

Stenting of Coronary Bifurcation Lesions: Case Series

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Aim. To assess the procedural success and major cardiac event rate after stenting of coronary bifurcation lesions.

Methods. The prospective study included 36 patients with coronary artery bifurcation lesion treated with stenting between January 1999 and December 2001 at the Institute for Heart Disease, Skopje University Center. There were 23 men and 13 women, with a mean age of 62.5 ± 12.3 years. Seventeen patients had acute myocardial infarction and 19 patients had unstable angina. The follow-up lasted 6 months. The strategy of systematic coronary stenting in the bifurcation lesions involving a side branch of > 2.2 mm in diameter was prospectively evaluated according to the quantitative coronary angiography (QCA) measurements. Procedural success was defined as a residual stenosis of less than 20%. Major cardiac events included deaths, emergency coronary artery bypass grafting (CABG), Q-wave myocardial infarction, acute and subacute closure, repeated percutaneous transluminal coronary angioplasty (PTCA), and non-Q myocardial infarction.

Results. Out of a total of 36 bifurcation lesions, the left anterior descending/diagonal bifurcation lesion was found in 22 patients, circumflex/marginal in 8 patients, posterior descending artery/posterolateral artery in 4 patients, and left main coronary artery in 2 patients. The main branch of the coronary artery (mean \pm SD reference diameter, or the diameter of the normal coronary artery, 2.90 ± 0.36 mm) was stented in 35 patients and the side branch of the main coronary artery (2.35 ± 0.42 mm reference diameter) in 24 patients. The major cardiac events occurred in 3 patients: one had Q-wave myocardial infarction, one developed acute and subacute closure, and one underwent PTCA. There were no deaths or emergency CABG.

Conclusion. The development of new surgical strategies and stent design has improved the safety and immediate outcome of bifurcation stenting, but procedural success still needs to be matched by an equal clinical improvement and long-term patency.

Key words: angioplasty, transluminal, percutaneous coronary, coronary disease; coronary stenosis; myocardial infarction; stents; treatment outcome

A bifurcation lesion of the coronary arteries is defined as the presence of more than 50% of stenosis involving both a parent vessel and the ostium of its side branch (1). Balloon angioplasty of such stenosis is associated with a significant risk of side branch occlusion through plaque shift, dissection, or elastic recoil of the treated ostium, and several techniques have been developed in an attempt to reduce the treatments failure rate (2). If a stent is to be deployed in the parent vessel, compression and extrusion of the plaque may compromise flow in the side-branch, where it originates from the treated segments. Despite improvement in catheter and balloon design, procedural complications and a disappointingly high restenosis rate are inherently associated with balloon angioplasty of coronary bifurcation stenosis (3-6). For this reason, al-

ternative strategies using directional coronary atherectomy have been developed (7-9).

More recently, a plethora of techniques using single or multiple stent insertion for the treatment of stenosis at major coronary bifurcations have been described (10-15). Although the immediate angiographic results have made interventionalist feel secure, the mid- and long-term outcomes have been less certain. Since there is little information about the deployment characteristics of stents at bifurcation, there is also little understanding of potential mechanisms contributing to the poor subsequent clinical outcome.

In our study, the strategy of systematic coronary stenting of bifurcation lesions involving a side branch of ≥ 2.2 mm in diameter was prospectively evaluated

against the major cardiac event rate following the procedure.

Patients and Methods

Patients

The prospective study included 36 patients scheduled for the treatment of bifurcation lesions of the coronary arteries between January 1999 and December 2001. All patients underwent percutaneous transluminal coronary angioplasty and stenting, and were followed-up for 6 months. There were 23 men and 13 women. The mean age of the patients was 62.5 ± 12.3 years. Seventeen patients had acute myocardial infarction, nineteen patients had unstable angina. All patients had bifurcation lesions of major coronary arteries and were treated with culotte stent and T-stent technique. In all cases, both distal limbs of the bifurcations of coronary arteries were considered suitable for the treatment with a stent of 3.0 mm in diameter or larger. In 23 patients the bifurcation stenosis was part of a multivessel disease, and 10 patients had impaired left ventricular function. The lesion of coronary artery bifurcation involving left anterior descending and diagonal artery was found in 22 patients, of circumflex and marginal artery in 8 patients, posterior descending artery and posterior lateral artery in 4 patients, and of left main coronary artery in 2 patients. Procedural success was obtained in 35 patients in both branches and in 36 patients in the main branch (Table 1).

