Techniques in conduit harvesting

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Coronary artery bypass grafting is a commonly performed operation for the treatment of ischaemic heart disease. The success of it is largely dependent upon the quality and type of graft used. This article describes the application of and rationale behind techniques commonly used in conduit harvesting.

Coronary artery bypass surgery is the most commonly performed major operative procedure in the Western world. Initial attempts at revascularization, most notably the Vineberg technique (direct suture of the left internal mammary artery (LIMA) to the ventricle) (Vineberg, 1966), were followed by the aorto-coronary bypass grafting techniques first described in 1969 (Favaloro, 1969; Effler et al, 1970) which are the basis of today's procedures. Initially the conduit used to fashion the bypass grafts was lengths of reversed long saphenous vein. Now over 90% of the procedures carried out use at least one arterial graft (Izzat et al, 1994), commonly the LIMA. The quest for better long-term results and the application of the operation to more complex patients has led to the development of new techniques in harvesting a variety of different conduit.

Conduits used today fall into the broad categories of either venous or arterial grafts, and either pedicled or free. The techniques required (especially those for harvesting the long saphenous vein) make use of basic surgical principles and thus are operations commonly performed by surgical trainees.

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VENOUS CONDUIT

Three varieties of venous conduit are commonly used: the long saphenous and short saphenous vein from the leg and occasionally the cephalic vein from the arm.

The long saphenous vein

Preoperative testing: Preoperative history-taking should elucidate whether the patient has a previous history of deep venous thromboses or varicose veins either diagnosed or treated. Examination of the leg is vital to detect superficial varicosities and the stigmata of longstanding venous hypertension which might make the long saphenous vein unusable. A check should be made of the local arterial supply of the legs to avoid poor wound healing in the case of chronic arterial insufficiency. A history of deep venous thrombosis should be investigated with duplex scanning of the deep veins to ensure their patency.

Position: The patient is lying supine with the leg to be harvested slightly externally rotated.

Incision: The start of the incision is 1 cm anterior and superior to the medial malleolus. The incision is deepened, cutting down onto the vein (*Figure 1*). The length of the incision is that necessary for the amount of vein to be used. The direction of the incision is cephalad, usually to the knee.

Anatomy: The saphenous nerve is closely applied to the long saphenous vein. The long saphenous vein courses 2 cm behind the medial condyle of the knee.

Technique: It is important to cut down onto the vein in such a way that ensures that no skin flaps are created. A 'skin bridge' may be left at the knee to avoid any contracture of the scar in this area with subsequent limitation of movement at the knee joint.

Tricks of the trade: Tributaries of the long saphenous vein should be ligated almost flush to the vein in such a manner to ensure that no constriction in the vein occurs (if it is too short) or pouches (if it is long). The tributaries are ligated with a non-absorbable suture, e.g. 4/0 mersilene.

Testing the conduit: The vein is distended with heparinized normal saline (or heparinized blood) to ensure that the calibre of the vein is adequate for grafting and that there is no leaking from side branches or accidentally injured areas

(*Figure 2*). It is vital not to overdistend the vein (which destroys endothelial integrity).

Closure: The leg wound is closed in layers often with a closed drainage system left in situ in the thigh.

Areas of controversy:

1. With what and how it is best to test the vein
2. Whether to use a vein stripper in removing the vein from leg (Meldrum-Hanna et al, 1986). Recent advances in minimal access surgery have allowed the development of new techniques (Allen and Shaar, 1997) which may well diminish the morbidity associated with the open techniques
3. Whether it is necessary to close the fat layer (Angelini et al, 1984).

Figure 1. Initial dissection of long saphenous vein.

Figure 2. Testing of long saphenous vein.

The short saphenous vein

Preoperative testing: As for the long saphenous vein.

Position: The patient is lying supine with the leg to be harvested flexed at the knee (to 90°) and internally rotated at the hip.

Incision: The start of the incision is 1 cm posterior to the lateral malleolus of the ankle. The incision is carried superiorly cutting down on to the vein and is taken to the mid-point of the popliteal fossa going cephalad up the posterior aspect of the calf.

Anatomy: The sural nerve is closely applied to the short saphenous vein. The short saphenous vein joins the popliteal vein in the popliteal fossa.

Technique: It is important to cut down onto the vein in such a fashion as to ensure that no skin flaps are created.

Tricks of the trade: As for the long saphenous vein.

Testing the conduit: As for the long saphenous vein.

Closure: The leg wound is closed in layers.

