Off-pump total left anterior descending area re-vascularisation using left internal thoracic artery auto Y graft; angiographic early and 3-year follow-up results

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Abstract

Background: We evaluated the efficacy of a well-prepared left internal thoracic artery (LITA) auto Y graft for simultaneous left anterior descending artery (LAD) and diagonal artery (DA) re-vascularisation in selected patients for the reduction of the number of required grafts and improved graft patency, while limiting technical problems.

Methods: Twenty well-controlled diabetic patients, mean age 62.8±8.3, 17 males and three females, underwent isolated elective off-pump coronary artery bypass grafting using the LITA auto Y graft from July 2003 to August 2004.

Results: In-hospital data and angiographic results at 6 months after the surgery showed that there was no early mortality, early graft failure and major morbidity except for two cases of superficial wound infection. The 3-year follow-up results including angiographic findings (mean of 37±3.3-month follow-up) demonstrated that all patients are alive and have excellent graft patency in both the LAD and DA. Only two cases required right coronary artery (RCA) stenting during the follow-up period. Compared with our previous routine LITA composite Y graft technique, it is assumed that LITA auto Y graft technique may reduce the number of mobilised conduits or avoided sequential anastomosis.

Conclusions: This small study showed that our technique is technically feasible and may be safely performed to the selective patients. The LITA auto Y graft might be an additional surgical option, in terms of not only preserving the other grafts and maintaining patency in the LAD area bypass, but also preventing the need for sequential anastomoses.

1. Introduction

Surgical re-vascularisation of the left anterior descending artery (LAD) area using the left internal thoracic artery (LITA) has shown excellent results with superior graft patency and long-term freedom from significant coronary events. This outcome has been attributed to the unique physiological and histological characteristics of the LITA itself [1].

The diagonal artery (DA), which supplies the obtuse margin of the left ventricle, is usually grafted by a sequential LITA; the other options include the right internal thoracic artery (RITA), radial artery (RA), saphenous vein (SV) or gastroepiploic artery (GEA). However, sometimes the use of these conduits is not successful; the reasons for failure include graft shortness, postoperative sternal dehiscence, early spasm and a positive Allen’s test. In addition, reserving these conduits for a re-do bypass graft surgery in the future is an important consideration. Furthermore, when these grafts anastomose to the DA along with the circumflex branch, in a sequential manner, a diamond-shaped anastomosis is unavoidable for the preservation of the conduit length; this may eventually negatively affect the graft patency (seagull deformity).

In 1990 and 1996, Slater and colleagues, and Bonchek and colleagues individually introduced both the technical aspects and clinical usefulness of a surplus LITA [2,3]. Even with the many benefits of their methods, this technique has not been widely used and there is no published clinical follow-up data on patient outcome. The purpose of the present study was to evaluate the clinical efficacy of a well-prepared LITA auto Y graft for DA re-vascularisation in selected patients. The goal was to reduce the number of required grafts, improve the graft patency and limit the technical problems.
Table 1
Preoperative patient characteristics.

<table>
<thead>
<tr>
<th>Patients number</th>
<th>20</th>
<th>Mean diseased vessel</th>
<th>2.6 ± 0.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years old)</td>
<td>62.8 ± 8.3</td>
<td>1-vessel disease (%)</td>
<td>2 (10%)</td>
</tr>
<tr>
<td>Male:female</td>
<td>17:3</td>
<td>2-vessel disease (%)</td>
<td>4 (20%)</td>
</tr>
<tr>
<td>Mean ejection fraction (%)</td>
<td>50.5 ± 10.7</td>
<td>Left main disease (%)</td>
<td>6 (30%)</td>
</tr>
<tr>
<td>BSA (m²)</td>
<td>1.76 ± 0.15</td>
<td>3-vessel disease (%)</td>
<td>8 (40%)</td>
</tr>
<tr>
<td>Mean CCA</td>
<td>2.7 ± 0.8</td>
<td>Diabetes</td>
<td>20 (100%)</td>
</tr>
</tbody>
</table>

BSA: body surface area; and CCA: Canadian class for angina.

