Effect of target artery location and severity of stenosis on mid-term patency of aorta-anastomosed vs. internal thoracic artery-anastomosed radial artery grafts

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Abstract

Objective: To verify the effect of location and severity of stenosis of the target coronary artery (TCA) on mid-term patency of aorta-anastomosed vs. internal thoracic artery (ITA)-anastomosed radial artery (RA) graft. Methods: During a 3-year period 228 consecutive patients received an RA graft at our institution. In 131 cases the RA was anastomosed to the aorta whereas in 97 the proximal anastomosis was performed on a mammary graft. The two groups were comparable in terms of preoperative variables and TCA characteristics. At a mean follow-up of 6.5 years 128 cases of the aorta-anastomosed and 95 of the mammary-anastomosed group were submitted to control angiography. Results: Mid-term patency and perfect patency rates were 92.1 and 89.8% (118/128 and 115/128) for aorta-anastomosed RA vs. 86.3 and 84.2% for mammary-anastomosed grafts (82/95 and 80/95; \( P = 0.81 \) and 0.82). The location of TCA did not influence graft patency in the two groups. The severity of the TCA stenosis strongly influenced graft patency in both groups but the threshold for failure was clearly higher in the mammary-anastomosed group. Conclusions: ITA-anastomosed RA grafts are more vulnerable to the detrimental effect of chronic native competitive flow and should be used only for target vessel with subocclusive stenosis. The location of the distal anastomosis does not influence long-term RA patency.

Keywords: Radial artery; Coronary artery bypass; Flow competition

1. Introduction

Following the recent publication of the long-term angiographic results and the excellent patency rates testified by several groups of investigators, radial artery (RA) has gained an established place as a complementary arterial conduit for myocardial revascularization [1–3].

Since the early days of its reintroduction in coronary surgery, two different technical solutions for the performance of the proximal RA anastomosis have been proposed, viz. direct attachment to the ascending aorta and connection to an internal thoracic artery (ITA) graft (in a so-called Y or composite configuration) [4,5]. Despite theoretical arguments in favor of one or the other solution, to date no differences in the angiographic patency of these two types of graft have been clearly proven, and uncertainty still exists regarding the best surgical solution.

The present investigation was undertaken to compare the long-term angiographic patency and the susceptibility to chronic competitive coronary flow and location of the target vessel of these two types of RA graft configuration.

2. Patients and methods

2.1. Patients population

Since January 1993 the RA has been adopted as a complementary arterial conduit for CABG in our institution.
as a part of a large prospective investigation [1,3,6–10]. For institutional policy during the first 2 years of our experience the artery was mainly anastomosed to the ascending aorta and less frequently used a composite conduit. The 228 patients involved in this investigation represent those cases consecutively operated during a 3-year period (January 1995–January 1998) during which both modalities of proximal anastomosis (aorta and ITA) were used, depending on the operating surgeon’s preference. In 131 of those patients the RA was anastomosed to the aorta, whereas in 97 cases the proximal anastomosis was performed on an ITA graft. Of late, no difference in the adoption rate of composite grafts was noted between the operating surgeons.

2.2. Surgical technique

The RA was always harvested by the non-dominant arm; bilateral RA harvesting was never performed. Details of the surgical technique used for harvesting have been described in detail elsewhere [6]. In all cases before RA harvesting adequacy of ulnar compensation was assessed using a described Doppler method [7].

All the operations were performed by the same surgical team using cardiopulmonary bypass and cardioplegic arrest. The left internal thoracic artery (LITA) was usually used to graft the left anterior descending artery (LAD), while the RA was grafted to secondary target vessels (mainly obtuse marginal or posterior descending branches). No RA sequential grafts were performed. Great saphenous vein (GSV) grafts usually completed myocardial revascularization, whereas the right ITA and the gastroepiploic artery were used in a minority of cases.

The composite Y graft was performed according to the standard technique [5]. T-grafts were never used in the present series.

A chronic calcium channel blockers therapy using 120 mg of diltiazem per day was prescribed to all patients for the first postoperative year and prosecuted to a different extent as specified in detail in previous publications [10].

2.3. Follow-up and angiographic control

Each patient was followed up regularly at our institution 6 months after surgery and every year thereafter. At each time interval clinical examination was performed and the results of surface electrocardiography, stress 201-Tl myocardial scintigraphy, 24-h Holter monitoring and transthoracic echocardiography were carefully reviewed.

Angiographic control was proposed for all patients at any time in case of scintigraphic evidence of inducible ischemia, at early and mid-term follow-up and for the purpose of the present study. As at that time three patients had died (all from non-cardiac causes) and two refused all control angiographies, the overall number of patients restudied was 223 (128 in the aorta-anastomosed group vs. 95 in the composite grafts series).

Angiographic studies were performed via femoral approach; all grafts and the native coronary arteries were selectively cannulated and visualized and left ventriculography was performed.

Following a methodology previously validated by our group [1,3] at angiography RA grafts were classified into four subgroups: (1) perfectly patent; (2) patent with irregularity; (3) stringed; and (4) occluded.