Table 1. Clinical presentation and risk factors of ischemic heart disease in 36 patients undergoing stenting of coronary bifurcation lesion

Characteristics	No. of patients
Age (years, mean \pm SD)	62.5 \pm 12.3
Clinical presentation of the patients:	
acute myocardial infarction	17
unstable angina	19
Coronary artery bifurcation lesions:	
left anterior descending/diagonal bifurcation	22
circumflex/marginal bifurcation	8
and posterior descending artery/posterolateral bifurcation	4
left main bifurcation	2
Risk factors for ischemic heart disease:	
current smoking	15
hypertension	13
diabetes	10
hypercholesterolemia	13
family history	15
previous CABG ^a	1
previous myocardial infarction	9

^aCABG – coronary artery bypass grafting.

Patients included in the study met the following criteria: development of acute myocardial infarction within 6 h after the onset of chest pain, unstable angina pectoris, side branch diameter > 2.2 mm, and lesion of the coronary artery < 18 mm.

Patients with calcified lesions and lesion of the coronary artery > 18 mm were excluded from the study.

Procedure

The femoral approach was used in all cases. All patients were treated with aspirin and 250 mg ticlopidine (Ticlodix, Hemofarm, Vršac, Yugoslavia) for 30 days. During the procedure, all patients received 10,000 IU of intravenous heparin, with further doses administered as necessary to obtain an activated clotting time (ACT) of > 300 s. There were no failures in stent deployment during the procedure. Balance middle wave wire was used for both the distal main vessel and the side branch. Both the main and side branch were dilated before positioning the main vessel stent across the origin of the side branch. At this point, either the side branch wire was removed or the main vessel stent deployed, thereby trapping the side branch wire. The side branch was then rewired through the side of the main vessel stent, using a third wire if necessary, with subsequent removal of the jailed wire. Balloon inflation was performed from the main vessel into the side branch to separate the stent coils away from the side

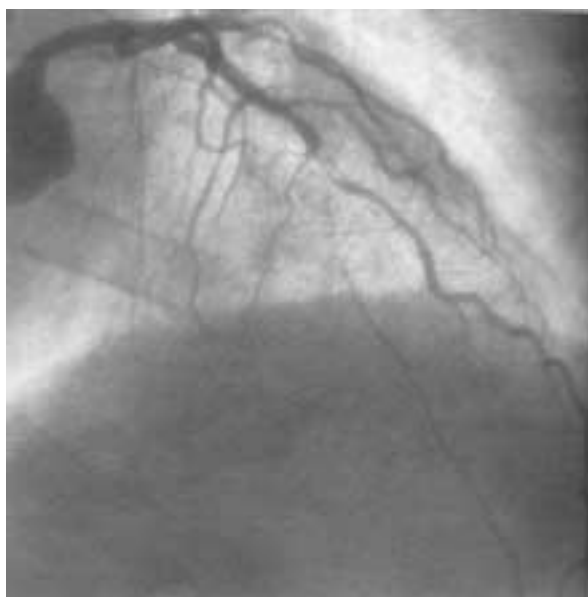


Figure 1. Percutaneous transluminal coronary angiography. Bifurcation stenosis at the junction of left anterior descending and diagonal arteries.



Figure 2. Percutaneous transluminal coronary angiography after the surgery. Stent deployment in the left anterior descending artery and "trapping" wire in the diagonal artery.

branch origin. The second stent then was positioned with its proximal portion in the main vessel and its distal portion in the side branch. The main vessel wire was removed, thereby preventing the wire becoming trapped between the two stents, and the second stent was deployed (Figs. 1 and 2).

