Circulation Journal
Official Journal of the Japanese Circulation Society
http://www.j-circ.or.jp

ORIGINAL ARTICLE
Cardiovascular Intervention

Long-Term Clinical Results and Predictors of Adverse Outcomes After Drug-Eluting Stent Implantation for Bifurcation Lesions in a Real-World Practice

– The COBIS (Coronary Bifurcation Stenting) Registry –

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Background: Limited data exists regarding long-term clinical results and predictors of adverse outcomes after drug-eluting stents (DES) implantation for coronary bifurcation lesions in a real-world practice.

Methods and Results: A total of 1,691 non-left main bifurcation lesions with side branches ≥2.0 mm in 1,668 patients undergoing DES implantation between January 2004 and June 2006 from 16 centers in Korea were evaluated. True bifurcation was found in 69.2% of lesions and 82.7% of lesions were treated with 1-stent technique. During follow-up (median 22 months), cardiac death occurred in 0.9%, myocardial infarction (MI) in 1.2%, target lesion revascularization (TLR) in 4.7% and stent thrombosis in 0.7% of patients. There was no significant difference in major adverse cardiac events (MACE: composite of cardiac death, MI and TLR) between the 1-stent and the 2-stent groups (6.1% vs 7.5%, P=0.36). Stent length in the main vessel (hazard ratio (HR) 1.02, 95% confidence interval (CI) 1.001–1.03, P=0.03), paclitaxel-eluting stent (HR 1.98, 95%CI 1.34–2.92, P=0.001) and kissing ballooning (HR 2.01, 95%CI 1.29–3.13, P=0.002) were independent predictors of MACE. Kissing ballooning increased the risk of MACE especially in the 1-stent group, but not in the 2-stent group.

Conclusions: In this large real-world registry, overall outcomes after DES implantation in bifurcation lesions were favorable and similar between the 1-stent and 2-stent groups. (*Circ J* 2010; **74:** 2322–2328)

Key Words: Bifurcation; Drug-eluting stents; Percutaneous coronary intervention

Coronary bifurcation lesions are one of the most challenging lesion subsets and known to have a lower angiographic success rate and a higher risk of procedural complications with a greater restenosis rate than non-bifurcation lesions.[1–3] Therefore, coronary bifurcation lesions have been the subject of many studies; however, real-world practice patterns and long-term clinical outcomes have not been adequately addressed by previous studies. Most previous studies focused on either treatment strategies or techniques and were of a small to medium sample size with a follow-up period of 6–12 months in a randomized setting.[1,4,5] Although a few of these previous studies used real-world data sets, these studies were not based on registries dedicated to bifurcation lesions and had only a medium sample size that was inadequate to identify prognostic factors by multivariate analysis.[6,7] Therefore, we investigated long-term clinical results and predictors of adverse outcomes after percutaneous coronary intervention (PCI) with drug-eluting stents (DES) for coronary bifurcation lesions using data from a dedicated, large, multicenter real-world registry.

Received April 12, 2010; revised manuscript received June 15, 2010; accepted July 1, 2010; released online September 28, 2010 Time for primary review: 36 days

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ISSN-1346-9843 doi:10.1253/circj.CJ-10-0352

Table 1. Baseline Clinical Characteristics

	All (n=1,668)	1-stent (n=1,376)	2-stent (n=292)	P value
Age, years	62±10	62±10	62±10	0.79
Male	1,116 (66.9)	931 (67.7)	185 (63.4)	0.16
Diabetes	513 (30.8)	437 (31.8)	76 (26.0)	0.054
Hypertension	987 (59.2)	820 (59.6)	167 (57.2)	0.45
Dyslipidemia	521 (31.2)	428 (31.1)	93 (31.8)	0.80
Current smokers	405 (24.3)	337 (24.5)	68 (23.3)	0.66
Chronic renal failure	55 (3.3)	47 (3.4)	8 (2.7)	0.56
Previous MI	139 (8.3)	114 (8.3)	25 (8.6)	0.88
Cerebrovascular event history	87 (5.2)	73 (5.3)	14 (4.8)	0.73
LVEF <50%*	203 (17.0)	174 (17.6)	29 (14.1)	0.23
Clinical diagnosis				0.42
STEMI	89 (5.3)	78 (5.7)	11 (3.8)	
Unstable angina/NSTEMI	880 (52.8)	722 (52.5)	158 (54.1)	
Stable angina	638 (38.2)	576 (41.9)	123 (42.1)	

MI, myocardial infarction; LVEF, left ventricular ejection fraction; STEMI, ST-segment elevation myocardial infarction; NSTEMI, non-ST-segment elevation myocardial infarction.
Values are mean±SD or n (%).
*LVEF was available in 1,195 patients.