2.4. Statistical analysis

Data are expressed as mean ± SD. Statistical analysis was performed with unpaired two-tailed t testing for the means or χ²-test for categorical variables.

Analysis was conducted by the software Statistica for Windows 4.1, Statsoft Inc. 1993.

3. Results

The main pre-, intra- and postoperative characteristics of the two groups of patients were comparable (see Tables 1–3).

At a mean follow-up time of 6.5 ± 1.8 years 28 of the 228 cases had clinical or scintigraphic evidence of ischemia recurrence (16 from the aorta-anastomosed group); in 14 of these cases (7 for each group) ischemia was at least in part related to RA graft malfunction.

At this follow-up time the angiographic results of aorta-anastomosed vs. mammary anastomosed grafts did not differ: as outlined in Table 4 patency and perfect patency rates were 92.1 and 89.8% (118/128 and 115/128) for aorta-anastomosed RA vs. 86.3 and 84.2% for ITA-anastomosed grafts (82/95 and 80/95, P = 0.81 and 0.82). Composite conduits had a higher incidence of string sign

Table 1

<table>
<thead>
<tr>
<th>Preoperative characteristics of the patients</th>
<th>Aorta-anastomosed group (n = 131)</th>
<th>ITA-anastomosed group (n = 97)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male/female</td>
<td>82/49</td>
<td>65/32</td>
<td>0.58</td>
</tr>
<tr>
<td>Mean age</td>
<td>60.5 ± 8.1</td>
<td>61.8 ± 9.1</td>
<td>0.25</td>
</tr>
<tr>
<td>Cardiac risk factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>15</td>
<td>11</td>
<td>0.85</td>
</tr>
<tr>
<td>Smoking</td>
<td>55</td>
<td>41</td>
<td>0.92</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>41</td>
<td>35</td>
<td>0.65</td>
</tr>
<tr>
<td>Hypertension</td>
<td>35</td>
<td>29</td>
<td>0.80</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>56</td>
<td>51</td>
<td>0.44</td>
</tr>
<tr>
<td>Number of diseased vessels</td>
<td>2.90 ± 0.51</td>
<td>2.88 ± 0.41</td>
<td>0.75</td>
</tr>
<tr>
<td>Mean ejection fraction</td>
<td>0.60 ± 0.15</td>
<td>0.59 ± 0.11</td>
<td>0.57</td>
</tr>
<tr>
<td>Anastomoses per patient</td>
<td>3.1</td>
<td>3.0</td>
<td>0.13</td>
</tr>
</tbody>
</table>
Although this difference did not reach statistical significance ($P = 0.27$).

Similarly, the location of the target vessel did not influence RA graft patency in the two groups (see Table 5).

As described in Table 6 the strong inverse relation between the severity of the target vessel stenosis and the RA angiographic status was confirmed by our data: 17 of the 28 cases of graft failures (60.7%) were reported when the artery was anastomosed to coronary vessels with $>70\%$ stenosis, without significant differences between the two types of graft configuration (10/30 $= 33.3\%$ in the aorta- and $7/21 = 33.3\%$ in the ITA-anastomosed series, $P = 0.77$). However, the target vessel stenosis threshold for RA graft failure was clearly higher in the mammary-anastomosed group (see Fig. 1): in coronary branches with $70–90\%$ stenosis the incidence of graft failure dropped to 2.4% (1/41) in the group of patients with aorta-anastomosed graft but remained as high as 25% (8/32) in the Y graft series ($P = 0.02$).

No difference was found in the RA failure rate according to the site of the proximal anastomosis when the conduit was anastomosed to vessels with subocclusive ($>90\%$) stenosis (2/57 aorta, 0/42 LITA, $P = 0.63$).

### 4. Discussion

Since its reintroduction in coronary artery surgery, the site of proximal anastomosis of the RA has been controversial. Although most surgeons continued to anastomose the artery to the ascending aorta as was done in the 1970s and for all other free conduits, some authors expressed the fear that the sharp $\Delta P/\Delta t$ typical of the hemodynamics of the ascending aorta could lead to accelerated intimal hyperplasia and consequent graft malfunction and failure [5]. The great versatility, excess length and the possibility of performing sequential and more distal anastomosis are further theoretical advantages claimed by those who sustain the superiority of the Y-shaped configuration [11].

On the other hand, two potential drawbacks of composite grafts must be balanced against these advantages: conduit-to-conduit anastomosis are more demanding and therefore have a greater failure rate than aortic anastomosis; this could result in failure of one or both conduits. Moreover, the inflow conduit must provide more flow which, if it cannot, could result in hypoperfusion.

To date no objective comparison between the angiographic results and patency rates of the aorta-anastomosed vs. LITA-anastomosed RA grafts has been published.

Our report demonstrates that in a large patient population of 223 cases at a mean follow-up of 6.5 years the angiographic results of aorta- and LITA-anastomosed RA grafts do not differ in terms of patency and perfect patency rate, but composite grafts have a higher incidence of string
sign (this difference does not reach statistical significance, probably due to small overall number of events).

