The use of internal thoracic artery grafts in patients with aortic coarctation

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Summary
The choice of conduits for surgical revascularization in patients with aortic coarctation can be puzzling, as the internal thoracic arteries can be dilated, atherosclerotic and unsuitable for grafting. Reports in the literature are controversial: in some cases, the internal thoracic artery was not suitable for revascularization, while in others, it could be used with discordant outcomes. Here, we review the literature on the subject.

Keywords: Aortic coarctation • Coronary artery disease • Coronary artery bypass graft • Arterial conduits

INTRODUCTION
Ischaemic heart disease is the leading cause of death after repair of aortic coarctation [1, 2]. When surgical revascularization is indicated in this setting, the choice of conduits can be cumbersome. In fact, severe atherosclerosis and unsuitability for coronary grafting of the internal thoracic artery (ITA) have been reported, and some authors have questioned the use of ITA graft in these patients.

In the present paper, we review the literature on the subject.

METHODS
A literature search was performed using PubMed, Ovid and Google Scholar databases. The ‘related articles’ function was used to broaden the search, and all abstracts, studies and citations were scanned and reviewed. Studies in all languages were sought. No date restrictions were placed on articles. The last date for this search was 8 November 2012. The databases of peer-reviewed journals focusing on cardiac surgery were searched, including published conference proceedings. Previous reviews, including cross-references, were also searched. References of the acquired articles were searched manually to identify any further studies for inclusion.

All articles reporting patients who underwent coronary artery bypass grafting (CABG) concomitantly or after treatment (surgical or endovascular) for aortic coarctation were included in this review, regardless of the type (acute, chronic stable) or extension (one, two and three vessels) of the coronary disease. The following data were extracted from each article: first author, year of publication, number of subjects, age of patients, time gap between the treatment for aortic coarctation and CABG, macroscopic finding on ITAs harvesting, clinical outcome, histological findings of discarded ITA segments and angiographic control, if available.

RESULTS
In the literature, 13 papers have been reported on the use of ITA grafts in patients with aortic coarctation, for a total of 15 patients (Table 1). In 9 cases, the artery proved to be unusually enlarged, calcified and with unsatisfactory flow and was not used, whereas in the remaining 6, an ITA graft could be used.

Cases with unsuitable internal thoracic artery
In 1995, Chen et al. [3] reported 2 patients previously treated for aortic coarctation who were referred for CABG. In both patients, at intraoperative examination, the left ITA (LITA) was found to be unusually large and heavily calcified, with a very weak pulse and a lumen diameter of about 0.5 mm (in 1 patient, the right ITA [RITA] was also explored, with the same results). Therefore, greater saphenous veins (GSVs) were used for CABG. The authors assumed that the delayed repair of aortic coarctation could have been the cause of the severe calcification and atherosclerosis of the RITA and LITA and discouraged the use of internal thoracic arteries in this group of patients.

The article by Chen was subsequently commented on by De Salazar et al. [4], who experienced the same situation in a 65-year-old CABG patient who had undergone previous...
correction of coarctation of the aorta. At operation, the LITA was dissected, but it was very large (3 mm in diameter) and heavily calcified. After division, no flow was evident and the lumen appeared occluded by severe calcified plaques. Proximal transection at the origin of the vessel revealed the same findings. Therefore, GSV grafts were used. Histological examination of the mammary artery demonstrated extracellular lipid deposits with calcification and fibrosis of the intimal and medial layers.

A similar case was reported by Dlingea et al. [5]: a 58-year old man with a disease of the left anterior descending (LAD) and circumflex artery who had undergone excision of the aortic coartation at the age of 19 was referred for surgical revascularization. At surgery, the LITA and RITA were excessively large in diameter, pulseless on palpation and heavily calcified. On transection, the lumen of the LITA was completely occluded along its entire length, and that of the RITA was virtually non-existent, permitting only a minimal flow of blood. Samples of the arteries were submitted for histopathological examination. The diameter of the LITA was 5 mm and that of the RITA 4 mm; the lumen of each artery was filled with yellow-grey material arranged in concentric rings. The microscopic appearances confirmed that the vessel lumina were occluded by atheromatous plaques showing dystrophic calcification. Once again, the authors advised against the use of ITA in this context.

Analogously, Castaño et al. [6] reported, in 1998, a 63-year old man with severe aortic stenosis and isolated LAD disease, who had previously undergone aortic coarctation repair. Since at preoperative angiogram, no evidence of LITA patency was found, the RITA was considered for CABG. However, after dissection, the artery appeared grossly diseased with an extensively atherosclerotic process, diffuse calcifications and poor distal flow. The GSV was then used. A microscopical study of the ITA revealed atherosclerotic changes and calcified plaques.

The following year, Rózanski et al. [7] described a case of a simultaneous repair of aortic coarctation and CABG. The LITA was found to be unusually large in diameter, pulseless and heavily calcified, and not suitable for myocardial revascularization.

In 2004, Dunst et al. [8] described the case of a 79-year old woman scheduled for CABG who had undergone aortic coarctation repair 41 years earlier. Intraoperatively, the LITA was revealed to be tortuous with absent palpable pulse and was then discarded. Histological evaluation of the resected artery showed extensive stenosing atherosclerosis with prominent intimal fibrosis and calcification. Again, the authors attributed the massive atherosclerotic damage of the LITA to the long-term hypertension in the prestenotic circulation, caused by the delayed repair.

Finally, in 2011, Alvarez et al. [9] described a 69-year old man presenting with severe aortic coarctation and coronary artery disease. Preoperative computed tomography scan revealed severely dilated LITA and RITA. Intraoperative assessment confirmed the findings, leading to GSV grafting.

