Off-pump coronary artery bypass grafting using skeletonized *in situ* arterial grafts

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Skeletonization is an advanced technique of graft harvesting for coronary artery bypass grafting (CABG), and while it requires meticulous attention, it has many advantages. For example, skeletonization of internal thoracic artery (ITA) can minimize sternal ischemia and lower the risk of mediastinitis, and is longer and larger than pedicled ITA. In this article we describe the surgical techniques demonstrated in our video, which details our techniques of skeletonization of arterial grafts and off-pump coronary artery bypass (OPCAB) exclusively using these *in situ* grafts. Our method of right gastroepiploic artery (GEA) skeletonization has only three technical steps. The first step is to pass thin vessel loops under the GEA. The second step is to unroof the tissue surrounding the GEA. The last step is to seal and sever all the branches. Skeletonization of the GEA not only prevents vasospasm but also leads to GEA dilatation, and facilitates inspection and makes sequential anastomosis easier. Bilateral use of the skeletonized ITA and use of the skeletonized GEA can cover most coronary artery target sites without any manipulation of the ascending aorta. In our consecutive series of over 1,000 patients, the stroke rate was 0.5%. Our method helps to make the technique simple and secure in this technically demanding operation, and we believe that OPCAB with these grafts provides the best possible coronary revascularization.

Keywords: Coronary revascularization; coronary artery bypass; off-pump coronary artery bypass (OPCAB); internal thoracic artery (ITA); gastroepiploic artery (GEA)

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Introduction

Skeletonization is an advanced graft harvesting technique for coronary artery bypass surgery (CABG). We have developed a simple routine technique using a Harmonic Scalpel (Ethicon Endo-Surgery, Cincinnati, OH). This video illustrates our approach to skeletonization of arterial grafts and off-pump coronary artery bypass (OPCAB), exclusively using these *in situ* grafts.

Although skeletonization is technically demanding and requires meticulous detail, this technique provides some advantages. Skeletonization of the internal thoracic artery (ITA) minimizes sternal ischemia and lowers the risk of mediastinitis. Additionally, skeletonized ITA has increased size and available graft length compared to pedicled ITA. This technique is further made easier, quicker and more secure by using a Harmonic Scalpel (1). Currently, *in situ* skeletonization of bilateral ITA accounts for approximately 70% of our isolated CABG operations, without making composite grafts.

Skeletonization of the right gastroepiploic artery (GEA) not only prevents vasospasm but also leads to GEA dilatation. This procedure facilitates handling and visibility whilst making sequential anastomoses easy. We have previously described our simple three-step technique for harvesting skeletonized GEA (2,3). Firstly, thin vessel loops

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are passed under the GEA at 5 cm intervals. Secondly, the tissue surrounding the GEA is unroofed. The last step is to seal and sever all the branches together with the soft tissue.

Bilateral use of the skeletonized ITA and skeletonized GEA covers most coronary artery target sites without any manipulation of the ascending aorta. The stroke rate of our 1,000 consecutive patients was determined to be 0.5%. Here we detail our techniques, focusing on the harvesting of skeletonized ITAs and GEA.

Case presentation

We operate on a 61-year-old diabetic male who presented with severe triple vessel coronary artery disease despite multiple percutaneous coronary interventions (PCI) (*Video 1*). Coronary angiography demonstrated severe stenosis in the proximal left anterior descending artery (LAD) and the proximal circumflex artery. The first diagonal was diffusely diseased and the second diagonal was relatively large but totally occluded due to previous stenting. The right coronary angiogram showed occlusion of the posterior descending artery (PDA) and further distal stenosis in the AV branch. Thus, the patient was referred for CABG.

We performed quintuple OPCAB, exclusively using the skeletonized *in situ* ITAs and GEA. Technical details regarding the harvest of skeletonized arterial grafts, off pump set-up, and construction of each anastomosis in this case are included.

Operative techniques

Monitoring arterial line, temperature and induction

The patient is positioned supine and general anesthesia is induced. Pressures in a radial arterial line and Swan-Ganz catheter are monitored throughout the procedure, concurrently with transesophageal echocardiography.

Conduit harvesting

A median sternotomy is extended approximately 5 cm caudally from the xiphoid process. Prior to harvesting ITAs, the peritoneal cavity is opened vertically and the GEA is inspected and palpated to confirm its suitability as a conduit.

Skeletonized left internal thoracic artery (LITA)

The left ITA was then harvested, starting with the endothoracic fascia incised using an electrocautery about 5 to 10 mm medial to the internal thoracic vein. As the fascia is pulled down with forceps, the vein is exposed using an inactive diathermy tip. The under-surface of the internal thoracic vein is clearly exposed and the ITA subsequently becomes visible.

The cautery tip gently separates the vein and ITA without activation. The trunk of the ITA is separated from the chest wall gradually. This allows for the perforating branch to be naturally exposed to view and cut. The Harmonic Scalpel with the dissecting hook has a unique ability to cavitate fat tissue. The activated tip of this scalpel is used to remove the soft tissue and the fascia from the ITA.

