Angioplasty for Long Diffuse Coronary Lesions

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Angioplasty for Long Diffuse Coronary Lesions

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HO ET AL.: Angioplasty for Long Diffuse Coronary Lesions. Long diffuse coronary artery stenosis is often encountered in elderly patients. Many of these patients have multivessel disease, previous myocardial infarction, diabetes and impaired left ventricular function. Due to a combination of diffuse disease, small caliber vessels and often heavy calcification, bypass graft surgery for such vessels is associated with poor short and long-term outcomes. By virtue of their length, long lesions often involve a multiple number of side branches or significant side branches, angulated segments, tapered segments and small caliber terminal branches. As a result, angioplasty for long diffuse lesions is associated with a slightly higher in-hospital complication rate and poorer long-term outcome. Despite the development of coronary stenting over the last decade, PTCA for long diffuse lesions remains problematic. Due to the nature of the disease, there is a higher risk of stent thrombosis and in-stent restenosis. Current approaches include the use of long balloons, rotational atherectomy, laser angioplasty, and a combination of primary or bail-out spot stenting. (J HK Coll Cardiol 2000;8:129-137)

Coronary Angioplasty, Long Diffuse Lesions

Introduction

Long diffuse lesions are commonly encountered in patients with coronary artery disease, representing around 20% of contemporary interventional practice. With advances in percutaneous transluminal coronary angioplasty (PTCA) hardware, imaging equipment and operator experience, an increasing number of complex coronary lesions are now being treated with a higher procedural success rate and lower in-hospital complication rate. Long diffuse lesions, however, remain a challenge to the interventionist because of a higher procedural complication rate and poorer long-term outcome compared to the "ideal" lesions. Historically, even lesion length >10 mm has been associated with increased morbidity and mortality. Not uncommonly, long diffuse lesions are found in patients with multivessel disease, particularly in the elderly and those with diabetes mellitus.3,4

During the mid 1980's, the American College of Cardiology/American Heart Association (ACC/AHA)
Task Force classified coronary lesions into three risk groups based on lesion morphology and characteristics. Lesion length was considered an important variable in predicting risk associated with PTCA. Type A lesions are <10 mm in length. Such lesions are associated with the lowest risk and highest success rate. Type B lesions are those between 10-20 mm in length and are considered to have an intermediate risk and success rate. Type C lesions include lesions >20 mm in length and are associated with the highest risk and the lowest success rate.

Despite the development of coronary stenting over the last decade, PTCA for long diffuse lesions is still problematic due to a higher risk of stent thrombosis as a result of the small caliber diffuse disease vessels with excessive metal surface area. Most importantly, the use of multiple stents or long stents may result in a higher incidence of in-stent restenosis.

Balloon Angioplasty for Long Lesions

During the 1980's, when the standard 20 mm length balloons were used, PTCA for long diffuse lesions was associated with excessive complication and low procedural success rates. Ghazzal et al described their experience of PTCA for a cohort of 181 consecutive patients with lesions >20 mm in length treated between January 1986 and December 1989. Using standard length (20 mm) angioplasty balloons, the primary success rate was only 85.8%. There was also a significant incidence of arterial complications and emergency surgery. Meier et al also noted an increase in complications associated with angioplasty of long lesions.

Increased balloon length has been proposed for long diffuse lesions. In a small randomised study of 44 patients, Bryner et al compared the effects of long (33 mm) vs standard-length (20 mm) balloons in patients with tandem lesions or lesions measuring 15-25 mm in length. The group treated with long balloons required fewer inflations and had a lower incidence of intimal dissection compared to the standard balloon group. (4/22 vs 12/22). Savas et al used long balloons to treat 109 lesions >20 mm in length (mean 38 mm). They reported a relatively high success rate (90%) and low major complication rate (2%). Despite these reports, which have mostly been descriptive series using historical controls, there is relatively little data from controlled or randomised series documenting the advantage of long vs short/standard PTCA balloons in long diffuse lesions.

Nevertheless, one can avoid multiple, repeated, and fragmented dilatations across the diseased vessel segment by using a long balloon. 30 and 40 mm long balloons are now readily available in most interventional suites. Theoretically, the longer balloons are more conforming to vessel curvature and produce a more gradual pressure distribution to the arterial wall, resulting in a more gradual transition in arterial stretch.