Finally, the main vessel was rewired through the side of the side branch stent and a balloon dilatation performed through the side of the second stent, thereby separating the stent coils to produce a clear main vessel lumen. T-stenting was performed with appropriate techniques for treatment of bifurcation lesions.

Major cardiac events included deaths, emergency coronary artery bypass grafting, Q wave myocardial infarction, acute and subacute closure, repeated percutaneous transluminal coronary angioplasty, and non-Q myocardial infarction.

Results

The left anterior descending/diagonal bifurcation was involved in 22 patients, circumflex/marginal 8 patients, and posterior descending and posterior lateral artery 4 patients, and left main bifurcation 2 patients. The reference diameter of the main branch (the diameter of the normal coronary artery) was 2.9 ± 0.2 mm. The main branch was stented in 35 patients, and the side branch (2.3 ± 0.4 mm reference diameter) in 24 patients. Procedural success, defined as deployment of the stent with residual stenosis less than 20%, was obtained in 24 patients in both branches and in 35 patients in the main branch. The major cardiac event occurred in 3 patients: one patient had Q-wave myocardial infarction, one developed acute and sub-acute closure, and one had to undergo repair with

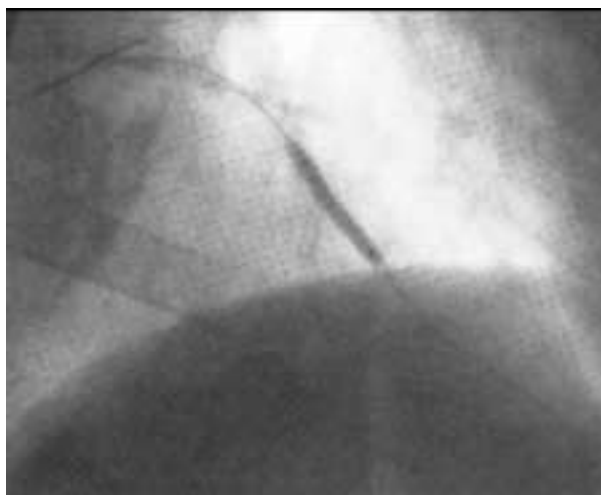


Figure 3. Percutaneous transluminal coronary angiography after the surgery. Stent deployment in the diagonal vessel with removal of left anterior descending artery wire.

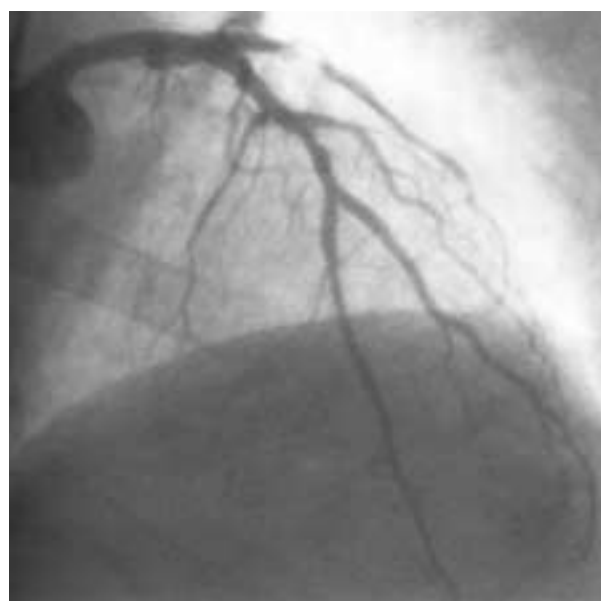


Figure 4. Percutaneous transluminal coronary angiography after the surgery. Final angiographic appearance of the culotte stent of left anterior descending artery wire.

percutaneous transluminal coronary angioplasty (Figs. 3 and 4). There were no deaths or emergency coronary artery bypass grafting.

At 6-month follow-up, 24 patients were symptom-free (no chest pain, dyspnea, or breathlessness), and 12 had recurrent angina pectoris. In 9 of these, balloon angioplasty with a culotte stent had to be repeated. Target lesion revascularization rate was 25% at 6-month follow-up.

