Repeat Median Sternotomy After Prior Ante-Aortic Crossover Right Internal Thoracic Artery Grafting

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ABSTRACT

Background: In situ bilateral internal thoracic artery (ITA), with ante-aortic crossover right ITA (RITA) is gaining popularity. However, the retrosternal position of the crossover RITA has raised concerns with regard to its compromise during subsequent resternotomy. Methods: Ten patients underwent repeat median sternotomy after prior ante-aortic crossover RITA grafting. Specific RITA routing and fixation had been performed in the initial operation. Preoperative imaging, including computed tomography (CT) angiography, was performed to confirm RITA position in relation to the sternum and assess feasibility. Results: Resternotomy was performed 4–48 months after the initial operation (median, 22 months). Nine crossover RITA grafts were functioning at the time of resternotomy. CT angiography was performed in four patients in whom the premarked RITA could not be localized on the plain chest radiograph. The feasibility of conducting a nonmodified resternotomy was determined based on preoperative imaging. All RITA grafts resumed their original position and none was injured during reentry. There was no early mortality, perioperative stroke, or reexploration for bleeding. One patient sustained myocardial infarction, however, not in a RITA-related distribution. CT angiography was predictive in confirming a free retrosternal space. Conclusions: Resternotomy after prior ante-aortic crossover RITA grafting can be performed at acceptable risk. Confirmation of a free retrosternal space by preoperative imaging may contribute to the safety of the procedure. Maneuvers performed during the first operation are useful in preventing RITA adherence to the sternum. (J Card Surg 2004;19:151-154)

Several arrangements of left-sided bilateral internal thoracic artery (ITA) grafting have been proposed, however, insofar as the superiority of one arrangement over the other remains undetermined. In situ bilateral ITA grafting with ante-aortic crossover RITA is increasing popularity thanks to its simplicity in achieving left-sided revascularization and its benefits in off-pump coronary artery bypass (OPCAB). It has been reasoned that OPCAB techniques may be facilitated by allowing tension-free RITA to left anterior descending (LAD) during displacement of the beating heart. Many surgeons, however, are reluctant to use this approach due to the “retrosternal” position of the crossover RITA, which may compromise subsequent resternotomy. To date definitive data concerning this issue are sparse.

The objective of this report was to evaluate the safety of repeat median sternotomy after prior ante-aortic crossover RITA grafting, and by extension, to assess the feasibility of preoperative imaging in detecting the RITA position in relation to the sternum.

MATERIAL AND METHODS

Between February 1998 and December 2001, ten patients underwent repeat median sternotomy after prior left-sided in situ bilateral ITA grafting. In the original procedure, in situ RITA was routed anterior to the aorta to graft the LAD artery, and left ITA was used to graft the circumflex marginal branches. Supplemental grafting of the right coronary artery (RCA) or its branches was achieved using a saphenous vein graft (SVG) or a right gastroepiploic artery (RGEA).

ITAs had been routinely mobilized as skeletonized vessels. Specific maneuvers applied in the first coronary artery bypass grafting (CABG) were aimed at preventing future RITA migration toward the sternum. The in situ RITA was tunneled through a right pericardial incision and advanced laterally. The graft was sagitally positioned on the aorta at the retrosternal position (Fig. 1B). A direct RITA course toward the LAD, which requires passage over the right ventricle (RV), was avoided. This was thought to prevent future RITA displacement toward the sternum. Approximation of the pericardial edges (right pericardial incision) maintained the tunneled RITA at the level of the aortic plane. This was followed by the approximation of the pericardial edges anteriorly and mediastinal fat advancement after. No foreign materials were used to cover the RITA.
Prior to sternal closure, a large metal clip was attached to the crossover RITA at the midline in order to aid radiographic localization of the graft.

The feasibility of a resternotomy was determined following preoperative imaging that verified a nonadherent RITA. Two modalities were used. Lateral chest radiographs were performed to detect the large metal clip that had been attached to the RITA in the first operation. This technique had previously proved useful, when serial lateral radiographs were used to monitor potential RITA migration toward to the sternum. The second modality used was CT angiography, done on a dual-slice helical CT (Marconi CT TWIN flash). This was initially indicated following failure to detect the metal clip on a plain radiograph but evolved to be the procedure of choice. Acquisition protocol consisted of a 3.2-mm slice width, pitch of 1.5, and reconstruction overlap of 1.6 mm. a contrast agent (150 mL) (ULTRAVIST, 300 mg/mL) was injected at a rate of 4 mL/sec. Noncontrast study of the chest with 8.8 mm slices was obtained prior to CT angiography to visualize the preattached metal clip.