The use of long balloons, however, has its own disadvantage. Firstly, long balloons are more prone to rupture. In patients with diffuse disease, particularly in heavily calcified vessels, high inflation pressure is often required to fully expand the lesion. In this context, the balloon may either rupture or create dissection at its two shoulders as a result of over-expansion in the relatively normal vessel segments at both ends of the lesion.

In vessels that taper over a 30-40 mm segment [e.g. the left anterior descending artery (LAD)], dilatation with a tapered balloon or 2 standard-length balloons with different size or dilatation pressures may be less traumatic compared to a single dilatation with a long, non-tapered balloon (Figure 1).

Complications

By virtue of their length, long lesions often involve a multiple number of side branch or significant side branches, angulated segments, tapered segments and small caliber terminal branches [as in the case of distal right coronary artery (RCA) lesions involving the posterior descending artery]. These are all factors potentially contributing to increased complications associated with PTCA.

In the 1985-1986 National Health, Lung and Blood Institute (NHLBI) Registry, diffuse and multiple discrete lesions were found to be a significant morphological predictor of acute closure, occurring in 8.5% of those with diffuse disease vs 3.3% of those with single, discrete lesions. Ellis et al retrospectively analyzed 4,772 PTCA procedures performed between 1982 and 1986 and found that lesion length ≥2 times vessel diameter was an independent predictor of acute closure.
ANGIOPLASTY FOR LONG DIFFUSE CORONARY LESIONS

Report from a series of 552 patients from the thoraxcenter undergoing conventional PTCA in 1991 and 1992 has also confirmed the ACC/AHA morphologic stratification in predicting procedural success and complication rates. The success rates were 94.5%, 88.8% and 56.4% for Types A, B and C lesions respectively. The corresponding complication (abrupt closure, surgery or death) rates were 1.2%, 3.7% and 12.8%.

Unfortunately, patients with long diffuse disease are often poor candidates for coronary bypass surgery. These patients are often elderly and/or diabetic. Many have previous myocardial infarction (MI) and impaired left ventricular function. Due to a combination of diffuse disease, multiple lesions in the same vessel, small caliber vessels and, often, heavy calcification, coronary artery bypass graft surgery (CABG) for such vessels is associated with poor short and long-term outcomes. Although endarterectomy combined with CABG may be used as an alternative, it has been associated with a marked increase in morbidity and mortality compared with CABG alone.

**Restenosis Rate**

Lesion length has been reported to be one of the angiographic factors associated with restenosis. The Multi-Hospital Eastern Atlantic Restenosis Trial (MHEART) Group obtained follow-up angiography in 510 patients enrolled in a controlled trial of the effects of methylprednisolone on restenosis after coronary angioplasty. Of the 598 successfully dilated coronary lesions analyzed, the strongest univariate relations to restenosis rate were found for lesion location, lesion length, percentage stenosis before and after PTCA, and vessel diameter. Lesions ≤4.6 mm in length had a significantly lower restenosis rate compared to those >4.6 mm in length (33% vs 45%, P = 0.001). Bourassa et al reported a 58% angiographic restenosis rate for lesions >10 mm in length compared with 32% for lesions <10 mm in length. Despite the use of long balloons, long lesions are associated with a higher restenosis rate. In a series treated with long balloons at the Duke University, the angiographic restenosis rate was 57% at follow-up. Fortunately, when restenosis occur following PTCA for long lesions, the restenotic segments tend to be shorter and can be easily redilated. In the Duke University series, the mean restenotic lesion length was only 7 mm compared with the original mean lesion length of 17.6 mm.

**Stenting for Long Diffuse Lesions**

While randomised and non-randomised studies...
over the last decade have demonstrated that coronary stents can improve short and long-term outcome for a variety of lesion types, including de novo lesions, restenotic lesions, total occlusions, and saphenous vein graft stenosis, the role of coronary stenting for patients with long diffuse lesions remains unresolved.

In the past, treatment of long lesions with stenting was unpopular because of a relatively high risk of stent thrombosis, particularly when multiple stents were used. Another factor discouraging interventionists from stenting long diffuse lesions was the high restenosis rate of up to 70% with the use of multiple stents in early series.

