

# Coronary artery bypass graft surgery; principles and choice of conduit

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## Introduction

In 1953, Dr and Mrs Gibbon reported the first successful intracardiac operation utilising cardiopulmonary bypass with a pump oxygenator. Since then there has been a huge increase in the number of cardiac procedures performed annually. The largest increase over the last 20 years has been in surgery for ischaemic heart disease with coronary artery bypass graft (CABG) surgery.

Approximately 2,000 adult cardiac procedures were performed in the cardiac units of Dublin and Cork in 1998. This volume of work has been performed in the presence of increased pressure on beds and other facilities in cardiac units. This in turn has led to earlier patient discharge following surgery to the care of the GP, referring hospital physician or convalescent home. Hence the need for a better understanding of the operation of CABG by those who will care for patients relatively soon after surgery when there is still the potential for problems to arise.

Many different conduits are used for CABG and a description of some of the commoner types is included. Finally, some of the more frequently asked questions at the cardiac surgical outpatients are answered.

## Technique of cardiac surgery

### Cardiac access

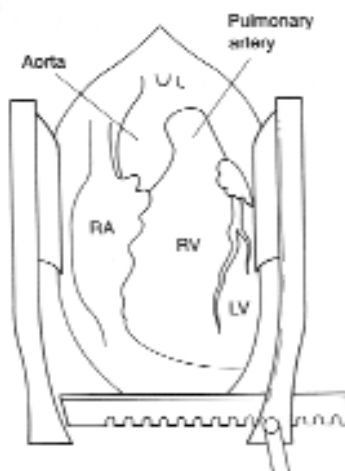


Figure 1. Sternum spread. Pericardium opened.

The most common incision is the median sternotomy. The sternum is cut with a saw. Immediately beneath the sternum is the pericardium which must be incised to expose the heart (figure 1). The sternum is wired with five to six stainless steel wires and these are usually left *in situ*. Drains are usually placed to the opened pleural and pericardial cavities. The pericardium is usually left open.

### Cardiopulmonary bypass (CPB)

Much confusion arises because of the use of the term 'bypass' to mean coronary artery bypass and 'bypass' used to describe the use of extracorporeal circulation (cardiopulmonary bypass) usually necessary to perform coronary artery bypass grafting.

The cardiopulmonary bypass circuit is used to do the pumping action of the heart and the gas exchange work of the lungs while the heart is still and being repaired. A perfusionist controls the CPB machine. A typical set-up is shown in figure 2.

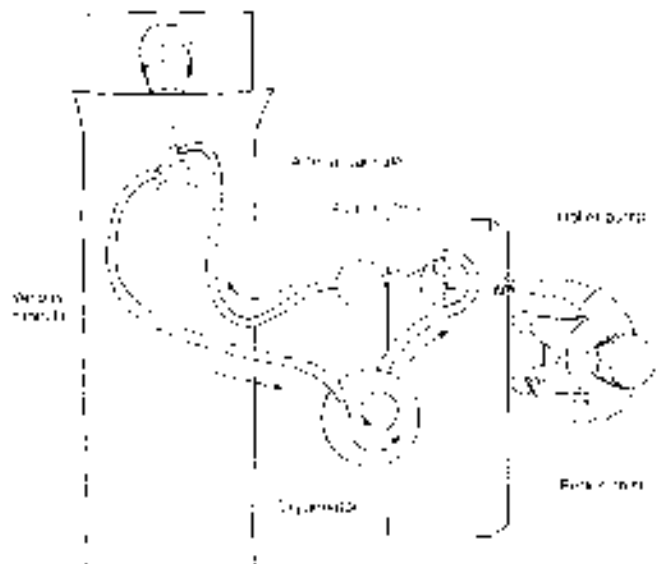


Figure 2. Extracorporeal bypass circuit.