### Cases in which an internal thoracic artery graft was used

The first reported successful case of the use of an ITA for myocardial revascularization in a patient with aortic coarctation dates...
back to 1993, when Fernandez de La Caleya et al. [10] described a simultaneous repair of coarctation and CABG in a 58-year old patient. At operation, the LITA appeared hypertrophied, but atheroma free, and was therefore used to perform sequential grafts. The postoperative course was uneventful.

In 2000, Yiu et al. [11] reported the second successful case: a 55-year old woman presented with a severe three-vessel disease and a previously undiagnosed coarctation of the aorta. A two-stage, hybrid procedure was carried out: aortic coarctation was first treated by a percutaneously implanted self-expanding stent; 1 month later, the patient underwent an elective coronary artery operation. The pedicled LITA was large, atheroma free, had excellent flow and was used to graft the LAD. The patient made an uneventful postoperative recovery, although no direct evidence of patent LITA-LAD graft was provided by the author.

Similarly, in 2005, Kühn et al. [12] reported the case of a 64-year old man suffering from aortic coarctation, aneurysm of the ascending aorta, bicuspid aortic valve and ischaemic heart disease (stenosis of the LAD and circumflex artery). The patient underwent a single-stage procedure through a median sternotomy, which included mechanical valve replacement, creation of a supracoronary ascending graft and extra-anatomical ascending-descending bypass and CABG, with a T-graft between the LITA and the radial artery. Although the authors do not describe the status of the LITA, it must have been normal and suitable for revascularization.

In the same year, Bedi and Singh [13] treated a 41-year old aortic coarctation patient in whom the LITA was found to be pliable and free of calcification, although dilated and with highly augmented flow (not directly measured). A successful off-pump pedicled LITA-LAD anastomosis was performed. Histopathology of the distal part of the LITA did not show any feature of atherosclerosis.

Yilmaz et al. [14] subsequently reported a small series of 4 patients simultaneously treated for aortic coarctation and additional cardiovascular pathologies. Two of them had coronary artery disease. Both patients underwent simultaneous repair of coarctation and CABG. In 1 patient, the LITA was used, while in the other it was found to be unsuitable and discarded.

More recently, Darwazah et al. [15] reported the case of a 41-year old man referred for myocardial revascularization who had undergone a successful repair of aortic coarctation 23 years earlier. At surgery, the LITA was found dilated (8 mm in diameter), with excellent flow and no evidence of calcification along the artery, so that it was used to graft the LAD. On postoperative day 5, the patient complained of sudden left-sided burning chest pain associated with new electrocardiographic changes. Cardiac catheterization showed total occlusion of the LITA in its distal third, without any flow to the LAD. At reoperation, LITA was opened distally, and a thrombus was found and extracted. GSV was used to graft the LAD distal to the LITA anastomosis. Histopathological examination of the LITA showed moderate atherosclerotic disease with dilatation of 6 mm in the distal main artery and 3 mm of the terminal branch.

The authors speculated on the possible cause of the occlusion, which was not clear, but could be explained by the poor distal run off of the LAD, the postoperative use of fresh frozen plasma and platelets, and by the great size mismatch between the huge LITA and the small LAD. The authors concluded that, in patients with aortic coarctation, ITAs should not be used for myocardial revascularization, even in the presence of moderate disease with excellent blood flow, as they are liable to undergo early occlusion.

### Table 2: Histological findings

<table>
<thead>
<tr>
<th>Author, year</th>
<th>LITA used?</th>
<th>Histological findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chen, 1995</td>
<td>No</td>
<td>Severely calcified plaque along the entire length. Extracellular lipid deposits within the intima, surrounded by a hyalinized zone containing myofibroblasts and mononuclear cells.</td>
</tr>
<tr>
<td>De Salazar, 1996</td>
<td>No</td>
<td>Extracellular lipid deposits with calcification and fibrosis of the intimal and media layers</td>
</tr>
<tr>
<td>Diligee, 1998</td>
<td>No</td>
<td>Atheromatous plaques showing dystrophic calcification</td>
</tr>
<tr>
<td>Castaño, 1998</td>
<td>No</td>
<td>Atherosclerotic changes and calcified plaques</td>
</tr>
<tr>
<td>Dunst, 2004</td>
<td>No</td>
<td>Extensive stenosing atherosclerosis with prominent intimal fibrosis and calcification</td>
</tr>
<tr>
<td>Bedi, 2005</td>
<td>Yes</td>
<td>No features of atherosclerosis</td>
</tr>
<tr>
<td>Darwazah, 2008</td>
<td>Yes</td>
<td>Moderate atherosclerotic disease with dilatation of 6 mm in the distal main artery and 3 mm of the terminal branch</td>
</tr>
</tbody>
</table>

LITA: left internal thoracic artery.

### Comment

A limited number of reports concerning CABG and aortic coarctation repair are described in literature [3–15]. In most cases, ITAs were not used due to severe atherosclerosis [3–9]. Six patients are reported in whom the LITA was used [10–15]; in five of them myocardial revascularization was successful, whereas in one (the only CABG performed after, and not in concomitance with, aortic coarctation repair), the distal third of the arterial graft occluded early, leading the authors to advise against the use of internal thoracic arteries, even in the presence of a good flow [15].

In the light of the reviewed literature, we believe that a history of previous repair of aortic coarctation does not necessarily rule out the possibility of grafting the coronaries by using the ITA, and that the benefits of ITA grafting should not be denied a priori to these patients. A careful evaluation of the conduits is obviously paramount in this context; to such an aim, preoperative transthoracic colour Doppler ultrasound and selective LIMA and RIMA catheterization at the time of the coronary angiogram may add useful information and allow an optimal preoperative planning.

Conflict of interest: none declared.
REFERENCES