Discussion

Procedural success of coronary stenting in our study was high, with 24 symptom-free patients at 6-month follow-up, and there were only 3 in-hospital major cardiac events. Nevertheless, the treatment of bifurcation lesions of the coronary arteries in the patients remains complex, with increased potential for inadequate initial angiographic improvement, increased early complications, such as acute and sub-acute closure of the coronary vessel, dissection of the coronary vessel and rupture of the coronary arteries, and increased restenosis rates (16).

Complications after percutaneous transluminal coronary angioplasty of bifurcation lesions of the coronary arteries in the patients have been related to extent of atherosclerosis at the site of origin of the branch vessel (reviewed in ref. 1).

After placing a stent in the main vessel of a bifurcation lesion, it is often necessary to perform further balloon inflation or stent placement through the stent struts in order to treat a lesion of the secondary vessel or side branch. Balloon inflation with dilatation through the cells of the stent in the main vessel results in stent strut disfigurement. This disfigurement causes various degrees of stenosis within the main vessel, secondary to stent strut deformity. The degree of the strut deformity, and therefore, stenosis, may vary significantly depending on the stent design and structure.

The STARS Trial (17) concluded that the side branch occlusion after elective stent placement was uncommon (5%), which means that the occlusion of the side branch is rare during the treatment of bifurcation lesions and is not associated with the final dissection in the parent vessel. Patients with side branch occlusion after stenting had more atherosclerotic disease in branch vessel origin, required more emergency coronary artery bypass grafting, and had twice the target lesion revascularization rates (22%) in the parent vessel than patients with no side branch closure.

The side branch occlusion rate after elective stent placement in the STARS Trial (17) was 5%, compared with our study where there were no side branch occlusions.

The National Heart Lung and Blood Institute (NHLBI) Dynamic Registry (18) showed that, despite the widespread use of newer percutaneous devices, treatment of the bifurcation remains difficult and associated with decreased success rates and increased complications, compared with nonbifurcation lesions.

Bestent prospective dual-center study (16) showed that using a simple strategy of provisional T-stenting of the side branch in the majority of cases, the Bestent could be used for treating bifurcation lesions with a high rate of success and an acceptable rate of target vessel revascularisation at 6-month follow-up.

The number of patients in the Bestent study (16) was twice the number of patients in our study. Our in-hospital outcome data showed no deaths following bifurcation stenting, compared with 1% deaths in the Bestent study (16). The acute and subacute closure in our study was found in a single patient.

At 6-month follow-up period, there were no deaths and myocardial infarction in our study, as opposed to 3% of deaths and 3% of Q-wave myocardial infarction in the Bestent Study (16). The restenosis rate was significantly higher in our study (9%) than in the Bestent study (4%) (16). One of the reasons for significantly lower restenosis rate in the Bestent study was the use of the Medtronic-Bestent endovascular coronary prosthesis (Medtronic Parkway Northeast, Minneapolis, MN, USA) in the treatment of bifurcation lesions of coronary arteries, which has restenosis rate less than 17%. The stents we used in our study (Crossflex, Johnson & Johnson, Vienna, Austria) have restenosis rate less than 35%.

The limitations of our study were the small number of patients and short follow-up period, which should have lasted at least 12 months. The transcatheter treatment of bifurcational coronary lesion is still a subject of controversy. Although coronary stenting of the bifurcations lesions on both lesions is associated with optimum immediate procedural success with current techniques, restenosis rate per lesion is still high. Improvements in stent design, dedicated stents or the use of mini and coated stents to treat side branches are required and could improve the long-term results.

