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Optimal Treatment of Nonaorto Ostial Coronary Lesions in Large Vessels: Acute and Long-Term Results

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Percutaneous interventions of nonaorto ostial coronary lesions are usually complex, often requiring a combined approach of debulking and stenting, insertion of multiple guidewires and long procedure duration. Debulking with atherectomy device preserves side-branch patency by reducing plaque shift while coronary stenting minimizes vessel recoil and restenosis. We retrospectively evaluated the acute and long-term results of rotational atherectomy (group R, n = 94), coronary stenting (group S, n = 39), and combination of rotational atherectomy and stenting (group R-S, n = 59) in a total of 192 patients with nonaorto ostial lesions. The number of patients with diabetes mellitus and rest angina was significantly higher in groups S and R-S. Clinical success rates were high and procedural complication rates were low and comparable in all three groups. Despite the similar reference vessel size and preprocedure minimal lumen diameter (MLD), postprocedure MLD showed a trend toward larger lumen in groups S (3.15 ± 0.18 mm) and R-S (3.21 ± 0.16 mm). Group S had significantly higher incidence of side-branch narrowing (30.7%), requiring intervention (15.4%). At long-term follow-up (mean of 9 ± 4 months), target lesion revascularization rate was significantly lower in groups R-S (11.9%) and S (15.4%) compared to group R (28.9%; *P* = 0.02). Our nonrandomized data suggest that stenting with or without rotational atherectomy provides the best long-term approach for the interventional treatment of nonaorto ostial coronary lesions. The clinical benefit and cost effectiveness of performing rotational atherectomy before stent implantation to reduce the incidence of side-branch closure requires further study. *Cathet Cardiovasc Intervent 2001;54:283–288.* © 2001 Wiley-Liss, Inc.

Key words: nonaorto ostial lesion; rotational atherectomy; stenting; restenosis

INTRODUCTION

Coronary interventions of ostial lesions remain a challenging task with a high rate of procedural complications and restenosis. Coronary interventions of nonaorto ostial lesions may have a slightly favorable outcome when compared to aorto ostial lesions [1] due to their location and less likelihood of vessel calcification. However, nonaorto ostial lesions tend to be more angulated and compromise of the side branch or the parent vessel can increase the complexity and complication rate of the procedure. The lack of efficacy of conventional balloon angioplasty in nonaorto ostial coronary intervention has been attributed to the high incidence of vessel recoil, resulting in suboptimal residual stenosis [2]. This in turn leads to a higher restenosis rate as documented in the literature [3]. Coronary stenting is effective in minimizing recoil and reducing restenosis, but is associated with a higher risk of side-branch compromise and resultant non–Q-wave myocardial infarction [4]. Side-branch compromise is likely to be due to plaque shifting. The use of rotational atherectomy for debulking is effective, but does not address the issue of vessel recoil and restenosis [5,6]. There has been no randomized trial to address the efficacy of the various treatment strategies for nonaorto ostial lesions, such as rotational atherectomy alone, coronary stenting alone, or the combination of both [3,6,7]. This retrospective study summarizes our experience with the use of rotational atherectomy, coronary stenting, and the combination of both rotational atherectomy and stenting for the treatment of nonaorto ostial coronary lesions in large vessels.

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MATERIALS AND METHODS

Patients

From January 1997 to September 1998, data from 192 patients undergoing percutaneous coronary intervention (selected from a total cohort of 1,765 patients) of single de novo nonaorto ostial lesions were included in the study. Criteria for inclusion were coronary vessel diameter of > 3.0 mm, lesion length < 15 mm, and diameter stenosis $\geq 60\%$. During the study period, patients with the following conditions or lesion types were excluded: cardiogenic shock ($n = 8$), acute myocardial infarction less than 72 hr ($n = 22$), bifurcation lesions or side-branch stenosis $> 50\%$ ($n = 58$), lesions involving vein or arterial graft ($n = 15$), the use of other debulking devices ($n = 17$), and lost for follow-up ($n = 22$ as follows: 12 in R group, 2 in S group, and 8 in R-S group). A total of 192 consecutive nonaorto ostial lesions were analyzed with 94 lesions treated with rotational atherectomy and adjunctive balloon angioplasty (group R), 39 lesions treated with stent alone (group S), and 59 lesions treated with a combination of rotational atherectomy and stent implantation (group R-S). Baseline clinical, angiographic, and procedural characteristics as well as in-hospital course were obtained for all patients from the medical record and coronary intervention database. Following discharge, all patients were followed up by telephone contact at 1, 6, and 12 months for cardiac events and the need for target lesion revascularization.