Methods

Study Population

This study utilized a multicenter registry dedicated to bifurcation lesions from 16 cardiovascular intervention centers in Korea, supported by the Korean Society of Interventional Cardiology. Inclusion criteria were: (1) coronary bifurcation lesions treated with DES between January 2004 and June 2006; and (2) main vessel (MV) diameter ≥2.5 mm and side branch (SB) diameter ≥2.0 mm. Exclusion criteria were the presence of cardiogenic shock, ST-segment elevation acute myocardial infarction (MI) within the previous 48 h, life expectancy <1 year and left main bifurcation. Bifurcation lesions were classified according to the Medina classification, in which the proximal MV, distal MV and SB components of the bifurcation are, in that order, each assigned 1 or 0 depending on the presence or absence of >50% stenosis of the vessel.[8] The study protocol was approved by the institutional review board at each participating institution.

PCI

All patients were administered loading doses of aspirin (300 mg) and clopidogrel (300–600 mg) unless they had previously received these antiplatelet medications. Anti-coagulation during PCI was performed according to the routine practices of each hospital. The treatment strategy, stenting techniques and selection of DES type were all left to the individual operator's discretion. Decisions to use glycoprotein IIb/IIIa receptor inhibitors or intravascular ultrasound (IVUS) were also made by the individual operators. After the procedure, aspirin (100–200 mg once daily) was continued indefinitely. The duration of clopidogrel treatment was, again, at the operator's discretion.

Data Collection and Angiographic Analysis

Demographic, clinical, laboratory, angiographic, procedural and outcome data were collected by an internet-based reporting system. When required, additional information was obtained from the medical records of other hospitals and by telephone contact. All baseline and procedural coronary cineangiograms were digitally stored on either a compact disc or hard disk in Digital Imaging and Communication in Medicine format. Angiographic and procedural characteristics of all cineangiograms were reviewed and qualitatively analyzed at the angiographic core laboratory of Cardiac and Vascular Center, Samsung Medical Center, Seoul, Korea. Angiographic success was defined as achievement of Thrombolysis In Myocardial Infarction (TIMI) 3 flow with a final residual stenosis <30% for the MV and <50% for the SB. Medina classification (1,1,1), (1,0,1) or (0,1,1) lesions were categorized as true bifurcation lesions.

Study Endpoints and Definitions

Clinical events were defined based on the recommendations of the Academic Research Consortium (ARC).[9] All deaths were considered cardiac unless a definite non-cardiac cause could be established. MI was defined as the presence of clinical signs of MI combined with a creatine kinase MB fraction (CK-MB) or troponin-T/troponin-I increase more than the upper normal limit that was not related to an interventional procedure. Target lesion revascularization (TLR) was defined as a repeat PCI of the lesion within 5 mm of deployed stent or bypass graft surgery of the target vessel. Target-vessel revascularization (TVR) was repeat revascularization of the target vessel by PCI or bypass graft surgery. A major adverse cardiac event (MACE) was defined as the device-oriented composite endpoint in the ARC recommendation: cardiac death, MI or TLR. Definite, probable and possible stent thrombosis (ST) was defined according to the ARC recommendations. The timing of ST was classified as early, late and very late (occurring within 1 month, 1 month to 1 year and greater than 1 year post index procedure, respectively). All events were reported at the participating centers and reviewed by an independent clinical event adjudicated committee.

