering device that removes mismatched antibodies in the blood to reduce transplant rejection could double the number of children able to receive a heart transplant.
- Growing living valve tissue for babies with congenital heart disease and in need of valve replacement surgery to reduce the need for additional and high-risk surgical re-intervention.

3D printed hearts, printed in different materials

Developing a fluid to protect the heart during surgery

During cardiac surgery the heart is intentionally and temporarily stopped so surgeons can operate more easily. This is usually achieved by using a fluid, called a cardioplegic solution. The fluid protects the heart muscle from damage during surgery.

In the 1970s, BHF-funded studies by Professor David Hearse and cardiac surgeon Mark Braimbridge led to a major breakthrough, developing a new cardioplegic solution called St. Thomas' 1 which was highly effective and widely used in cardiac surgery.

By the mid 1980s this collaborative effort resulted in the further development of an improved cardioplegic solution (St. Thomas' 2- "Plegisol"). This is one of the best examples of 'bench to bedside' translational research and a development that effectively transformed techniques particularly for CABG surgery during a period of rapid expansion. A practical advance that was cheap, simple and effective.

The solution has also been used to preserve donor hearts for longer than previously possible - by keeping them cool and infusing them with a solution that lowered the heart tissue's demand for oxygen. This fluid has been used in hospitals all over the world and helped make many more heart transplants possible.

Influencing clinical practice

From new surgical procedures to risk scores to identify high risk patients, BHF-funded research has made remarkable advances in adult and paediatric surgery which have influenced clinical practice. Examples include:

- Developing the Ross procedure, the first widely adopted heart valve replacement operation to treat severe aortic valve disease.
- Creating the UK Cardiac Surgical Register to enable hospitals to compare surgical outcomes and set practice standards.
- Developing the 'de Leval' operation, a widely performed procedure to treat congenital cardiac defects.
- Supporting one of the largest trials undertaken in cardiac surgery, the Arterial Revascularisation Trial (ART), to find out which blood vessels should be used as grafts for CABG.

Pioneering heart valve replacement surgery

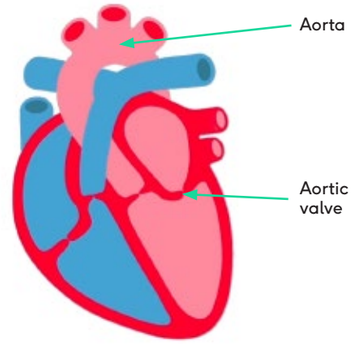
At the start of the 1960s, scientists did not know how to treat heart valve disease. But after receiving one of our first research grants, heart surgeon Mr Donald Ross went on to pioneer and perform a world-first operation to treat people with faulty aortic valves. This technique is now known as the Ross procedure.

The aortic valve is one of the four valves in the heart, and the one which blood has to pass through when pumped out of the heart and into the rest of the body. The Ross procedure involved not one but two valve replacements. First, the faulty aortic valve was removed and the patient's own healthy pulmonary valve was used to replace it. A preserved valve taken from a human donor was then placed in the position originally occupied by the patient's pulmonary valve.

The thinking at the time was that the original healthy pulmonary valve would have the best chance of withstanding the high-pressure battering that the aortic valve faces with each heartbeat.

This procedure was a revolution in heart valve surgery, and is still used by specialist surgeons today, especially for treating infants and children born with heart defects.

The aortic valve



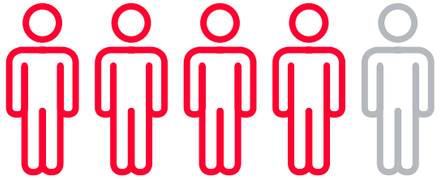
Improving patients' lives

BHF support for cardiac surgery has played a role in improving patient's lives by:

- Playing a key role in improving heart transplant techniques. The first UK heart transplant patient survived just 45 days, now the average patient survival after a heart transplant is 14 years. New BHF research into transplant rejection has the potential to double the number of children able to receive a heart transplant.
- Developing the Ross procedure, a heart valve replacement operation to treat severe aortic valve disease. In 1963 the rate of mortality in heart valve replacement patients was 71%, this dropped to 15% in 1968, just 5 years later. The Ross procedure is still used around the world today and four in every five patients live for at least another 20 years afterwards.
- Contributing to advances in paediatric surgery which have meant that people born with congenital heart disease now live longer lives into adulthood. BHF-funded researchers have created a follow-up system for survivors of congenital heart disease to identify which factors make a difference to their long-term survival.

Before BHF, the majority of babies diagnosed with severe congenital heart disease in the UK died before their first birthday.

Today, thanks to research, more than four out of five survive to adulthood.



Robin's story: The Ross procedure

Robin was 17 when, after a routine check-up with his GP, he discovered he had a problem with his aortic valve. He later found out that he was born with congenital heart disease. After many years of careful follow up, his consultant cardiologist recommended to fix the problem with his aortic valve with the Ross procedure when he was 28.

This type of surgery is usually done in children, but he thought Robin was still young enough to be able to have his own pulmonary valve moved across to replace the diseased aortic valve. And it would mean Robin would avoid the complications that could come with a mechanical valve, like the need for lifelong blood thinning drugs. In his week-long recovery on the hospital ward, Robin, who was an engineer at the time, met a junior doctor who made him rethink his future career plans. Robin joined medical school as a graduate and later trained in cardiology.

Today, 22 years after his Ross procedure, Robin is himself a consultant cardiologist and uses his own experience as a patient to try and reassure heart patients when they are getting anxious about their own upcoming heart operation.

Looking to the future

The support of BHF has aided the development of cardiovascular surgery for over 60 years. From the development of the technology and equipment required to support the heart during surgery to developing new surgical procedures that have reduced mortality and extended lifespan, BHF has transformed modern cardiac surgery into the routine and safe procedures that are undertaken today.

Looking ahead, advances in technology will lead to changes for the practice of cardiac surgery with more focus towards alternative or less invasive treatment. The development of advanced therapeutics, to repair and regenerate heart tissue could help to revolutionise the field in the future, by preventing or delaying the need for heart surgery or improving patient outcomes after surgery.

The BHF is playing a part in the revolution of cardiac surgery, supporting new ideas and training the next generation of medical professionals to ensure those needing heart surgery have the best possible outcomes.

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

bhf.org.uk