Venous blood that normally returns to the right atrium is removed down the venous cannula to the CPB oxygenator by gravity. Carbon dioxide is removed and oxygen administered. Anaesthetic gases can also be administered. The oxygenated blood is now pumped through a filter back to the aorta. This effectively excludes the heart from the circulation. However the heart continues beating and most CABG operations are performed on non-beating hearts.

A cross clamp applied to the aorta between the competent aortic valve and entry of the aortic cannula will render the heart ischaemic by stopping blood entering the coronary arteries (figure 3). A solution, high in potassium, instilled into this

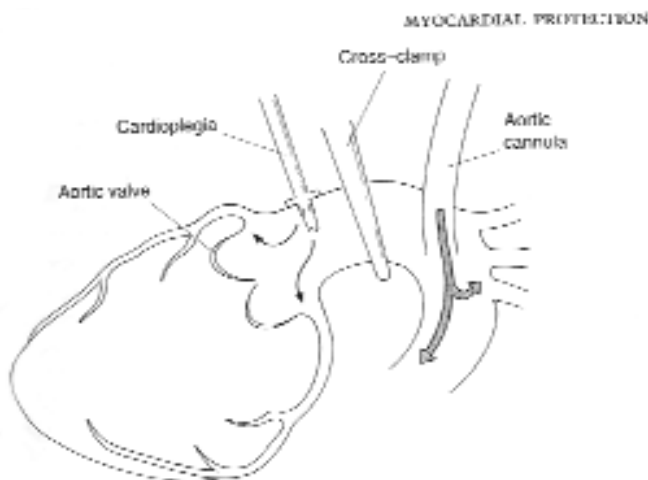


Figure 3. Administration of cardioplegia.

portion of the aorta will pass into the coronary arteries and induce diastolic arrest. This can be a crystalloid solution or a blood and potassium mixed solution. This technique of myocardial protection during periods of ischaemia is called cardioplegia. Repeated doses can be administered to protect the heart while the cardiac repair is performed.

For blood to flow in the CPB circuits it is anticoagulated with heparin. The anticoagulation of heparin is reversed at the end of the procedure with protamine. Cannulating and decannulating the aorta may result in particulate emboli which can result in stroke.

The passage of blood through the extracorporeal circuit can induce an inflammatory reaction. This can lead to platelet depletion and decreased function with severe postoperative haemorrhage. Cardiopulmonary bypass is responsible for the short-term and reversible problems of poor concentration and

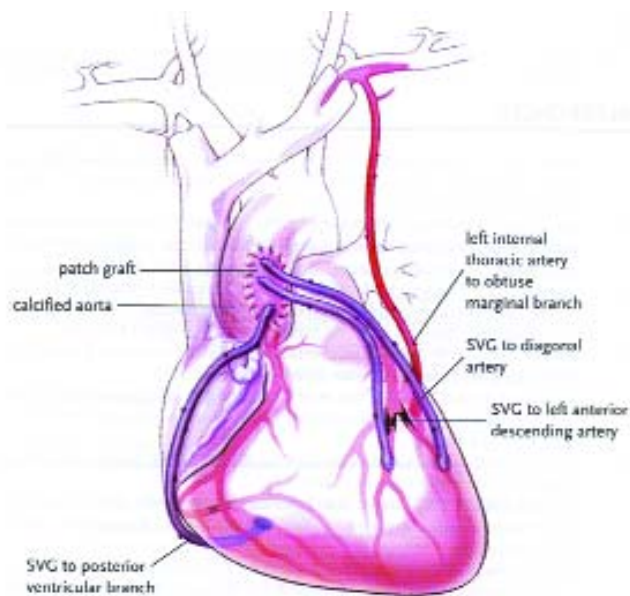


Figure 4. CABG grafts. Note unusual graft pattern.

recall seen in some patients after cardiac surgery. These usually resolve over a few weeks.

CABG surgery aims to relieve the pain of angina and reduce the risk of premature death. In essence, the problem lies in narrowing or occlusion of the coronary artery with failure of forward flow to the myocardium with resultant angina. CABG rectifies this problem by offering blood, an alternative pathway to the myocardium by re-routing blood around the narrowing or occlusion (figure 4).