2. Materials and methods

2.1. Study design

Because we were unaware of the previously quoted technique, which was the same as we applied for, according to our Institutional Review Board (IRB) and Ethics Committee recommendations, this study was planned in a prospective manner on a small scale in the initial planning stage. After the IRB and Ethics Committee approved our study protocol and the patients provided written informed consent, 20 patients, mean age 62.8 ± 8.3, 17 males and three females underwent isolated elective off-pump coronary artery bypass grafting using the LITA auto Y graft from July 2003 to August 2004 (Table 1). Continuous data are presented as mean ± standard deviation.

2.2. Study population and inclusion/exclusion criteria

The prospectively designed inclusion criteria and exclusion criteria for the study population are listed in Table 2. Because a great number of the patients who are planning a CABG in our centre have diabetes, we enrolled only diabetic patients in our study population and tried to evaluate the clinical outcomes of LITA auto Y graft within this group.

2.3. Outcomes

In-hospital mortality and the associated morbidities including the angiography results at 6 months after the surgery were evaluated. The major complications included the need for a second-look sternotomy for bleeding, wound infection, neurological problem, renal failure, arrhythmia, recurrent angina/myocardial infarction and heart failure. The 3-year follow-up morbidity and mortality including the angiography results were also evaluated. Finally, it was analysed whether this technique may reduce or prevent the number of grafts and sequential anastomosis, compared with our usual technique of LITA composite Y graft.

2.4. Surgical technique

The operative details for the LITA auto Y graft have been described previously elsewhere [2]. Thorough investigation of the angiograms and target points was performed preoperatively for every operation by both the cardiac interventionist and the cardiac radiologist. To prevent immediate postoperative graft spasm, intravenous diltiazem (5–15 μg kg⁻¹ min⁻¹) or nitroglycerin (20–40 μg min⁻¹) or milrinone (0.4–0.8 μg kg⁻¹ min⁻¹) were commonly used perioperatively and intra-operatively for 24 h. After routine median sternotomy, the LITA harvest was performed by an experienced surgeon using a combination of sharp dissection and ultrasonic scalpel procedures. Care was taken not to grasp and not to exert excessive traction on the artery. The LITA harvesting was performed from the subclavian artery to the upper-level of the distal bifurcation, simultaneously with other graft harvesting. All LITA grafts were prepared in a semi-skeletonised manner. Diluted papaverine solution was frequently sprayed on the arterial graft during harvest to minimise vasospasm. Mechanical dilation was not applied in any of the cases. After confirmation that systemic heparinisation and the initial LITA flow was completed, the LITA auto Y graft anastomosis was performed following accurate coronary artery target point identification. The LITA proper to the LAD anastomosis was always conducted first and then the LITA side arm to DA anastomosis was performed (Fig. 1). Making the LITA auto Y graft is technically quite simple because we can easily estimate the distance between the target point and the Y-shaped anastomosis point. If another area of re-vascularisation was needed, aorto-coronary anastomosis using an arterial or venous conduit was carried out. Anastomosis sites and the other grafts used are listed in Table 3. All left circumflex and ramus intermedius artery bypass grafting was performed using RA (n = 12). Conduits that grafted to right circumflex territory were RA (n = 4), SV (n = 4) and GEA (n = 1). Graft flow was routinely evaluated using a transit time flowmeter (BF 1001; Medi-Stim AS, Oslo, Norway) in the operating field. Suboptimal graft flow in LAD defined as below 15 ml min⁻¹ in the setting of normal blood pressure, or less than 50% of the initial LITA flow at the same blood pressure, did not occur in any of the patients. Because we did not have any previous reference for this type of graft.

Table 2
Inclusion and exclusion criteria.

