Atherosclerotic involvement of the radial artery in patients with coronary artery disease and its relation with midterm radial artery graft patency and endothelial function

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Background: The radial artery has recently been proposed as an alternative arterial conduit for surgical myocardial revascularization. This study was conceived to evaluate the degree of atherosclerotic involvement of the radial artery in patients with coronary artery disease and the eventual influence of a subtle degree of preoperative atherosclerosis on the midterm results of radial artery grafts.

Methods and Results: The intima-media thickness of the radial artery, common carotid artery, and internal thoracic artery was evaluated in 42 coronary artery disease patients and in 26 control patients. All radial arteries were then used for myocardial revascularization; 30 patients submitted to control angiography after 5 years. The mean intima-media thickness was 0.92 ± 0.22 mm for the common carotid artery, 0.54 ± 0.16 mm for the internal thoracic artery, 0.55 ± 0.11 mm for the radial artery in coronary artery disease patients versus 0.79 ± 0.14 mm, 0.52 ± 0.11 mm, and 0.56 ± 0.09 mm, respectively, in control patients ($P = .001$ only for the common carotid artery). No correlation was found between the intima-media thickness of the carotid, internal thoracic, and radial artery. No correlation was found between the preoperative intima-media thickness of the radial artery and the midterm patency and endothelial-mediated vasodilating capacity of radial artery grafts.

Conclusion: In coronary artery disease patients, radial artery atherosclerotic involvement is more frequent than that of the gold standard internal thoracic artery but still by far less severe than that of the common carotid artery. The early atherosclerotic signs often observed in the radial artery do not seem to have the potential to influence radial artery graft patency and endothelial function.

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After the reports of excellent early and midterm clinical and angiographic results, the radial artery (RA) has gained widespread diffusion as alternative arterial conduits for coronary artery bypass procedures.¹⁻³

However, few series have investigated the degree of atherosclerotic involvement of the RA in patients with surgical coronary artery disease (CAD), and some histopathological data suggest a not negligible incidence of early atherosclerosis.^{4,5}

This prospective study was conceived to evaluate the degree of atherosclerotic involvement of the in situ RA and to verify the possible influence of eventual atherosclerotic lesions on the midterm patency of RA grafts.

TABLE 1. Clinical characteristics of the 2 cohorts of patients

Variable	Controls (n = 26)	CAD patients (n = 42)	P value
Male/female gender	16/10	25/17	.92
Age	59.5 ± 14.2	65.5 ± 7.2	.12
Fibrinogen (mg/dL)	309.6 ± 114.0	344.4 ± 80.6	.14
Smokers	12	21	.95
Diabetes	4	18	.004
Hypertension	12	25	.40
Dyslipemia	2	22	<.001
Previous myocardial infarction	0	28	<.001

CAD, Coronary artery disease.

For this purpose the intima-media thickness (a well known early marker of atherosclerosis) of the in situ RA was measured echographically in patients with CAD and in control patients, and the midterm angiographic results of the same RA used as coronary artery bypass grafts were evaluated in relation to the preoperative atherosclerotic involvement of the artery.

Methods

Patient Population

The study population consisted of 42 patients with angiographically documented triple-vessel CAD referred for surgical myocardial revascularization at our institution from January 1996 to December 1997 and of 26 control patients who were hospitalized during the same period for either atrial septal defect (17 patients) or atrial myxoma (9 patients) and in whom coronary angiography denied the presence of CAD.

As part of the routine preoperative examination all patients underwent carotid echo-Doppler assessment following a previously described methodology⁶; carotid disease of any degree of severity was excluded.

The main clinical characteristics of the 2 cohorts of patients are summarized in Table 1. The 2 groups were comparable, although CAD patients had a superior prevalence of dyslipemia, diabetes, and previous myocardial infarction.

Echographic Measurements

Preoperatively common carotid artery (CCA), internal thoracic artery (ITA), and RA ultrasound imaging were carried out with Acuson 128 XP10 ART echo color Doppler (Simens, Munich, Germany), by means of a 7-MHz linear probe with 40-mm opening. All the arteries were scanned longitudinally.

The diameter and intima-media thickness (IMT) of both common carotid arteries were evaluated 5 mm proximal to the bifurcation. ITAs were evaluated in the third intercostal space at the level of the parasternal line. Radial arteries were evaluated at the level of the interior third of the wrist (approximately 3 cm proximal to the crease of the wrist). All echographic measurements were performed at the selected points only in case of absence of disease; in case of presence of atherosclerosis or intimal thickening, measurements were performed in the most diseased segment.