While the ITA is gently pulled down using curved DeBakey forceps, the surrounding tissue is separated from the ITA with the activated tip of the Harmonic Scalpel. Proximally, the vein is clipped and divided, clearing the view for the ITA. The mediastinal branch is divided, and the skeletonized ITA trunk is then harvested all the way to the top where the ITA arises under the left subclavian vein.

Skeletonized right internal thoracic artery (RITA)

Similar techniques are used to harvest the RITA. Starting with incision of the fascia, the under-surface of the vein is exposed. This is followed by separation of the vein and ITA using the cautery tip, which exposes small ITA branches. Extreme care should be taken not to injury any branches of the ITA.

The Harmonic Scalpel is used to treat small branches of ITA by applying the activated tip gently for a few seconds. Subsequently, protein coagulation is induced which seals the cut surface safely. The right ITA is harvested near its origin all the way to the subclavian vein, with all branches are securely divided in the same way.

Skeletonized GEA

A small laparotomy is extended into the diaphragm in the midline and to the attachment of the liver. This extension greatly facilitates the GEA harvest as well as the OPCAB procedure.

The GEA is harvested in skeletonized fashion using the Harmonic Scalpel with the coagulating shears tip. The first step of this procedure is to pass thin vessel loops under

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the GEA at 5 cm intervals, followed by cautery incision of the anterior layer of the greater omentum. The soft tissue between the GEA and its satellite vein is carefully undermined using “mosquito” forceps and only the artery is encircled with the rubber vessel loops. This is carried out through the entire necessary length from the level of the pylorus.

The second step is to unroof the tissue surrounding the GEA. The anterior layer of the greater omentum is divided with the Harmonic Scalpel coagulating shears between the vessel loops. The “tissue pad” jaw of the shears is inserted through the soft tissue in such a way that the GEA trunk is protected from heat of the Harmonic Scalpel. This step exposes the GEA throughout its entire length. When we occasionally encounter omentum thick with adipose tissue, we clear away the fat around the GEA by stroking it gently with the activated tip of the Harmonic Scalpel.

The GEA gives off thin-walled gastric and omental branches. The next step then is to seal and sever all the branches together with the soft tissue. By gently pulling up the vessel loops, the whole surrounding tissues are detached by coagulating shears approximately 2 mm away from the GEA. During dissection, we rarely encounter bleeding from the satellite vein or any other vessels. The whole skeletonization of the GEA takes 10 to 20 minutes, without injuring the arterial trunk.

After the omentum is hemostatic, intravenous heparin is infused. The distal end of the graft is then divided, diluted milrinone solution instilled, and a hemoclip is applied. The GEA is then wrapped in a papaverine-soaked sponge. With these preparations, the GEA later becomes a maximally dilated arterial conduit. The GEA is brought anterior to the pylorus and the liver through the vertical incision in the diaphragm to reach the heart.

Set-up and positioning for OPCAB

The left and right ITAs are divided and prepared in the same fashion. The pericardium is opened in an inverted T shape and two pericardial edge sutures are placed only at the left cut margins. The pericardium is cut to make the route for the left ITA to reach the lateral aspect of the heart without kinking.

Two deep pericardial sutures of 0 PDS are placed for the heart positioning, without apical suction device used. A pericardial incision of a few centimeters, parallel and anterior to the superior vena cava, is made in the right upper part of the pericardium to let the right ITA into the pericardial space.

Anastomoses

The skeletonized *in situ* RITA is used for the target site, the distal LAD. Neither composite vessel nor sequential grafting for the LAD is used. Instead, the ITA is always used for the LAD in the individual graft fashion, which in this case is a 2.0 mm vessel with a mildly thickened arterial wall. An intracoronary shunt of 2.0 mm is introduced, used with a 7-0 polypropylene running suture.

After completion of the anastomosis, the fibrous tissue around the skeletonized RITA is fixed on the heart surface to avoid twisting or kinking. The graft flow is assessed by transit time flow-metry (VeriQc, MediStim, Oslo, Norway) following each anastomosis construction.

The next target is the first diagonal branch, which has tight diffuse stenosis. The skeletonized left ITA is grafted in side-to-side fashion. The anastomosis is arranged in parallel fashion, again with a 7-0 polypropylene. Transit time flow-metry is used to confirm good blood flow and pattern.

The second diagonal branch, a totally occluded vessel and barely visible by the preoperative angiogram, is then grafted with the end of the left ITA. It is crucial that the graft covers a broad region of the anterolateral wall. The 1.2 mm diameter target site is grafted with the left ITA without shunting due to poor arterial wall quality.

The skeletonized GEA is used for the totally occluded PDA and posterolateral branch of the circumflex artery. The adjacent anastomosis between GEA and PDA is constructed in the diamond fashion, and a coronary shunt of 1.5 mm is inserted. The heart can be positioned vertically without hemodynamic compromise.