Procedural Technique

All patients underwent percutaneous coronary intervention via the femoral artery and with weight-adjusted heparin dose of 50–70 units/kg to aim for an activated clotting time of 200–250 sec with abciximab use and 250–300 sec with no abciximab. Aspirin 325 mg was administered prior to procedure and continued indefinitely. Patients who received intracoronary stents received ticlopidine 500 mg during the procedure and 250 mg twice daily for 2 weeks postprocedure. Rotational atherectomy was performed in an optimal fashion using the Rotalink system (Boston Scientific Scimed, Minneapolis, MN) with a final target burr-to-artery ratio of approximately 0.70 [8]. Postdilatation with a semicompliant balloon with a balloon-to-artery ratio of 1:1 was performed and prior to any stent implantation. The Nir (Boston Scientific Scimed) and MultiLink Duet (Guidant, Santa Clara, CA) stents were utilized. The stent deployment technique was meticulous to ensure that the ostium of the vessel was covered and stent struts did not encroach the side branch. Postdilatation with a noncompliant balloon was undertaken if the stent appeared angiographically underexpanded. In cases of compromise of the side-branch lumen, the decision to intervene the side branch was left at the operator's discretion.

Quantitative Coronary Angiography

A single experienced observer (E.S.) who was unaware of the purpose and outcome of the study independently performed quantitative angiographic analysis on all angiograms. Analysis was performed using the CMS Medis system and the end-diastolic frame revealing the most severe lesions with the least amount of foreshortening and overlap was selected. The known-size guiding catheter tip was used as the calibration standard. Angiographic views were obtained after routine injection of 100–200 μg of intracoronary nitroglycerine. Reference vessel diameter, percent diameter stenosis, minimal luminal diameter (MLD) pre- and postintervention, and lesion length were measured.

Definitions

Nonaorto ostial lesion was defined as $\geq 60\%$ stenosis within 3 mm of ostium of a vessel not at the aortic origin. The lesion type was classified according to the standard American College of Cardiology/American Heart Association (ACC/AHA) criteria. Complex lesions were defined as lesions exhibiting overhanging edges or ulceration. Moderate vessel calcification was defined as densities noted only with cardiac motion prior to contrast injection and severe calcification as radiopacities noted without cardiac motion prior to contrast injection. Non–Q-wave myocardial infarction was defined as elevated creatine kinase-MB (CK-MB) above 3 times the upper limit of normal. Side-branch narrowing was defined as postprocedure $\geq 70\%$ diameter stenosis of the side branch. Side-branch intervention was defined as need for unplanned intervention of the side branch due to procedural complications such as chest pain, ECG changes, $<$ TIMI III flow. Angiographic success was defined as residual stenosis $\leq 30\%$ with at least Thrombolysis in Myocardial Infarction (TIMI) grade 2 flow in the distal vessel. Clinical success was defined as angiographic success in the absence of any major complications (death, Q-wave myocardial infarction, CK-MB elevation above 8 times upper limit of normal, and emergent coronary artery bypass surgery). Major adverse cardiac events (MACE) were defined as death, myocardial infarction, or urgent revascularization.