Although some authors have reported a reduced patency rate when the RA is anastomosed to the postero-lateral or posterior descending branches [12], in our series the location of distal anastomoses did not influence long-term angiographic results and conduits used for diagonal or marginal branches had a patency similar to that of grafts directed to posterior and postero-lateral target vessels. This finding was independent of the site of the proximal anastomosis.

As already described [1,3] the only factor that clearly influenced RA patency was the severity of the stenosis of the target coronary vessel. All RA failures in fact occurred when the conduit revascularized vessels with non-occlusive stenosis (see Table 6).

However, this strong inverse relationship between severity of the stenosis of the revascularized vessel and patency seemed to be more important and tight for composite RA conduits. In fact, the patency rate of aorta-anastomosed conduits was jeopardized when the target vessel stenosis was <70%, but almost normalized when the native stenosis exceeded this limit (see Table 6 and Fig. 1). In contrast, composite RA grafts exhibited sub-optimal patency for a wider range of target vessel stenosis and their patency rate substantially increased only for more severe degrees of coronary obstruction (Table 6; Fig. 1).

It seems then that when RA grafts are proximally anastomosed to the ascending aorta they become more vulnerable to the detrimental effect of chronic native competitive flow and then tend to have a higher incidence of string sign.

This finding has not been reported by those series who compared single and Y-shaped ITAs [13]; however the hemodynamic of single ITA grafts is substantially different from that of aorta-anastomosed RA conduits, and most of all, the reactivity and dependence from native flow of the ITA are substantially different from those of the RA, so that applicability of the results of these investigations to the present setting seems to be of little scientific value.

The main limitation of this study is its non-randomized nature; although the comparison of two contemporaneous series of cases assigned to one or another treatment modality according to the surgical judgment is by far less rigorous than a prospective randomized series, the large number of patients restudied by angiography and the completeness of the angiographic follow-up are strong points in favor of the reliability of our observations.

In conclusion, ITA-anastomosed RA grafts seem to be more vulnerable to the detrimental effect of chronic native competitive flow than aorta-anastomosed conduits; Y grafts should then probably be reserved to target vessel with subocclusive stenosis.

In contrast, the location of the distal anastomosis do not influence long-term RA patency, whatever graft configuration is used.

Table 6

<table>
<thead>
<tr>
<th>Severity of target coronary artery stenosis (%)</th>
<th>Aorta-anastomosed group</th>
<th>ITA-anastomosed group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;70</td>
<td>10/30</td>
<td>7/21</td>
<td>0.77</td>
</tr>
<tr>
<td>70–90</td>
<td>1/41</td>
<td>8/32</td>
<td>0.02</td>
</tr>
<tr>
<td>&gt;90</td>
<td>2/57</td>
<td>0/42</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Fig. 1. Mid-term patency rate of radial artery grafts in relation to the site of proximal anastomosis and the severity of target vessel stenosis.
References


Appendix A. Conference discussion

Dr R. Poston (Baltimore, MD, USA): Because this wasn’t a randomized trial, another possible explanation of your findings is that the radial to the mammary proximal anastomosis was performed in those with more severe aortic atherosclerosis; patients indicated for a “no-touch” technique. These types of patients would be expected to have more severe distal coronary disease and increased graft failure rates due to poor runoff. A way to have accounted for this issue would be to measure intraoperative flow, and even more elegantly, to have measured graft flow before and after native artery occlusion to confirm the flow competition that you are implicating. Did any of the surgeons in your group do that?

Dr Gaudino: At the time of that study intraoperative flow measurement was not so common, so we have no data on intraoperative flow. However, you must consider that for institutional policy, patients enrolled for our radial artery trial were in general healthy patients and aortic atherosclerosis was very rare. It is obvious that a randomized trial would be more rigorous on this issue. But it is interesting to note that Y grafts also had a higher incidence of string sign. So it seems that this type of graft configuration is more subject to the effect of competitive flow. In fact, the conduit tends to be more exposed to the effect of chronic atherosclerosis.

Dr E. Berrekleuw (Eindhoven, The Netherlands): I must disagree with your conclusions. Actually you showed quite nicely that in a competitive situation with stenosis of less than 70 degrees there is no significant difference between both groups. So you only showed that in a very small subset of patients with a stenosis of 70 to 90% stenosis in a group of 73 patients there are some differences. But you have to consider that that is a very small subset of patients and a small sample size.

Dr Gaudino: Well, you know the fact is that we all know that at very low degree of stenosis, less than 70%, the radial artery is a bad conduit, and it is whatever type of proximal anastomosis you use. The difference is in the subset of patients in whom the stenosis is mild to severe: in those patients if you put the radial artery on the aorta, you have better results. If you put it on the mammary artery, probably due to a rheological factor, the conduit tends to be more exposed to the effect of chronic competitive flow.

I think that the two groups that you mentioned can be considered together, and in this regard the numbers are not so small. It is obvious that a larger trial would give us more data, but for the moment these are the data that we have.