In no condition were the operative settings and resternotomy technique modified. Resternotomy was performed using oscillating saw (Aesculap, Tuttlingen, Germany) as is done routinely in redo operations (in our department) and stand-by cardiopulmonary bypass (CPB) was available in the operating room. After dividing the sternum, the underlying tissue was dissected at its posterior table. A sternal retractor was fully opened only after the crossover RITA was located and mobilized to avoid tension on the graft. When used, CPB was instituted through the ascending aorta (above the crossing RITA) and cardioplegic arrest was initiated by antegrade delivery, following transient blocking of in situ patent grafts. OPCAB was facilitated by the Octopus system, (tissue stabilizer and the Starfish heart positioner). Preconditioning was carried out by transient blocking of the blood flow proximal and distal to the planned arteriotomy. Allocation to either group was by the surgeon’s preference.

RESULTS

Resternotomy was performed 4 to 48 months (median, 22 months) after the initial operation. There were 2 women and 8 men, ranging in age from 58 to 74 years, mean 68 ± 5.2 years. Indications for reoperation were repeat CABG in seven patients and late sternal dehiscence in three patients. All operations were performed on a nonemergent basis. There were no repeat operations for valvular procedures (aortic or mitral). Patients’ characteristics are listed in Table 1. Preoperative angiography demonstrated nine functioning crossover RITAs at the time of resternotomy (Table 1).

Helical CT (Fig. 1) was performed in four patients. Reconstructed views were obtained in all of these cases for improved demonstration of the retrosternal space (Fig. 1B).

None of the crossing grafts was injured during resternotomy. The original RITA position was preserved (Fig. 1B,C) and adherence to the sternum was not documented. Three patients underwent OPCAB grafting and four patients had conventional CABG. All

**Figure 1.** A preoperative demonstration of the crossover right internal thoracic artery (ITA) by computerized tomographic (CT) angiography. A. Axial view. B. Computed reconstruction of the sagittal view. C. Computed reconstruction of the coronal view. The right ITA is advanced laterally, rather than obliquely, in order to prevent its passage over the right ventricle.
TABLE 1
Patient’s Profile

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Patent Grafts at Reoperation</th>
<th>Stenosed Grafts</th>
<th>Procedure</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>66</td>
<td>M</td>
<td>RITA → LAD</td>
<td>LITA → Marg: 70%* RGEA → PDA: 100%</td>
<td>SVG → Marg + PDA</td>
<td>CABG</td>
</tr>
<tr>
<td>2</td>
<td>65</td>
<td>F</td>
<td>RITA → LAD</td>
<td>RITA → LAD: 100%</td>
<td>RA → Marg</td>
<td>OPCAB</td>
</tr>
<tr>
<td>3</td>
<td>73</td>
<td>M</td>
<td>LITA → Marg</td>
<td>LITA → Marg: 90%</td>
<td>RA → LAD</td>
<td>OPCAB</td>
</tr>
<tr>
<td>4</td>
<td>74</td>
<td>F</td>
<td>RITA → LAD</td>
<td>LITA → Marg: 60% SVG → PDA: 100%</td>
<td>SVG → Marg + PDA</td>
<td>OPCAB</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>M</td>
<td>RITA → LAD</td>
<td>RITA → LAD: 70% SVG → PDA: 80%</td>
<td>RA → LAD</td>
<td>CAGB</td>
</tr>
<tr>
<td>6</td>
<td>71</td>
<td>M</td>
<td>—</td>
<td>LITA → Marg: 90% SVG → PDA: 90%</td>
<td>SVG → Marg + PDA</td>
<td>CAGB</td>
</tr>
<tr>
<td>7</td>
<td>70</td>
<td>M</td>
<td>RITA → LAD</td>
<td>—</td>
<td>Bilateral pectoralis muscle advancement</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>58</td>
<td>M</td>
<td>RITA → LAD LITA → Marg RGEA → PDA</td>
<td>—</td>
<td>Unilateral pectoralis muscle advancement</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>68</td>
<td>M</td>
<td>RITA → LAD</td>
<td>—</td>
<td>Bilateral pectoralis muscle advancement</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>72</td>
<td>M</td>
<td>RITA → LAD LITA → Marg</td>
<td>—</td>
<td>Bilateral pectoralis muscle advancement</td>
<td></td>
</tr>
</tbody>
</table>

*The percentages represent the degree of graft stenosis at time of resternotomy.

RITA, right internal thoracic artery; LITA, left ITA; RGEA, right gastroepiploic artery; SVG, saphenous vein graft; RA, radial artery; LAD, left anterior descending artery; Marg, circumflex marginal artery; PDA, posterior descending artery; OPCAB, off-pump coronary artery bypass grafting; CABG, coronary artery bypass grafting.

operations were conducted as preplanned, and the use of OPCAB did not reflect inability to cannulate or clamp the aorta. The average grafts per patient were 1.71 ± 0.76 (range, 1–3), (Table 1). Eight SVGs and four radial arteries (RA) were used. Three of the four RA grafts were connected proximally on intact patent in situ ITA graft from the prior operation and five proximal SVG anastomoses were constructed on the aorta.