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
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<tbody>
<tr>
<td>1. Proximal LAD or proximal-mid LAD stenosis with clinically important DA stenosis (over 70%).</td>
<td>1. Preoperatively statin medication due to hyperlipidaemia.</td>
</tr>
<tr>
<td>2. Sufficient LITA length to anastomose both LAD proper and diagonal branch in a state of LITA auto Y graft itself.</td>
<td>2. Combined valvular heart disease or major co-morbidity including systemic disease except diabetes (ex, renal failure, COPD, cerebral disease, peripheral artery disease).</td>
</tr>
<tr>
<td>4. Patients who have diabetes with or without hypertension but well controlled by oral medication; preoperative haemoglobin A1c level between 6.0% and 6.9%.</td>
<td>4. Emergent operation.</td>
</tr>
<tr>
<td>5. Preoperative normal ejection fraction (40% &lt; ejection fraction &lt; 70%).</td>
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technique, DA graft flow was recorded in the raw after we confirmed the normal pulsatile index value (<4).

2.5. Angiography follow-up

Follow-up angiograms (Fig. 1) were performed in all study populations with a bi-plane cardiovascular cine angiography system (Integris BH 5000, Philips Medical Systems, Amsterdam, the Netherlands B.V). Gauge 4F catheters were inserted through the radial or femoral artery. A complete study of the coronary arteries and of all the implanted grafts and a left ventriculogram were performed by the cardiologist and cardiac radiologist. These follow-up angiography studies were performed primarily in the 6 postoperative months (early results). Then, on the 37.2 ± 3.3th postoperative month, secondary follow-up angiography was performed (mid-term results).

3. Results

The in-hospital mortality and the associated morbidities including the angiography results at 6 months after the surgery are listed in Table 4. These findings were presented at the 36th annual meeting of Korean Society for Cardio-thoracic surgery in 2005; at that time, there was no mortality, early graft failure and major complication except two cases of superficial wound infections. The 3-year follow-up results showed that all patients are alive and have excellent graft patency at both the LAD and DA (100%). All RAs and GEA also showed intact graft patency. There was one case of recurrent angina 18 months after surgery. From this patient, newly developed focal 70% of stenosis in LCA was identified. Medical treatment was enough to relieve her symptoms. Two patients required right coronary artery (RCA) stenting during the follow-up period because of SV graft failure of RCA.

Compared with our previous routine LITA composite Y graft technique, it is assumed that LITA auto Y graft technique reduce the number of mobilised conduits or avoided sequential anastomosis by using the surplus LITA.

4. Comments

In 1990 and 1996, Slater and Bonchek each introduced the technical aspects and clinical usefulness of a surplus LITA [2,3]. However, only one retrospective clinical report and no systematic follow-up has been published on these techniques [4]. Recently, complete re-vascularisation and total arterial re-vascularisation has become the common trend for coronary artery bypass surgery. The involved procedures require not only extensive surgical skill but also a greater number of arterial grafts. Among these arterial conduits, the ITA has been considered the best graft conduit for the LAD area re-vascularisation because the ITA has distinct molecular and cellular characteristics; these properties contribute to its unique resistance to atherosclerosis and long-term patency. Therefore, if the Y-shaped graft with a single ITA is appropriately performed for total LAD area re-vascularisation, we may not need to perform sequential grafting, as well as reduce the number of arterial grafts and maintain excellent long-term patency.

Many investigators have documented the elastic histological structure in the medial layer of the ITA and proposed a correlation between the elastic type of vessel and the absence of atherosclerosis [5—9]. Van Son and colleagues demonstrated that the reduction of the elastic lamellae may represent an increase in the intimal thickening and be a
precursor to atherosclerosis. They noted that these findings are most frequently observed in the distal segment of ITA [5]. He and colleagues [10,11] demonstrated that the distal section of the ITA is the most reactive region of the graft to vasoconstrictive drugs and the main portion, composed of more than 60% of the total length of the graft of the ITA, was found to be less reactive than the distal portion and, possibly, the proximal portion. The distal end is a more efficient physiological regulator of flow because this section contains relatively more smooth muscle cells and is smaller in diameter than the proximal end. Recently, therefore, it is generally accepted that trimming the small and highly reactive distal end of the grafts may be important and clinically feasible for the prevention of acute and late graft failure.