Areas of controversy:

1. The mid-term and long-term patency of the short saphenous vein (Raess et al, 1986)
2. How to position the patient to make the difficult dissection easier.

The cephalic vein

Preoperative testing: It is vital to ensure that no peripheral cannulae have been sited in the arm over the last month. It is also important to avoid any arteriovenous fistulae in renal patients.

Position: The patient is lying supine with the arm to be harvested placed on an arm board at 70° to the body (take care over any brachial plexus injuries!). The forearm is pronated at the elbow with the hand slightly medially flexed at the wrist.

Incision: The start of the incision is in the anatomical snuff box. The incision is carried superiorly cutting down onto the vein and is taken to the antecubital fossa. Any further extension (to allow harvesting of the basilic vein) should allow a 'skin bridge' at the elbow.

Technique: As for the long saphenous vein but dissection should be gentler because of the very thin walls of the cephalic vein and their resulting fragility.

Tricks of the trade: As for the long saphenous vein.

Testing the conduit: As for the long saphenous vein.

Closure: The wound is closed in layers.

Areas of controversy:

1. The short-term, medium-term and long-term patency of the cephalic vein.

ARTERIAL CONDUIT

Since 1986 the pedicled LIMA has been the graft of choice to the left anterior descending artery (Loop et al, 1986). The unique biological properties of the proximal LIMA has lead to the superior patency rate of the LIMA (90% at 10 years) which has been translated into superior late survival and later recurrence of symptoms when compared to venous conduits (Cooper et al, 1996a,b).

Internal mammary artery

Preoperative testing: Visualization of the LIMA angiographically at the time of cardiac catheterization may be performed if there is any concern over its patency, e.g. radiotherapy to the chest.

Position: The patient is lying supine.

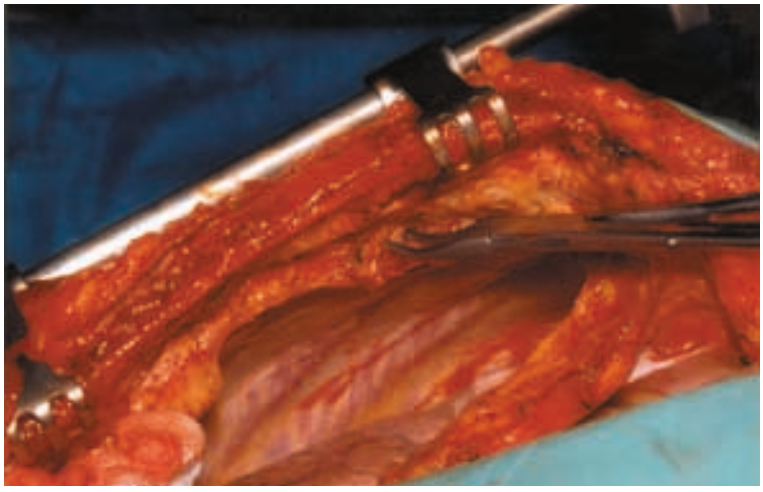

Figure 3. Initial dissection of left internal mammary artery.

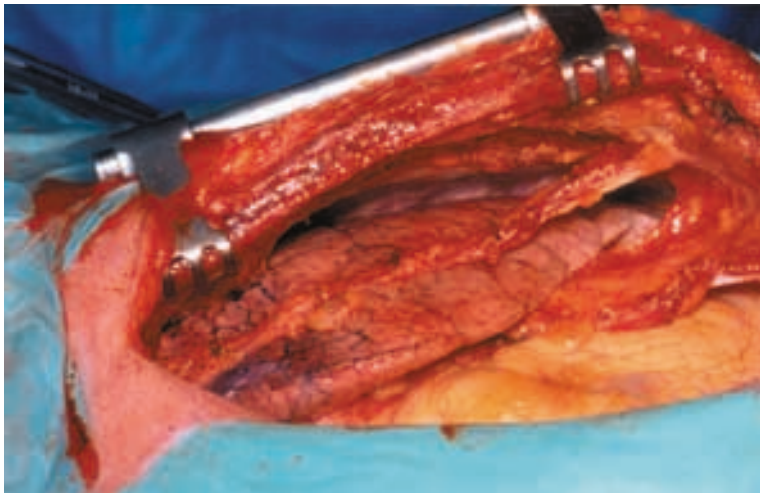

Figure 4. Completed dissection of left internal mammary artery.