Lastly, the posterolateral branch of the circumflex artery is grafted with the end of the GEA. This posterolateral branch is a previously stented large vessel, but with newly progressed severe stenosis in the proximal portion. Following positioning of the heart, a coronary stent of 2.0 mm is inserted. Under hemodynamically stable conditions with no arrhythmia, the anastomosis is constructed in an end-to-side fashion.

Systolic blood pressure was maintained over 80 mmHg throughout the procedure with no inotropic agents or pressor medications. Norepinephrine, phenylephrine or dobutamine have mostly never been necessary in the intraoperative management of our OPCAB procedures.

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Intraoperative graft assessment

All anastomoses showed no bleeding and thus no additional suture was required. The intraoperative fluorescence imaging (SPY, Novadaq, Toronto, ON Canada) demonstrates excellent graft flow from the GEA into the PDA and the posterolateral branch of circumflex artery. Furthermore, two ITAs were shown during the early phase, which indicates excellent graft flow.

The final graft flow assessment was performed prior to the chest closure. VeriQc, a transit-time flow-metry apparatus, easily assesses all skeletonized arterial conduits. The GEA flow is excellent, showing over 100 mL per minute with an appropriate flow curve pattern. The right ITA to LAD is assessed next and showed over 30 mL per minute with a good pattern. The left ITA also demonstrated good flow and a good curve pattern.

The anterior part of the diaphragm and the peritoneum are closed the same continuous suture to leave adequate passage for the GEA route. Subsequently, the upper half of the mediastinal soft tissue is approximated. The right ITA is completely covered with the mediastinal tissue.

The early graft patency is confirmed using CT angiography prior to discharge, as shown via three-dimensional reconstructions in the video. The right ITA to LAD, the left ITA to the first and second diagonal branches, the GEA to the PDA and the posterolateral branch of the circumflex artery were all proven to be patent grafts.

Comments

Whilst bilateral internal thoracic artery (BITA) grafting has been reported to demonstrate better long-term results than single internal thoracic artery (SITA) grafting (4,5), the best way to use the right ITA remains controversial.

Reduced early graft patency has been reported recently in RITA free grafts used in composite grafts compared to *in situ* grafts (6), despite the ease of its use. Complete skeletonization lengthens the *in situ* right-side ITA enough to reach the left-side coronary area, including the distal LAD. We have used the skeletonized *in situ* right-side ITA to revascularize the LAD in the majority of our cases, and the left ITA to graft circumflex and diagonal branches. The skeletonized *in situ* GEA has been used for the PDA and other inferolateral target arteries.

We have demonstrated superiority in bilateral use of skeletonized *in situ* ITA in high-risk patients undertaking OPCAB (7). Additionally, we have demonstrated better clinical outcomes with skeletonized GEA compared with the saphenous vein (8). Recently, long-term patency rates for skeletonized *in situ* GEA (94.7% at 5 years, and 90.2% at 8 years) have been shown to be superior compared to the pedicled GEA or saphenous vein (9).

In conclusion, we have demonstrated our method of OPCAB using skeletonized *in situ* arterial grafts. Meticulous preparation of ITA and GEA is most important for high-quality coronary revascularization. Our method ensures that the technique simple and secure in this technically demanding operation, and thus provides the best possible coronary revascularization for OPCAB patients.

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References

1. Higami T, Kozawa S, Asada T, et al. Skeletonization and harvest of the internal thoracic artery with an ultrasonic scalpel. Ann Thorac Surg 2000;70:307-8.
2. Asai T, Tabata S. Skeletonization of the right gastroepiploic artery using an ultrasonic scalpel. Ann Thorac Surg 2002;74:1715-7.
3. Asai T. Technique and results for skeletonized GEA using the Harmonic Scalpel in combination with other arterial grafts in off-pump coronary artery bypass surgery. In: He GW. eds. Arterial Grafting for Coronary Artery Bypass Surgery. 2nd ed. Berlin: Springer Verlag, 2006:196-200.
4. Buxton BF, Komeda M, Fuller JA, et al. Bilateral internal thoracic artery grafting may improve outcome of coronary artery surgery. Risk-adjusted survival. Circulation 1998;98:II1-6.
5. Lytle BW, Blackstone EH, Loop FD, et al. Two internal thoracic artery grafts are better than one. J Thorac Cardiovasc Surg 1999;117:855-72.
6. Pevni D, Hertz I, Medalion B, et al. Angiographic evidence for reduced graft patency due to competitive flow in composite arterial T-grafts. J Thorac Cardiovasc Surg 2007;133:1220-5.
7. Kinoshita T, Asai T, Suzuki T, et al. Off-pump bilateral versus single skeletonized internal thoracic artery grafting in high-risk patients. Circulation 2011;124:S130-4.
8. Suzuki T, Asai T, Matsubayashi K, et al. In off-pump surgery, skeletonized gastroepiploic artery is superior to saphenous vein in patients with bilateral internal thoracic arterial grafts. Ann Thorac Surg 2011;91:1159-64.

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9. Suzuki T, Asai T, Nota H, et al. Early and long-term patency of in situ skeletonized gastroepiploic artery after off-pump coronary artery bypass graft surgery. Ann Thorac Surg 2013;96:90-5.

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