Statistical Analysis

All continuous variables are presented as mean $\pm$ SD and categorical variables expressed as percentages. The three groups were compared by chi-square analysis for the dichotomous variables and by ANOVA for continuous variables. A P value of < 0.05 was considered

TABLE I. Baseline Clinical Characteristics

Characteristics	Group R (n = 94)	Group S (n = 39)	Group R-S (n = 59)
Age (years)	68 ± 12	66 ± 8	69 ± 11
Male (%)	78	77	81
Stable/crescendo angina (%)	53.1[a]	20.5	39.0
Rest angina (%)	28.7	48.7[a]	35.6[a]
Postmyocardial infarction (%)	19.1	30.8[a]	25.4[a]
Hypertension (%)	50.0	48.7	52.5
Hypercholesterolemia (%)	53.2	53.8	54.2
Diabetes mellitus (%)	20.2	33.3[b]	35.6[b]
Left ventricular ejection fraction (%)	44 ± 12	48 ± 8	47 ± 11
Multivessel disease (%)	29.8	35.8	35.5
Abciximab use (%)	65.9	64.1	76.3

[a]$P < .001$.
[b]$P < 0.05$.

TABLE II. Angiographic Characteristics

Characteristics	Group R (n = 94)	Group S (n = 39)	Group R-S (n = 59)
Nonaorto ostial vessel involved			
Left anterior descending or diagonal branch (%)	60.6	56.4	61.0
Circumflex (%)	24.4	30.8	28.8
Right coronary artery (%)	15.0	12.8	10.2
ACC/AHA lesion			
B_2 (%)	71.2	89.7	76.3
C (%)	28.8[a]	10.3	23.7[a]
Lesion length (mm)	10.2 ± 2	9 ± 2	11 ± 2
Complex lesion (%)	26.6	33.3	25.4
Moderate to heavy calcification (%)	55.3[b]	15.4	54.2[b]

[a]$P < 0.05$.
[b]$P < 0.01$.

TABLE III. Procedural Characteristics

Characteristics	Group R (n = 94)	Group S (n = 39)	Group R-S (n = 59)
Mean number of burrs	2.1 ± 0.2		1.8 ± 0.2
Maximal mean burr size (mm)	2.1 ± 0.1		2.0 ± 0.1
Mean ablation duration (sec)	184 ± 72[a]		118 ± 42
Number of stents		1.1 ± 0.2	1.2 ± 0.1
Number of balloons	1.1 ± 0.2	1.6 ± 0.3	1.5 ± 0.2
Maximal balloon size (mm)	3.2 ± 0.2[b]	3.5 ± 0.2	3.5 ± 0.3
Maximal inflation pressure (atm)	4 ± 1[a]	15 ± 3	12 ± 2
Procedure duration (min)	48 ± 28	54 ± 12	54 ± 16

[a]$P < 0.01$.
[b]$P = 0.08$.

significant. Multiple regression analysis was performed for the independent predictors of target lesion revascularization.

RESULTS

Patient Characteristics

The mean age of the patients and the degree of male gender preponderance were similar in all groups (Table I). Stable angina was higher in group R, while rest angina and post-MI patients were significantly higher in groups S and R-S. The proportion of patients with hypertension and hypercholesterolemia were similar in all three groups, but the prevalence of diabetes mellitus was significantly higher in group S (33.3%) and group R-S (35.6%; $P < 0.05$ vs. group R). The mean left ventricular ejection fraction was similar in all groups. Abciximab was used in about 68% of patients and there was no significant difference in usage between the three groups.

Angiographic and Procedural Characteristics

The vessels intervened were similar in all groups (Table II). The ostial left anterior descending artery and ostial diagonal represented the major site of intervention in all three groups. The majority of lesions were ACC/AHA classification type B_2 but a higher proportion of type C and moderate to heavy calcification lesions were present in groups R and R-S ($P < 0.01$). The maximal balloon size and maximal inflation pressures were significantly lower in group R compared to groups S and R-S (Table III).

Angiographic Results

The reference vessel size and preprocedure MLD were similar between the three groups (Table IV). The final MLD was 2.91 ± 0.21 mm in group R, 3.15 ± 0.18 mm in group S, and 3.21 ± 0.16 mm in group R-S (P = 0.08).

Procedural Results

The angiographic and clinical success rates of 98.2% in group R, 97.4% in group S, and 98.3% in group R-S, along with the incidence of major complications, were not significantly different in all groups (Table V). One patient in group S developed subacute stent thrombosis and one patient in group R developed acute closure 6 hr after intervention, requiring reintervention. The incidence of side-branch narrowing and side-branch intervention was significantly higher in group S (30.7% and 15.4%, respectively; $P < 0.05$ compared to group R or R-S). The incidence of CK-MB elevation was comparable in the three groups, with insignificantly higher incidence of slow flow in group R.