However, Marx and colleagues, and Svedson and colleagues[12,13] reported that there was no correlation between different histological types and the incidence of intimal thickening in the distal ITA graft. They suggested that there might be an extremely variable number and arrangement of elastic lamellae in the hybrid segments. Based on their findings and the results of others, they emphasised that there is no limitation for the use of the distal part of the ITA for CABG procedures. The differences observed in these studies suggest that the factors involved in the determination of graft patency of the ITA are many and depend on other factors in addition to the histopathology of the graft. These findings can prompt us to use the distal part of ITA as a suitable graft conduit in selected patients. Another important factor to consider is that the free ITA graft diameter can be increased postoperatively – similar to the in situ ITA graft; this depends on the coronary blood flow requirements. For example, the diameters of free ITA grafts increased more in patients when a proximal coronary artery lesion progressed than in other circumstances [1].

Similar to our technique, Odayan and Paterson [4] reported the mean 8.4-month angiographic follow-up results of LITA auto Y graft procedures with sequential anastomosis in mainly the LAD with circumflex area. There were no deaths or episodes of myocardial infarction. However, two of three patients with isolated ostial stenosis developed recurrent symptoms. Odayan and Paterson noted a diameter mismatch between the free graft and the circumflex artery and recommended the use of an appropriate-sized graft suitable for the native circumflex coronary artery in this situation. Their findings were fairly consistent with our other study results [14] and may be due to differences of target vessel characteristics (diagonal artery vs circumflex artery) and stenotic degree [15].

Sequential grafting on the beating heart is technically demanding. Exposure and stabilisation of the target vessels are crucial steps in sequential grafting with the off-pump coronary artery bypass (OPCAB) technique. Furthermore, the technical aspects with regard to the type of anastomosis seem to be important factors for graft patency and recurrence of symptoms. Sequential re-vascularisation of the LAD area using the LITA with or without composite graft usually requires a diamond-shaped anastomosis. Although sequential anastomosis generally results in excellent graft patency equal to end-to-side anastomosis, based on subgroup analysis, the sequential grafts constructed in a diamond-shaped anastomosis tend to be remain less patent than with a sequential anastomosis constructed in the length of the vessel (Dion and colleagues [16] 97.2% vs 91.5%, p = 0.004). It may be necessary to use a longer arterial conduit or another graft in order to prevent the diamond shape that results from sequential anastomosis. However, making the LITA auto Y graft is technically quite simple because we can easily estimate the distance between target point and Y shape anastomosis point. This fact can make us save the graft length.

A question that remains to be answered is whether the mean DA graft flow of 15 ml min\(^{-1}\) is a sufficient flow rate for DA re-vascularisation. If we hypothesise that the normal pulsatile index may imply exclusion of the technical fault in the anastomosis site [17], because we identified the normal pulsatile index to all study populations, then as a conservative estimate this value does not represent inadequate graft size, but the required blood amount for DA area. With reference to our patients’ symptoms and clinical findings, we may assume that it does not mean insufficient graft flow, even if borderline. However, this is a mere hypothesis and still remains an argument for the auto Y graft.

Finally, our results showed that the LITA auto Y graft on a pedicled conduit can achieve multiple-vessel re-vascularisation less invasively and with a limited number of arterial grafts without aortic manipulation. The LITA auto Y graft appears to provide a conduit for patients with a severely or critically stenosed proximal LAD and a big diagonal lesion.

5. Conclusion

Although a small study population was evaluated, the present investigation demonstrated that coronary artery re-vascularisation using the LITA auto Y graft might be an additional surgical option, in terms of not only preserving the other grafts and maintaining patency in the LAD area bypass, but also preventing the need for sequential anastomoses. This technique provides total arterial re-vascularisation with an aorta no-touch technique in the setting of off-pump coronary artery bypass grafting, by saving the conduit. Larger prospective well-controlled trials are needed to confirm these findings.

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References