With advances in anti-platelet regimes, stent deployment techniques, stent-catheter delivery systems and stent design, short and long-term results of coronary stenting have improved significantly over the last decade. With these advances, several recent studies have suggested that coronary stenting may be a promising treatment for long diffuse disease. Kornowski et al examined acute and long-term outcomes in 117 patients treated with ≥3 contiguous stents in a single coronary vessel during 1994-1995. Overall procedural success in the absence of death, acute MI, or emergency CABG was 97.4%. The incidence of repeat target vessel revascularisation at 1 year was only 13.3%. These results compare favorably with those for patients with focal lesion and those treated with ≤2 stents. In another study, from June 1993 to December 1995, 47 consecutive patients were implanted with ≥4 (mean 4.5 ± 1, range 4-7) stents to cover ≥2 adjacent diseased native coronary segments. Despite the long length (63 ± 20 mm) of the lesions treated, angiographic success in the absence of major complications was achieved in 96%. Long-term follow-up at 430 ± 199 days was completed in all patients. Seventy-six percent of the patients were asymptomatic. Three patients underwent CABG while 13 patients (28%) underwent repeat angioplasty.

In a prospective registry of 187 patients who underwent PTCA with the long (32 mm) NIR® (SCIMED, Boston Scientific International, B.V., France) stent, a high procedural success rate (93%) with a low major complication rate was reported. At 6-month follow-up, the clinical event rate was 8.5%, target lesion revascularisation (TLR) was 6% and angiographic restenosis rate was 27%.

Caution, however, should be exercised in interpreting such descriptive series. To date, few randomised stent trials have included patients with long lesions. The relatively high success rate and low repeat revascularisation rate could be due to selection bias such as the exclusion of patients with small or highly tortuous vessels. Moreover, multiple stenting for long diffuse lesions is also costly.

In a recent analysis on 1,090 lesions in 725 patients, the restenosis rates for stented segment length ≤20 mm; length >20 but ≤35 mm; and length >35 mm were 23.9%, 34.6% and 47.2% respectively. Kobayashi et al compared follow-up results of the short and long NIR® stents with the Palmaz-Schatz® (PS) (Cordis a Johnson & Johnson, FL, USA) stent. Restenosis rates were 16.5% in lesions with a PS stent, 13.3% in those with a 16 mm NIR® stent and 47.4% in those with a 32 mm NIR® stent. Thus, long stented segment is an independent predictor of restenosis, and a more selective approach is recommended.

Balloon angioplasty ± bail out stenting probably remains the most popular form of approach currently adopted by interventionists for long diffuse lesions. Currently available data do not yet support a strategy of elective stenting for diffuse coronary lesions. Recent studies with a focus on balloon angioplasty with "provisional stenting" have suggested a reasonably low restenosis rate and, possibly similar rates of repeat revascularisation compared to elective stenting.

Excimer Laser Angioplasty in Long Lesions

Laser angioplasty has been attempted for diffuse stenosis but have failed to demonstrate any advantage over balloon angioplasty alone with respect to the initial and long-term clinical and angiographic outcome. In a randomised trial of excimer laser angioplasty vs balloon angioplasty in 308 patients with stable angina and coronary lesions >10 mm in length, there was no difference in the angiographic success rate (80% vs 79%), MI (4.6% vs 5.7%), CABG (10.6% vs 10.8%), and repeat angioplasty rates during 6 months of follow-up (21.2% vs 18.5%) between the laser group and the balloon group. The restenosis rate was 51.6% in the laser group vs 41.3% in the balloon group. Of note
was that 98% of the laser angioplasty procedures were followed by balloon angioplasty.

The European Coronary Excimer Laser Angioplasty Registry evaluated the clinical and angiographic outcome of 470 patients who underwent laser angioplasty from January 1991 to January 1993. Failure occurred in 56 (12%) interventions. By multivariate analysis, the strongest predictor of failure was the intention to treat long segmental lesions. Complications in this study included acute closure (7.8%), perforation (1.9%), MI (2.1%), CABG (1.9%) and mortality (1.5%). In the Excimer Laser Coronary Angioplasty (ELCA) Registry involving 3,000 consecutive patients, procedural success was 90%. Contrary to the findings of Baumbach et al, there was no significant difference in success or complication rates with respect to lesion length. Twenty percent of the lesions treated in the ELCA Registry were >20 mm in length. No significant differences in success rates or major complications were detected between lesions <10 mm, 10-19 mm, 20-29 mm, and >30 mm in length. However, coronary perforation occurred in 1.2% of the patients, even though this dropped to 0.4% in the last 1,000 patients. In the ELCA registry, the overall restenosis rate was 46%, increasing to 59% for lesions >10 mm in length.