Clinical Outcome and Long-Term Follow-Up

The 30-day MACE was 5.1% in group S, 2.1% in group R, and 1.7% in group R-S (Table VI; P = NS).

TABLE IV. Quantitative Coronary Analysis

Variable	Group R ($n = 94$)	Group S ($n = 39$)	Group R-S ($n = 59$)
Reference vessel diameter (mm)	3.12 ± 0.42[a]	3.27 ± 0.21	3.25 ± 0.18
Baseline % diameter stenosis	76 ± 14	72 ± 12	71 ± 16
Final % diameter stenosis	17 ± 7[a]	4 ± 3	1 ± 2
Minimal luminal diameter (mm)			
Baseline	0.84 ± 0.12	0.92 ± 0.21	0.92 ± 0.18
Postrotational atherectomy	1.94 ± 0.21		1.88 ± 0.18
Final	2.61 ± 0.21[a]	3.15 ± 0.18	3.21 ± 0.16

[a]$P = 0.08$.

TABLE V. Procedural Results*

Results	Group R ($n = 94$)	Group S ($n = 39$)	Group R-S ($n = 59$)
Clinical success (%)	98.2	97.4	98.3
Major complications (%)	1.1	2.6	0
Acute closure (%)	1.1	2.6	0
Side-branch narrowing (%)	13.8	30.7[a]	20.3
Side-branch intervention (%)	3.2	15.4[a]	6.8
Slow flow (%)	9.6	2.6	5.1
NHLBI dissection ≥ C (%)	2.1	0	5.1
CK-MB elevation (%)	17.0	23.1	20.3

*NHLBI, National Heart Lung and Blood Institute; CK-MB, creatine kinase-MB.
[a]$P < 0.05$.

TABLE VI. Long-Term Follow-Up at 9 ± 4 Months*

Events	Group R ($n = 94$)	Group S ($n = 39$)	Group R-S ($n = 59$)
30-day MACE (%)	2.1	5.1	1.7
CCS angina class III–IV (%)	6.4	7.7	8.5
Myocardial infarction (%)	3.2	5.1	3.4
Coronary artery bypass surgery (%)	2.1	2.6	1.7
Death (%)	1.1	0	1.7
TLR (%)	30[a]	15	12

*MACE, major adverse cardiac events; CCS, Canadian Cardiovascular Society; TLR, target lesion revascularization (repeat angioplasty or bypass surgery).
[a]$P < 0.02$.

Long-term follow-up at a mean duration of 9 ± 4 months was available in all patients. The incidence of Canadian Cardiovascular Society (CCS) angina class III–IV, myocardial infarction, coronary artery bypass surgery, and mortality were similar in all three groups at follow-up. The target lesion revascularization rate (TLR) was significantly higher for group R (30%) compared to group S (15%) and group R-S (12%; $P < 0.02$). On multivariate regression analysis, diabetes mellitus (OR 2.43; 95% CI 1.34–4.12) was the only predictor of subsequent TLR.

DISCUSSION

Aorto ostial and nonaorto ostial coronary lesions continue to present difficult challenge to interventional cardiology as evident by the various approaches that are currently being utilized for their treatment [1–4]. Few reports in the literature suggest that the debulking (directional atherectomy or rotational atherectomy) with or without stenting is the preferred approach in the treatment of nonaorto ostial coronary lesions due to the poor short- and long-term result with plain balloon angioplasty [5,6]. The preferred approach for nonaorto ostial stenosis should take into account the following factors: size of the culprit vessel, likelihood of side-branch compromise, degree of vessel calcification, and the likelihood of restenosis [1].