Incision: The chest having been opened via a median sternotomy and haemostasis achieved, the appropriate hemisternum is elevated by means of a specialized retractor and the patient rotated away (on the table) to allow adequate exposure of the posterior aspect of the hemisternum. The fascial attachments of the pleura to the mediastinal tissues are divided and the internal mammary artery with its adjacent lying veins are visualized. Two parallel tramlines are cut (by use of the diathermy) 1 cm lateral and medial parallel to the veins. Structures to avoid superiorly are the subclavian artery and vein and the phrenic nerve.

Technique: Diathermy dissection is carried out staying as far away from the artery as possible. Side branches are ligated with Hemoclips™ (PillingWeck Inc., N. Carolina, USA) (*Figure 3*). Care must be taken to avoid diathermy too close to the artery to avoid thermal injury to the wall and endothelium of the internal mammary artery. The dissection is taken to just below the bifurcation of the artery around the level of the sixth intercostal space (where the endothelial function and properties of the mammary artery changes). Superiorly the subclavian vein is identified and the first intercostal artery divided (*Figure 4*). Systemic heparin is administered and the pedicled internal mammary artery divided inferiorly (and the stump doubly ligated and/or oversewn).

Tricks of the trade: Producing a muscular pedicle allows harvesting to be carried out more easily. It is more difficult to carry out the superior dissection of the right internal mammary than the left. If both internal mammaries are to be harvested, it is best to take the left first then the right (to allow any harvesting of conduit in the left arm, e.g. radial artery).

Testing the conduit: The mammary artery should be allowed to bleed from its cut end. Although there are algorithms of volume of blood over a period of time (i.e. 50 ml/min bleeding signifies adequate flow), 'experience' often gives the best guide as to the bleeding and the calibre of the cut end of the mammary. A soft clamp is applied to the distal end of the pedicle and the pedicle wrapped in a gauze swab soaked in a vasodilatory substance, e.g. papaverine, to maximize LIMA calibre to aid anastomosis and maximize initial flow.

Areas of controversy:

1. Whether to open the pleura or not (Rolla et al, 1994; Matsumoto et al, 1997)
2. How to dilate the internal mammary artery (Mills, 1991)
3. Whether to skeletonize the artery or not (Horii and Suma, 1997)

4. Whether to use the artery distal to its inferior bifurcation
5. Whether it is necessary to ligate the first intercostal artery
6. Which patient groups it is unsafe to harvest both internal mammary arteries in (to avoid sternal devascularization, dehiscence and mediastinitis)
7. The long-term patency of the right internal mammary and the use of bilateral mammary artery grafting.

Right gastroepiploic artery

Preoperative testing: It is important to elucidate a past history of upper abdominal surgery or pathology which may make harvest of the right gastroepiploic artery (RGEA) impossible.

Position: The patient is lying supine.

Incision: The incision is a 2–5 cm extension of the median sternotomy incision and enters the peritoneum via the linea alba in the midline. The stomach can then be drawn through this incision to allow mobilization of the RGEA.

Anatomy: The RGEA is closely applied to the inferior border of the stomach medially, it is vitally important to find the junction of the RGEA with the left gastroepiploic artery (LGEA).

Technique: The RGEA is first dissected off the greater omentum in the greater sac, and the junction of the RGEA and LGEA is identified. The RGEA is then mobilized off the inferior border of the greater curvature of the stomach (making use of a powered stapler to ligate and divide the perforating vessels) back to its origin adjacent to the pylorus. With a pedicle of RGEA and surrounding fat obtained, the final attachments to the LGEA are divided and the end of the RGEA opened to allow estimation of flow. The pedicled graft is then taken posterior or anterior to the left lobe of the liver and delivered via a cruciate incision into the pericardium.

Tricks of the trade: The RGEA is very susceptible to twisting, so staples on one side of the artery enable correct alignment to be obtained.

Testing the conduit: The RGEA should be allowed to bleed from its cut end. Although there are algorithms of volume of blood over a period of time (i.e over 30 ml/min would suggest adequacy of flow), 'experience' often gives the best guide as to the bleeding and the calibre of the cut end of the RGEA. A soft clamp is applied to the distal end of the pedicle and the pedicle wrapped in a gauze swab soaked in a vasodilatory substance, e.g. papaverine. The RGEA is a very friable and delicate vessel.

Closure: Closure is performed with closure of the median sternotomy. It is vital to get accurate and sturdy closure en masse to the linea alba with prolene or loop nylon to avoid epigastric hernias.

Areas of controversy:

1. Whether it is necessary to route the RGEA anterior or posterior to the left lobe of the liver (Dietl et al, 1995)
2. How far it is necessary to extend the median sternotomy incision
3. The early flow rate of the RGEA
4. The long-term patency of the RGEA.