In a more recent study, 215 patients with 244 lesions were prospectively randomised at 14 clinical centers to laser vs stand-alone PTCA. After laser treatment, all patients underwent balloon PTCA. Although procedural success rate was similar in the two groups, the use of laser vs PTCA alone resulted in more major and minor complications (18.0% vs 3.1%), MI (4.3 vs 0%), death (1.7% vs 0%), and major adverse events (10.3% vs 4.1%). Around 42% of the lesions treated in this study were >10 mm in length. Although there is no subgroup analysis for long lesions, it would appear that there is no overall immediate or long-term benefit for laser angioplasty over stand-alone PTCA.

Rotational Atherectomy in Long Lesions

Long lesions are also associated with a lower primary success rate, a higher in-hospital complication rate and higher restenosis rate compared to short lesions when high-speed rotational atherectomy is applied. The "slow flow" phenomenon, a complication associated with rotablation, has been observed more often amongst long lesions. Predictors of "slow flow" include long lesions combined with diffuse disease (plaque burden), small caliber and limited distal runoff. In the Rotablator Multicenter Registry, of 143 lesions 15-25 mm in length, procedural success was achieved in 92%. However, these lesions were associated with a higher incidence of Q and non-Q MI (2.8% and 6.2%) compared with lesions of <10 mm in length (0.7% and 4.0% respectively). In a report by Teirstein et al using the rotablator in a small cohort of patients not suitable for balloon angioplasty, where 3/4 of the patients had diffuse disease defined as stenosis >10 mm in length, procedural success was achieved in only 70% of the patients with long lesions as oppose to 92% of the patients with lesions <10 mm in length. Non-Q MI occurred in 19% of the patients and was associated with longer lesions. Angiographic follow-up at 6 months also showed a higher restenosis rate (75% vs 22%) for lesions >10 mm vs lesions <10 mm in length.

Few reports have specifically compared restenosis rate between rotablator and conventional PTCA for long lesions. Large descriptive series which included both long and short lesions have so far failed to demonstrate any clear-cut advantage of rotational atherectomy over conventional PTCA in terms of restenosis rate during long term angiographic follow up. Brown et al reported the 1 year follow-up results in 525 patients with 670 lesions treated with rotablation by the New Approaches to Coronary Intervention (NACI) investigators. Overall, TLR was required in 27% of the patients. At one year, 30% had experienced death, Q-MI, or TLR, and long lesions was one of the independent predictor of events. Although not reported separately, the TLR for long lesions would be much higher than the 27% reported for the entire cohort. In the Rotational Atherectomy Multicenter Registry, 6-month angiographic follow-up result was available on 64% of 874 lesions treated. The overall restenosis...
rate of 38% appears similar to other techniques.\textsuperscript{41} Kobayashi et al reported their results on 162 lesions in 126 who underwent rotational atherectomy followed by stenting between May 1995 and February 1997. Despite stenting, the restenosis rates still ranged from 31% to 50%, depending on the final burr size and final burr: vessel ratio.\textsuperscript{43}

Our Experience in Managing Long Diffuse Lesions

Between September 1997 and August 1999, consecutive patients who underwent an elective first or repeat angioplasty by our university team were analyzed. The indication for angioplasty included stable angina, unstable angina and post-MI angina. A total of 409 lesions in 349 patients were evaluated (Table 1). Adjunctive devices (rotational athrectomy) was used in 2% of the cases. No ELCA was used in this series. Patients were divided into Group I (lesion length \( \leq 20 \) mm) and Group II (lesion length \( >20 \) mm). Mean lesion length was 27 mm in Group II vs 11 mm in Group I. There were significantly more patients with triple vessel disease in Group II. There were slightly more patients with hypertension, diabetes, and hyperlipidermia in Group II compared to Group I, although this did not reach statistical significance.

There was no difference between the two groups with regard to in-hospital complication. Procedural success, defined as residual stenosis of <30% without any in-hospital death, CABG or MI, was significantly higher for Group I compared to Group I in (97% vs 87.5%). During follow-up at a mean of 13 ± 5 months, event-free survival was significantly lower in Group II compared to Group I (78.6% vs 87.8%) (Table 2). Significantly more patients in Group II developed recurrent angina, requiring repeat catheterisation and TLR (21.5% vs 9.7%) (Figures 2 and 3).