TABLE 2. Intima-media thickness and diameter of the studied arteries in the 2 cohorts of patients

	Controls	CAD patients	P
Right			
Common carotid artery	0.79 ± 0.14	0.92 ± 0.22	.001
IMT			
Common carotid artery diameter	6.52 ± 1.56	6.55 ± 1.15	.92
Internal thoracic artery	0.52 ± 0.11	0.54 ± 0.16	.57
IMT			
Internal thoracic artery diameter	1.98 ± 0.35	2.04 ± 0.47	.57
Radial artery IMT	0.56 ± 0.09	0.55 ± 0.11	.69
Radial artery diameter	1.89 ± 0.25	1.93 ± 0.56	.73
Left			
Common carotid artery	0.78 ± 0.13	0.95 ± 0.25	.002
IMT			
Common carotid artery diameter	6.42 ± 1.46	6.67 ± 1.17	.43
Internal thoracic artery	0.51 ± 0.10	0.57 ± 0.17	.10
IMT			
Internal thoracic artery diameter	1.95 ± 0.39	2.05 ± 0.43	.33
Radial artery IMT	0.55 ± 0.10	0.56 ± 0.12	.72
Radial artery diameter	1.91 ± 0.29	1.99 ± 0.58	.51

CAD, Coronary artery disease; IMT, intima-media thickness.

Measurements were performed; the diameter and intima-media thickness of both common carotid arteries were evaluated 5 mm proximal to the bifurcation. Internal thoracic arteries were evaluated in the third intercostal space at the level of the parasternal line. Radial arteries were evaluated at the level of the interior third of the wrist, approximately 3 cm proximal to the crease of the wrist.

The internal diameter of the vessels was evaluated using echographic image magnification and measuring the intima-intima distance in telediastole.

The IMT was measured in the far wall of the artery in telediastole (in concomitance with the R wave of the electrocardiogram), measuring the distance between the first echogenic border line (transition vascular lumen-intimal region) and the second echogenic border line (medial-advential region).

The use of the echo/ultrasound technique in evaluating the specific characteristics of the vascular wall, with particular regard to the ITA and the RA, has been described and validated by others.¹⁻⁴

Surgical Technique

As detailed elsewhere,⁵ decision about RA suitability for coronary artery bypass grafting is usually taken in the operating room during surgical harvesting; patients with moderate to severe atherosclerotic involvement or diffuse calcification are excluded. In this series the examined RAs were found to be free from significant atherosclerosis or calcification and were used as coronary artery bypass conduit for surgical myocardial revascularization in all CAD patients. Target RA vessels were the right coronary artery in 19 patients, the obtuse marginal branch in 14, and the diagonal in 9.

TABLE 3. Correlation between the intima-media thickness of the studied arteries

	<i>R</i>	<i>P</i>
CAD patients		
Common carotid IMT and internal thoracic artery IMT	.0055	.9800
Common carotid IMT and radial artery IMT	.4068	.0600
Internal thoracic artery IMT and radial artery IMT	.3407	.1200
Controls		
common carotid IMT and internal thoracic artery IMT	.5437	.0041
common carotid IMT and radial artery IMT	.1970	.3300
internal thoracic artery IMT and radial artery IMT	.2706	.1800

CAD, Coronary artery disease; IMT, intima-media thickness.

TABLE 4. Results of the midterm angiographic control in 30 patients

	Internal thoracic artery	Radial artery
Perfectly patent	30	28
Patent with irregularities	0	0
String	0	1
Occluded	0	1

Angiographic Follow-up

At a mean interval of 61 ± 7 months from surgery 30 of the 42 CAD patients submitted to angiographic control; none of the remaining patients died or had angina recurrence. During the procedure the RA response to endovascular acetylcholine infusion was also evaluated following a previously described method⁶ to assess midterm RA endothelial function.

Statistical Analysis

Data are presented as mean $\pm$ standard deviation. Comparison between groups were performed by chi-square test for nonparametric data; for parametric data *t* test and Wilcoxon test were performed on the basis of their distribution. The correlation of variables was done using the Pearson coefficient. All analyses were done by using Intercooled Stata 6.0 for Windows (Statistics/Data Analysis, Stata Corporation, College Station, Tex). Statistical significance was established at $P < .05$.

Results

The main echographic results of the preoperative evaluation are summarized in Table 2.

The mean IMTs of the common carotid arteries were significantly higher among CAD patients, whereas no difference between CAD patients and controls was found with regard to the IMTs of the internal thoracic and radial arteries.