The native diseased artery is left *in situ*. Having decided on CABG the conduits available include:

#### Veins

Long saphenous  
Short saphenous  
Arm vein

#### Arteries

Internal thoracic artery  
Radial artery  
Right gastroepiploic artery

An ideal conduit should have the following characteristics:

- sufficient length
- internal diameter 2-3mm
- freedom from atheroma

#### Veins

The long saphenous vein is the most commonly used conduit for CABG. It can usually give sufficient length, has a suitable diameter and is free from atheroma (figure 5). If it is diseased the short saphenous or cephalic vein can be harvested whilst the sternum is being opened. Vein grafts deteriorate with time. It is generally quoted that the patency at 10 years is 50%.

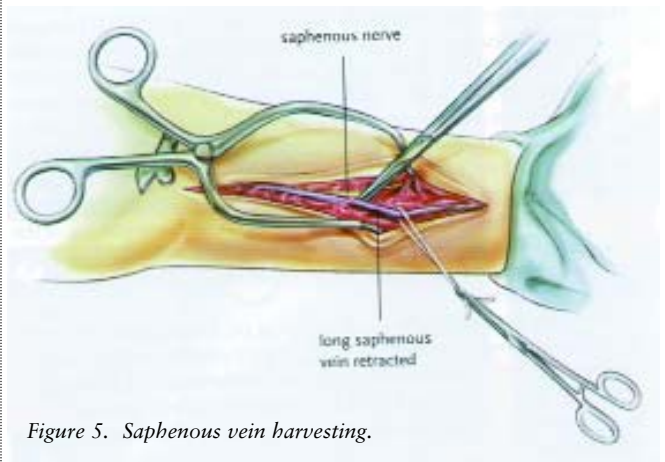


Figure 5. Saphenous vein harvesting.

#### Arteries

The internal thoracic artery (ITA) (figure 6) has proven excel-

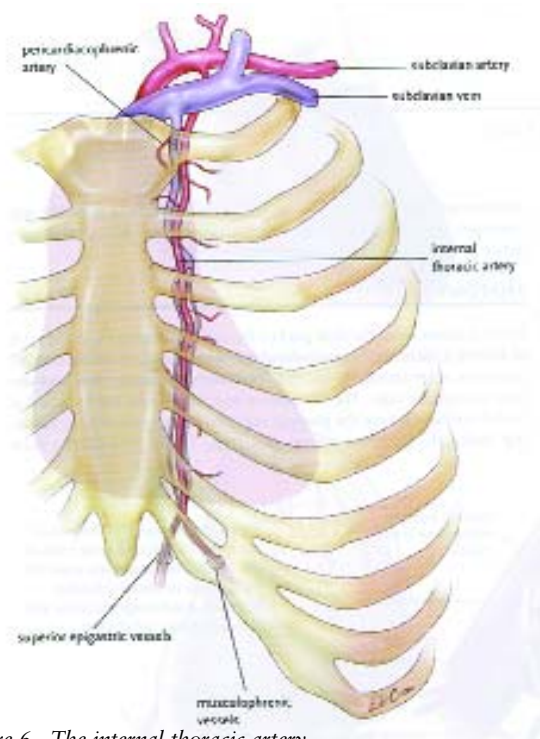


Figure 6. The internal thoracic artery.