The radial artery

Preoperative testing: Owing to the variable state of the palmar arches it is mandatory to assess the state of the ulnar and radial arteries before radial artery harvest to avoid hand ischaemia. This is best carried out preoperatively by the duplex ultrasound scanning of the forearm to assess the anatomy, calibre and flow of the radial and ulnar arteries. The accuracy and reliability of the Allen's test in this situation is presently under review.

Position: The patient is lying supine with the arm to be harvested placed on an arm board at 70° to the body (take care over any brachial plexus injuries!).

Incision: The start of the incision is at the proximal palmar crease at the point where the radial pulse can be felt. The incision is taken down onto the radial artery and followed up to the elbow, along the course of the artery deep to brachioradialis to the point where the biceps tendon is just visible.

Anatomy: The radial artery, unlike the saphenous and cephalic veins, is a deep structure in the volar forearm completely surrounded by muscle until it is just proximal to the palmar creases.

Technique: Having exposed the whole length to be harvested, dissection proper should begin. It is easiest to harvest the artery with its two attached veni comittantes. In contrast to most venous harvest there are multiple side branches in two groups, deep muscular perforators and multiple superficial branches. All must be carefully ligated and divided between small ligaclips (*Figure 5*). Diathermy dissection in radial artery harvest should be avoided. Before division of the artery it is mandatory to make a final perioperative check of the patency of the palmar arch.

The proximal end of the artery is now lightly clamped, and a small incision is placed distal to the clamp. A good flow of blood indicates good ulnar artery flow into the palmar arch and allows for radial artery harvest. A poor flow indicates

inadequate ulnar flow and means that the incision should be repaired and the radial artery not taken. The artery is now divided carefully ensuring there is no damage to the ulnar artery proximally at the brachial artery bifurcation. Proximal and distal stumps are ligated with 3/0 mersilene.

Tricks of the trade: The patient should be warned of neurological sequelae, i.e loss of sensation at the base of the thumb. It is routine to avoid radial artery harvest from the dominant arm and to warn the patient of possible arm/hand cramp if he/she is a manual labourer. No venous or arterial cannulae should be placed in the arm before harvest. It is useful to have a pulse oximeter attached to the thumb to show adequacy of hand blood flow during harvest. The radial artery should be stored in heparinized saline with a vasodilator, e.g. papaverine or glyceryl trinitrate, until just before anastomosis.

Testing the conduit: The graft is inspected with gentle hydrostatic dilatation with a mixture of heparinized blood and papaverine. Any leaking side branches should be clipped. It is also vital to ensure adequate dilatation of the vessel to aid anastomosis and maximize early flow.

Closure: The deep fascia is closed with interrupted sutures (to avoid any potential compartment syndrome). The skin is closed with a subcuticular stitch. No pressure dressings should be applied and the arm should be elevated.

Areas of controversy:

1. The mid-term and long-term patency of the radial artery (Brodman et al, 1996).

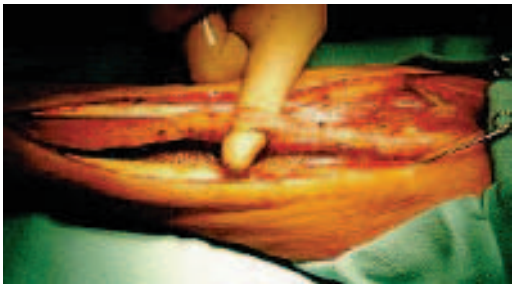

Figure 5 . Dissected radial artery ready for harvest.

KEY POINTS

- Coronary artery bypass grafting is a very commonly used technique in the treatment of ischaemic heart disease.
- Conduit harvesting is essential in optimizing short-term and long-term surgical results.
- The long saphenous vein remains a very commonly used conduit.
- The internal mammary artery, because of its unique biology, gives the best patency and increases long-term patient survival.
- The radial artery is increasingly being used in coronary surgery but its medium-term and long-term patency is still not fully known.

CONCLUSIONS

The above are the most commonly harvested conduits used in coronary bypass grafting. As well as these, a number of other conduits have been used including the inferior epigastric artery (Mills and Everson, 1991) and the splenic artery (Mueller et al, 1993). So far prosthetic grafts have had poor short-term results in the coronary circulation, and although there will undoubtedly be development in their patency, autogenous grafts still remain the gold standard.

The accurate, atraumatic and expeditious harvest of conduit is an essential part of coronary artery surgery. For many surgical trainees this will be their introduction to vascular surgical techniques. HM

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