Statistical Analysis

Continuous variables are presented as mean±standard deviation or median with interquartile range. Categorical variables are presented as frequency with percentages. Continuous variables were analyzed using the independent sample t-test, and categorical variables were analyzed with the χ^2-test or Fisher's

Table 2. Angiographic and Procedural Data

	All (n=1,691)	1-stent (n=1,398)	2-stent (n=293)	P value
Site of bifurcation				<0.001
Left anterior descending/diagonal	1,288 (76.2)	1,039 (74.3)	249 (85.0)	
Left circumflex/obtuse marginal	310 (18.3)	279 (20.0)	31 (10.6)	
Right coronary/posterior descending	93 (5.5)	80 (5.7)	13 (4.4)	
Medina classification				<0.001
0, 0, 1	28 (1.7)	15 (1.1)	13 (4.4)	
0, 1, 0	166 (9.8)	148 (10.6)	18 (6.1)	
0, 1, 1	204 (12.1)	143 (10.2)	61 (20.8)	
1, 0, 0	123 (7.3)	117 (8.4)	6 (2.0)	
1, 0, 1	113 (6.7)	98 (7.0)	15 (5.1)	
1, 1, 0	203 (12.0)	193 (13.8)	10 (3.4)	
1, 1, 1	853 (50.4)	683 (48.9)	170 (58.0)	
True bifurcation*	1,170 (69.2)	924 (66.1)	246 (84.0)	<0.001
Stent technique				–
Main vessel stenting only		1,398 (82.7%)		
T-stenting			140 (8.3)	
Crush			100 (5.9)	
V-stenting			43 (2.5)	
Culotte			10 (0.6)	
Final kissing ballooning	686 (40.6)	458 (32.8)	228 (77.8)	<0.001
IVUS guidance	539 (31.9)	401 (28.7)	138 (47.1)	<0.001
Main vessel				
Maximal stent diameter	3.1±0.3	3.1±0.3	3.2±0.3	0.08
Total stent length	30.7±13.0	30.8±13.2	30.0±11.7	0.27
Side branch				–
Maximal stent diameter	2.7±0.3	–	2.7±0.3	
Total stent length	21.6±8.7	–	21.6±8.7	
Stent type				0.07
Sirolimus-eluting stent	1,070 (63.3)	873 (62.4)	197 (67.2)	
Paclitaxel-eluting stent	573 (33.9)	480 (34.3)	93 (31.7)	
Others	48 (2.8)	45 (3.2)	3 (1.0)	
SB TIMI flow after procedure				0.005
0–2	108 (6.4)	100 (7.2)	8 (2.7)	
3	1,583 (93.6)	1,298 (92.8)	285 (97.3)	
Procedural success†				
Main vessel	1,671 (98.8)	1,381 (98.8)	290 (99.0)	0.99
Side branch	1,084 (64.1)	801 (57.3)	283 (96.6)	<0.001

IVUS, intravascular ultrasound; TIMI, Thrombolysis In Myocardial Infarction.
Values are mean±SD or n (%).
*Defined as Medina classification (1, 1, 1), (1, 0, 1) or (0, 1, 1).
†Defined as achievement of TIMI 3 flow with a final residual stenosis <30% for the main vessel and <50% for the side branch.

exact test. The occurrence of adverse events during the follow-up period was analyzed by the Kaplan–Meier method. Differences between event-free survival curves were compared by the log-rank test. The Cox proportional hazard model was used to identify the independent predictors of MACE. The following variables were selected for the analysis with the Cox model: age, sex, acute coronary syndrome, diabetes, true bifurcation, 1-stent vs 2-stent technique, final kissing ballooning, IVUS guidance, stent type, SB procedural success, MV stent diameter, MV stent total length and clopidogrel use for more than 6 months. Statistical significance was accepted for a 2-sided value of $P<0.05$. All analyses were performed using the Statistical Analysis Software package (Version 9.1, SAS Institute, Cary, NC, USA).

Results

Baseline Aharacteristics and Procedural Data

Among 1,919 patients registered, 251 patients were found to fail to fulfill the inclusion criteria by core laboratory cineangiographic analysis and were excluded from the study. A total of 1,691 bifurcation lesions in 1,668 patients were included in this study. Baseline clinical characteristics are presented in Table 1. Approximately two-thirds of patients (66.9%) were male and the mean age was 62±10. More than half of all patients presented with acute coronary syndrome. Diabetes was noted in 30.8% of patients. Echocardiogram was performed in 1,195 patients and left ventricular systolic dysfunction defined as ejection fraction <50% was observed in 17.0% of these patients. No significant differences in the

Table 3. Intraprocedural Complications and Periprocedural Cardiac Enzyme Elevation