Present Study

In the present study, we compared three different interventional approaches in the management of nonaorto ostial lesions in large vessels utilizing rotational atherectomy with adjunctive balloon angioplasty, coronary stenting alone, or a combination of rotational atherectomy and stenting. Nonaorto ostial lesions that were amenable to directional atherectomy were excluded from the study. We found that all three approaches yielded a very high clinical success rate with a low rate of major complications, but stenting alone or rotational atherectomy with stenting is associated with the largest MLD postintervention and the least degree of residual stenosis. The use of rotational atherectomy as a debulking device with or without stenting clearly reduced the risk of side-branch narrowing and side-branch intervention. Most importantly, the stenting with or without rotational atherectomy is associated with the best long-term outcome (TLR rate of 12% in R-S, 15% in S, and 29% in R group). Therefore, combination of rotational atherectomy and stenting provided the best acute procedural results, while stenting with or without rotational atherectomy provided the lowest restenosis despite the higher

prevalence of acute coronary syndrome, diabetes, and complex angiographic lesions.

Previous Studies

Previous studies with rotational atherectomy for nonaorto ostial coronary lesions have demonstrated its safety and high clinical success rate [5,6]. However, the angiographic restenosis rate for nonaorto ostial lesions intervention with rotational atherectomy was reported to be as high as 39% [6]. In the present study, despite the comparable maximal mean burr size employed and reference vessel size, the MLD achieved with rotational atherectomy and adjunctive balloon angioplasty was slightly smaller compared to MLD attained with the combination of rotational atherectomy and stenting. Despite this observed difference in MLD after different devices (the bigger-is-better hypothesis) in the present study, on multivariate analysis postprocedure MLD was not predictive of TLR. It is not clear if a more aggressive step burr approach with a higher final burr-to-artery ratio by providing a larger MLD may result in less restenosis after rotational atherectomy alone. Also, long-term results of different interventional modalities in the treatment of nonaorto ostial lesions in small vessels (size < 3.0 mm) and those involving side-branch and bifurcation lesions may be different, as they were not evaluated in the present study.

It is well accepted that intracoronary stenting of the proximal left anterior descending artery achieves a larger MLD when compared to balloon angioplasty [7,9,10]. Small observational studies have documented a high clinical success rate with coronary stenting of nonaorto ostial lesions [11–13]. In one series of 48 elective patients, the incidence of procedural related non-Q–wave MI was 10%; at subsequent follow-up, recurrence of angina occurred in 27% of patients, with repeat angioplasty performed in 14.5% and bypass surgery in 4.1% [11]. Our study revealed insignificantly higher CK-MB release (23.1%) and major procedural complications (2.6%), and significantly higher incidence of side-branch compromise (30.7%) and intervention (15.4%) in the stent-alone group. Side-branch compromise poses a significant risk with stenting. Aliabadi et al. [4] reported the incidence of side-branch occlusion to be 6% and significant side-branch compromise ($> 50\%$ stenosis but TIMI grade 3 flow) to be 23% in patients that had normal side-branch morphology prior to stenting. Our study suggests that side-branch compromise can be minimized with the use of rotational atherectomy prior to stenting, although the clinical significance and added cost of rotational atherectomy requires further study.

Based on our data, whenever feasible, the preferred approach for nonaorto ostial lesions in large vessels (not involving side-branch or bifurcation lesions) should be a combination of rotational atherectomy and stenting. We believe that this combined strategy offers the most optimal long-term result while minimizing the acute procedural complication rate. In addition, it is likely that the routine use of abciximab in these complex interventions (such as in 68% of cases in the present study) may reduce the acute complication rate of side-branch closure and periprocedural CK-MB elevation. It remains to be seen whether this strategy is the most cost-effective approach to nonaorto ostial intervention.

Study Limitations

This is a nonrandomized study that nevertheless highlights the inherent difficulties that all interventional cardiologists face while treating the nonaorto ostial coronary lesions. The device selection for the treatment of nonaorto ostial coronary lesions was left to the operator's discretion (72% of cases were done by a single operator, S.K.S.), but certain lesion-specific factors dictated device selection, such as rotational atherectomy for calcified lesions and stenting alone in complex lesions and acute coronary syndrome. Another limitation of the present study was the lack of routine angiographic follow-up, although all patients were followed up and had clinically driven catheterization (symptoms or stress test) and repeat target lesion ravascularization. In the absence of randomized trials, this study allows important comparative outcome analysis to be made with the differing approaches to the treatment of nonaorto ostial coronary lesions in large vessels.

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