Three of ten patients underwent repeat operation for late sternal dehiscence (Table 1): An oscillating saw was used to complete the division of the sternum in each case. There was no early mortality. One patient sustained a perioperative myocardial infarction (MI) in the distribution of the lateral wall; however, his clinical recovery was unremarkable. There were no perioperative strokes or re-explorations for bleeding.

CONCLUSIONS

The findings of the current report suggest that repeat median sternotomy after prior ante-aortic crossover RITA grafting can be performed at acceptable risk. Preoperative imaging is useful in determining the feasibility of this approach.

Although in situ bilateral ITA grafting with ante-aortic crossover RITA confers several benefits,2,4,5 this approach continues to be debated primarily because of the potential risk of compromising the “retrosternal” RITA during subsequent resternotomy. Also, concerns had been raised with regard to the ability to cannulate and clamp the aorta in the presence of the crossing graft. Scant data are available on these issues.

The feasibility of resternotomy was determined following preoperative imaging of a free retrosternal space. We had used a large metal clip attached to the RITA, at the midline, whenever cross-configuration was applied in the first procedure. This was done originally to detect the RITA on follow-up lateral chest radiographs; as part of a previous study aimed to assess the efficacy of RITA routing and fixation in preventing its adherence to the sternum.2 Preoperative dual slice helical CT, however, could localize the RITA through segments of its course and provide better anatomical understanding. CT features of 3.2 mm slice width with 1.6 mm reconstruction overlap were sufficient to demonstrate the required areas. However, improved visualization may be further achieved by advanced CT, producing 1 to 2 mm axial slices. The fact that in the proposed course, at its retrosternal position, the RITA is not in contact with the heart, prevents imaging motion artifacts. As a result, CT appears to be valuable when choosing between resternotomy and alternative approaches. Magnetic resonance imaging was not used in this cohort, but it may be of value when intravenous contrast is contraindicated.

The use of foreign materials had been advocated as an additional safeguard for graft protection during subsequent redo operation. These include the incorporation of a retrosternal crossover RITA into a polytetrafluoroethylene graft1 a Gore-tex patch, and use of polyhydroxybutyrate polymers.5 However, foreign material may interfere with the detection of RITA tenting, may mask bleeding ITA branches and, theoretically, promote infection. One of the objectives in this report was to assess the efficacy of the proposed initial RITA routing in avoiding subsequent adherence to the sternum. The present observations confirmed that the crossing RITA resumed its position on the plane of the aorta. Advancement of RITA laterally, in a manner by which it transverses the superior ascending aorta, reduces the
risk of displacement by the right ventricle toward the sternum. Since this maneuver requires additional graft length, the use of skeletonized RITA was highly appropriate.

Data on resternotomy after prior ante-aortic crossover RITA grafting are limited. Joyce et al. reported the damage of one (9%) patent RITA, which was successfully repaired in 11 redo operations. Their preoperative strategy cannot be deduced from this report and it is unclear whether preventive maneuvers were applied during the original CABG. It is noteworthy that injury to a noncrossing patent left ITA was reported to be 5% (5 of 97) of ITA grafts by Coltharp et al., and 3.3% after standard redo CABG by Lytle et al. The preferred reentry approach when the position of an angiographically patent RITA in relation to the sternum cannot be imaged is at question. Reentry through alternative thoracotomy should be considered in these cases. Recently, Takahashi et al. have demonstrated the feasibility of transdiaphragmatic approach in redo CABG. Most patients included in their report had prior RITA to LAD grafting. However, the exposure provided by this access is limited to the inferior wall; thus, it would be appropriate for selected patients only.

After successful resternotomy, technical complexity was also related to the placement of aortic clamps, in particular, the side-biting clamp. Regrafting may be facilitated by the OPCAB and use of patent grafts as inflow sites for new ones. However, the safety of transiently blocking old patent grafts during beating heart redo should be further evaluated. In this study, one radial artery was constructed on a patent RITA on the beating heart. The use of mechanical anastomotic devices may further facilitate the procedure by eliminating the need for clamping the aorta during construction of proximal anastomoses.

A larger cohort is required to establish the rate of injury to ante-aortic crossover RITA during resternotomy. However, given the low incidence of redo operation after bilateral ITA grafting, it is expected that data on surgical outcome will be hard to come by. Accumulating experience may contribute to the small pool that is presently available.

In conclusion, resternotomy after prior ante-aortic crossover RITA grafting appears to be safe. Preoperative imaging may contribute to the safety of the procedure. CT angiography is a useful tool in confirming a free retrosternal space.

REFERENCES