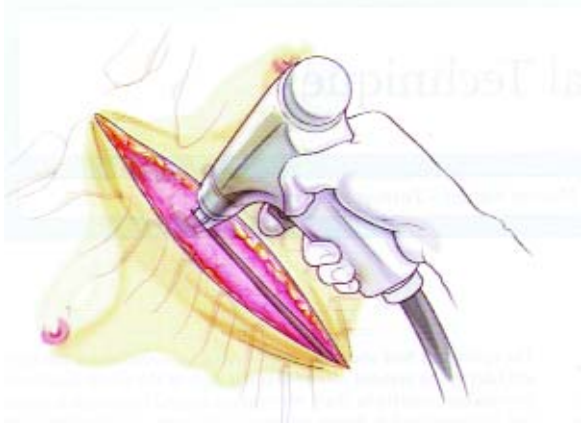


Figure 7. Completed CABG.

lent long-term patency and improved patient survival when used as a bypass graft. The left internal artery is nearly always anastomosed to the left anterior descending artery (LAD) as a pedicled graft (figure 7). It is a dynamic graft and can grow to accommodate the demands placed on it by the myocardium it supplies. The right internal thoracic artery is not as commonly used but can be used as a free graft.

The excised radial artery can also be used as a coronary bypass conduit. For those who advocate total arterial revascularisation it provides an additional conduit. Early results of prospective trials show patency rates at least as good as vein grafts.

The gastroepiploic artery is also used as a pedicled arterial graft. It is employed when the more usual conduits will not suffice. Their use is becoming more frequent in some parts of the world and early patency results are reported to be in the region of 90%. In Ireland, most patients will receive a pedicled left internal thoracic artery graft to the left anterior descending artery and free vein grafts (saphenous or arm vein) to the remaining diseased coronary arteries.

### Common problems

Following CABG there are some commonly experienced problems. These are as follows:

#### *Chest wall pain*

This usually results from spreading the sternum to access the heart. There is often a degree of paraesthesia along the left sternal border. This most probably results from nerve damage at the time of internal thoracic artery harvesting. It is usually self-limiting and settles with time.

#### *Palpitation; atrial fibrillation*

Some 10% of patients will experience some arrhythmia, usually while still in hospital. Atrial fibrillation reverts to sinus rhythm when treated. Patients may be on the antiarrhythmic therapy for a few weeks following discharge but it is usually discontinued at the postoperative visit.

#### *Leg swelling*

The leg that the vein has been taken out of usually remains a little swollen for a few weeks. This gradually resolves.

#### *Leg pain*

Most patients experience leg pain and this is most severe around the knee. Most respond to non-steroidal anti-inflammatories and the advice to elevate the leg when sitting. Superficial infection can be treated with dry dressings but an infection that is proving difficult to clear may need wound exploration.

#### *Sternal debiscence*

This occurs where sternal union does not occur. Sometimes there is associated infection. It is seen more commonly in diabetic patients, patients in whom both internal arteries have been used (predisposing to ischaemic sternal necrosis), patients on steroids, those with chronic obstructive pulmonary disease and in the obese.

### Long-term outlook

The one year survival is 95%, 88% at five years and 75% at ten years. Half the deaths are due to myocardial infarction or heart failure. Progression of both native and graft disease is a major contributor to death. Aggressive risk factor modification and the enhanced graft patency with low dose aspirin should improve the long-term outlook.

### The future

#### *Off pump CABG*

As already described the development of the cardiopulmonary bypass machine and techniques of myocardial protection led to the performance of coronary surgery for ischaemic heart disease. CPB is not without its own problems and so work has been directed on performing CABG on beating hearts without the use of CPB.

Early results suggest that there is less bleeding and decreased cerebral and pulmonary damage. The quality of anastomosis and patency rates of grafts to beating hearts has been questioned. The operation performed is usually internal thoracic artery to left anterior descending artery. Given that CABG is primarily the treatment of choice for patients with impaired ventricular function and three vessel disease, indications for single graft off pump bypass need to be clearly outlined.

#### *Following discharge*

It is current practice that patients do not drive for about four to six weeks following discharge. The problems relate to not being able to wear a seat belt, not being able to look over their shoulder or make a sudden stop.

Patients can fly in about seven to ten days following discharge but most wait a little longer because of the discomfort involved. Most patients can return to an 'office' type of job at six to eight weeks postoperatively. Those with a more active job should be encouraged to take recovery for up to 12 weeks.

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