Current Approach to Long Lesions

With improvement in intravascular ultrasound (IVUS) software and hardware, interventionists can now make a more rational decision on their choice of adjunctive devices in dealing with long diffuse lesions. In our practice, the rotablator is generally reserved for heavily calcified lesions where the PTCA balloon may not cross and for lesions that do not yield to balloon dilatation. For closely-located tandem lesions or long lesions with little tapering, our approach is to use a

| Table 1. Baseline clinical and angiographic characteristics |
|-----------------|-----------------|----------|
| Group I | Group II |
| \( \leq 20 \) mm (n=297) | >20 mm (n=112) |
| Age | 62.39 ± 7.59 | 63.11 ± 7.74 |
| Male | 242 (81.5%) | 89 (79.5%) |
| Hypertension | 178 (57.1%) | 68 (60.7%) |
| Diabetes | 84 (28.3%) | 38 (33.9%) |
| Hyperlipidermia | 188 (63.3%) | 78 (69.6%) |
| Triple vessels disease | 45 (15.2%) | 35 (31.3%) | < 0.001 |
| Mean reference diameter (mm) | 3.1 ± 0.4 | 3.0 ± 0.3 |
| Mean lesion length (mm) | 10.8 ± 3.2 | 26.8 ± 5.6 |
| Procedural success | 288 (97.0%) | 98 (87.5%) | < 0.0001 |
| Stenting performed: | | |
| No. of stents | 208 (70.0%) | 74 (66.1%) |
| Mean stent length (mm) | 16 ± 3.1 | 23.2 ± 5.7 |
| Complication: | | |
| Death | 0 | 0 |
| CABG | 1 (0.3%) | 0 | ns |
| Q-MI | 3 (0.9%) | 1 (0.1%) | ns |

\textit{ns} = not significant
Table 2. Clinical outcome during follow-up at 13 ± 5 months

<table>
<thead>
<tr>
<th></th>
<th>Group I ≤20 mm (n = 297)</th>
<th>Group II &gt;20 mm (n = 112)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients at follow-up</td>
<td>281 (94.6%)</td>
<td>108 (96.4%)</td>
<td></td>
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<tr>
<td>TLR</td>
<td>27 (9.7%)</td>
<td>21 (21.5%)</td>
<td>0.007</td>
</tr>
<tr>
<td>Death of any cause</td>
<td>1 (0.3%)</td>
<td>1 (0.9%)</td>
<td>ns</td>
</tr>
<tr>
<td>MI (Q or Non-Q)</td>
<td>0 (0%)</td>
<td>1 (0.9%)</td>
<td>ns</td>
</tr>
<tr>
<td>Event-free survival</td>
<td>261 (87.8%)</td>
<td>88 (78.6%)</td>
<td>0.018</td>
</tr>
</tbody>
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ns = not significant

Figure 2. A 62-year-old man with triple vessel disease and old inferior Q-MI. The LAD is diffusely diseased from the proximal to mid-segments (arrows). Following stenting with two 3.0 × 20 mm balloon-expandable coil stents, there was no significant residual stenosis.

Figure 3. A 68-year-old man with triple vessel disease and previous MI underwent staged PTCA to his RCA. The RCA was diffusely diseased in the proximal and mid-segments (arrows). Following the deployment of two balloon-expandable slotted-tube stents (3.5 × 23 mm; 3.5 × 18 mm), there was no significant residual stenosis.
30 mm to 40 mm long balloon. For multiple discrete lesions, particularly when the relatively "disease-free" segments (those <60% stenosis) involve significant side branch (such as the diagonal branch in a diffusely diseased LAD), our approach is to use a standard-length (20 mm) balloon or even a short (15 mm) balloon for initial dilatation of those discretely diseased segments. In such situations, non-overlapping, short, or standard length stents are used to cover only those areas with suboptimal angiographic results or those vital areas (e.g. proximal LAD) that have been dilated with a balloon. Some operators may prefer "spot-stenting", covering only those areas with significant dissection or residual stenosis. Other operators would cover the entire diseased segment. If possible, one should resist the temptation to dilate non-critical lesions, reserving the use of long stents or overlapping stents for suboptimal angiographic results or for long dissection. One should not forget that CABG still plays an important role in the management of long diffuse lesions where the distal vessel is graftable and especially in diabetics with multivessel disease.

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Reference