Figure 1. Midterm radial artery graft status in relation to preoperative intima-media thickness. IMT, intima-media thickness. Statistical analysis revealed a lack of difference between the 3 groups; IMT < 0.40 = 12 patients; IMT > 0.40 < 0.60 = 11 patients; IMT > 0.60 = 7 patients.

No difference in luminal diameter was found between the 2 groups for all examined arteries.

No correlation was found between the IMT of the CCA, ITA, and RA, although CAD patients showed a trend toward significance with regard to the correlation between the IMTs of the carotid and radial arteries (see Table 3).

Results of the midterm angiographic control performed in 30 CAD patients are summarized in Table 4. Briefly, 28 of the 30 RA grafts were perfectly patent, 1 was stringed, and 1 was occluded, whereas all ITA grafts were widely patent.

No correlation was found between the preoperative IMT of the RA and the midterm RA graft patency (see Figure 1). Similarly, no correlation was found between the preoperative IMT of the RA and the midterm endothelial-mediated vasodilating capacity of RA grafts (see Table 5).

Discussion

In recent years the RA has gained increased popularity as a coronary artery bypass conduit. Several groups have reported excellent clinical and angiographic results using this artery for surgical myocardial revascularization, and the midterm angiographic outcome has been proven to be excellent.^{5,7-8}

However, the RA has a peculiar histological and vasoactive profile,^{9,10} and only scant information is available on the degree of its atherosclerotic involvement in patients affected by CAD.

Different investigators have evaluated the histopathological aspects of distal samples of RA harvested from coronary artery bypass patients and reported evidence of initial atherosclerosis at least in some specimens¹⁰⁻¹² (although these studies were limited by the fact that the authors

TABLE 5. Long-term radial artery diameter changes following endovascular acetylcholine infusion in relation to the preoperative intima-media thickness

	IMT < 0.40 mm	IMT > 0.40 < 0.60 mm	IMT > 0.60 mm
Baseline	2.72 ± 0.18 mm	2.67 ± 0.12 mm	2.65 ± 0.14 mm
Acetylcholine	2.94 ± 0.32 mm*	2.91 ± 0.27 mm*	2.92 ± 0.31 mm*

IMT, Intima-media thickness. Statistical analysis revealed lack of difference between the 3 groups.

* $P < .05$ compared to baseline.

analyzed only the segment of the vessel that remained after conduit utilization for coronary artery bypass graft).

Other investigators using ultrasound evaluation reported low overall incidence of overt atherosclerosis in the RA but found signs of early atherosclerotic involvement in a not negligible portion of patients¹⁻³; however no direct comparison with other conduits was performed in these series, and the eventual influence of this early atherosclerosis on RA graft patency could not be established.

In the present series we preoperatively evaluated the echographic IMT of the CCAs, ITAs, and RAs in 42 patients with CAD and in 26 control patients and correlated the preoperative IMT with the midterm outcome of RA grafts. The IMT of the CCA was significantly higher in the study patients (reflecting the more severe atherosclerotic involvement in these patients) but the IMT of both the ITA and the RA was not influenced by the presence of coronary artery pathology (see Table 2). CAD patients showed a trend toward significance with regard to the correlation between the IMT of the carotid and radial (but not internal thoracic) arteries, testifying to the well-known intrinsic resistance to atherosclerosis of the gold standard conduit⁴ and, probably, an initial degree of pathology in the RA.

However, midterm angiographic control demonstrated that this early atherosclerosis had no effect on midterm RA graft patency and endothelial-mediated vasodilating capacity.

Although one could speculate that atherosclerosis does not have a significant effect on saphenous vein grafts until 5 years after coronary artery bypass and, thus, that it is conceivably possible that, similarly, disease will develop in the examined RA grafts only after the midterm angiography, we have demonstrated that all RA grafts that are perfectly patent 5 years after surgery remain perfect at 10 years (unpublished data) and the absolute lack of correlation between preoperative IMT and midterm RA angiographic status renders this hypothesis at least unlikely.

In addition, it must be acknowledged that due to the number of patients studied, a type II statistical error cannot be excluded with certainty. However, as significant P values were detected between some of the studied variables, the

eventual undetected differences (if present) are extremely likely to be minimal and with limited clinical implications.

In conclusion it seems that in patients with surgical CAD the RA atherosclerotic involvement is more frequent than that of the gold standard ITA, but still by far less severe than of the CCA. In any case the early atherosclerotic signs often observed in the RA using subtle histopathological or echographic methods do not seem to have the potential to influence RA graft patency and endothelial function in the years after surgery.

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