References

- Baim DS. Coronary angioplasty. In: Grossman W, Baim DS, editors. Cardiac catheterization, angiography and intervention. 4th ed. Philadelphia (PA): Lea & Febiger; 1990. p. 477-80.
- Castaneda-Zuniga WR, Formanek A, Tadavarthi M, Vlodaver Z, Edwards JE, Zollikofer C, et al. The mechanism of balloon angioplasty. *Radiology* 1980;135:565-71.
- Tan KH, Sulke N, Taub N, Sowton E. Percutaneous transluminal coronary angioplasty of aorta ostial, non-aorta ostial, and branch ostial stenoses: acute and long-term outcome. *Eur Heart J* 1995;16:631-9.
- Mathias DW, Mooney JF, Lange HW, Goldenberg IF, Gobel FL, Mooney MR. Frequency of success and complications of coronary angioplasty of a stenosis at the ostium of a branch vessel. *Am J Cardiol* 1991;67:491-5.
- Renkin J, Wijns W, Hanet C, Michel X, Cosyns J, Col J. Angioplasty of coronary bifurcation stenoses: immediate and long-term results of the protecting branch technique. *Cathet Cardiovasc Diagn* 1991;22:167-73.
- Weinstein JS, Baim DS, Sipperly ME, McCabe CH, Lorell BH. Salvage of branch vessels during bifurcation lesion angioplasty: acute and long-term follow-up. *Cathet Cardiovasc Diagn* 1991;22:1-6.
- Brener SJ, Leya FS, Apperson-Hansen C, Cowley MJ, Califf RM. A comparison of debulking versus dilatation of bifurcation coronary arterial narrowings (from the CAVEAT I Trial). *Coronary Angioplasty Versus Excisional Atherectomy Trial-I. Am J Cardiol* 1996;78:1039-41.
- Altmann DB, Popma JJ, Pichard AD, Kent KM, Satler LF, Keller MB, et al. Impact of directional atherectomy and adjacent branch vessels. *Am J Cardiol* 1993;72:351-3.
- Rihal CS, Garratt KN, Holmes DR Jr. Rotational atherectomy for bifurcational lesions of the coronary circulation: technique and initial experience. *Int J Cardiol* 1998;65:1-9.
- Carrie D, Karouny E, Chouairi S, Puel J. "T"-shaped stent placement: a technique for the treatment of dissected bifurcation lesions. *Cathet Cardiovasc Diagn* 1996;37:311-3.
- Robinson NM, Balcon R, Layton CA, Mills PG, Timmis AD, Rothman MT. Intravascular ultrasound assessment of culotte stent deployment for the treatment of stenoses at major coronary bifurcations. *Int J Cardiovasc Intervent* 2001;4:21-7.
- Fort S, Lazzam C, Schwarz L. Coronary "Y" stenting: a technique for angioplasty of bifurcation stenosis. *Can J Cardiol* 1996;12:678-82.
- Schampaert E, Fort S, Adelman AG, Schwartz L. The V-stent: a novel technique for coronary bifurcation stenting. *Cathet Cardiovasc Diagn* 1996;39:320-6.
- Teirstein P. Kissing Palmaz-Schatz stents for coronary bifurcation stenoses. *Cathet Cardiovasc Diagn* 1996;37:307-10.
- Khoja A, Ozbek C, Bay W, Heisel A. Trouser-like stenting: a new technique for bifurcation lesions. *Cathet Cardiovasc Diagn* 1997;41:192-6.
- Gobeil F, Lefevre T, Guyon P, Louvard Y, Chevalier B, Dumas P, et al. Stenting of bifurcation lesions using the Bestent: a prospective dual-center study. *Catheter Cardiovasc Interv* 2002;55:427-33.
- Cutlip DE, Leon MB, Ho KK, Gordon PC, Giambartolomei A, Diver DJ, et al. Acute and nine-month clinical outcomes after "suboptimal" coronary stenting: results from the STent Anti-thrombotic Regimen Study (STARS) registry. *J Am Coll Cardiol* 1999;34:698-706.
- Al Suwaidi J, Yeh W, Cohen HA, Detre KM, Williams DO, Holmes DR Jr. Immediate and one-year outcome in patients with coronary bifurcation lesions in the modern era (NHLBI dynamic registry). *Am J Cardiol* 2001;87:1139-44.

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