	All (n=1,668)	1-stent (n=1,376)	2-stent (n=292)	P value
Intraprocedural complications	13 (0.8)	12 (0.9)	1 (0.3)	0.71
Cardiac death	4 (0.2)	3 (0.2)	1 (0.3)	0.54
Emergency bypass surgery	5 (0.3)	5 (0.4)	0 (0)	0.59
Coronary perforation	4 (0.2)	4 (0.3)	0 (0)	0.99
Cardiac tamponade	1 (0.1)	1 (0.1)	0 (0)	0.99
Peak CK-MB*				
>1×UNL	486 (33.0)	388 (32.5)	98 (35.4)	0.36
>3×UNL	227 (15.4)	181 (15.2)	46 (16.6)	0.55
>5×UNL	162 (11.0)	132 (11.1)	30 (10.8)	0.92

CK-MB, creatine kinase MB fraction; UNL, upper normal limit.
Values are n (%). *Available in 1,471 patients.

Table 4. Long-Term Clinical Outcomes

	All (n=1,668)	1-stent (n=1,376)	2-stent (n=292)	P value
All-cause death	33 (2.0)	27 (2.0)	6 (2.1)	0.92
Cardiac death	15 (0.9)	12 (0.9)	3 (1.0)	0.80
MI	20 (1.2)	15 (1.1)	5 (1.7)	0.37
Stent thrombosis*	11 (0.7)	9 (0.7)	2 (0.7)	0.99
TLR	79 (4.7)	65 (4.7)	14 (4.8)	0.96
TVR	100 (5.9)	83 (6.0)	17 (5.8)	0.89
Any PCI	165 (9.8)	141 (10.2)	22 (7.5)	0.16
CABG	4 (0.2)	3 (0.2)	1 (0.3)	0.54
MACE	106 (6.4)	84 (6.1)	22 (7.5)	0.36

TLR, target lesion revascularization; TVR, target vessel revascularization; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; MACE, major adverse cardiac event, composite of cardiac death, MI and TLR. Other abbreviation see in Table 1.
Values are n (%). *Definite or probable stent thrombosis.

baseline clinical characteristics between the 1-stent and 2-stent groups were found.

Angiographic and procedural data are presented in Table 2. The left anterior descending/diagonal artery was the most frequent index-lesion location. True bifurcation lesions were noted in 1,170 lesions (69.2%). Most lesions were treated with MV stenting alone (1,398 lesions, 82.7%). The left ascending artery/diagonal lesions and true bifurcation lesions were noted more frequently in the 2-stent group compared with the 1-stent group. Among the 2-stent group, T-stenting technique was used most frequently (47.8%) followed by crush technique (34.1%), V-stenting (14.7%) and culotte stenting (3.4%). Final kissing balloon inflation was performed in 32.8% of lesions treated with 1-stent technique and 77.8% of lesions treated with 2-stent technique. IVUS was used in approximately one-third of all lesions. Sirolimus-eluting stent (Cypher, Cordis/Johnson & Johnson, Warren, NJ, USA) was used in 63.3%, paclitaxel-eluting stent (Tauxs, Boston Scientific, Natick, MA, USA) in 33.9% and other DES in 2.8%. Although angiographic success was achieved in 98.8% in the MV, the rate of angiographic success was only 64.1% in the SB.

Clinical Outcomes

Intraprocedural complications occurred in very few patients. Periprocedural cardiac enzyme elevation was noted in 33.0% of patients with elevations more than 3 times the upper normal limit occurring in 15.4% of patients (Table 3). Complete clinical follow-up data were obtained in 97.8% of the overall cohort. One-year all-cause mortality was 1.3%. One-year cardiac death, MI, TLR and MACE rates were 0.7%, 0.8%, 3.4% and 4.5%, respectively. During the follow-up period (median 22 months, interquartile range 15–31 months), 33 patients (2.0%) died. Cardiac death, MI and TLR occurred in 0.9%, 1.2% and 4.7% of patients, respectively, leading to a rate of 6.4% for MACE (Table 4). The MACE and TLR rates were not significantly different between the 1-stent and 2-stent groups (6.1% vs 7.5%, P=0.36 and 4.7% vs 4.8%, P=0.96, respectively) (Figure).

Definite or probable ST was noted in 11 patients (0.7%) during the follow-up period: early ST in 6 patients (0.4%); late in 2 patients (0.1%); and very late in 3 patients (0.4%). The status of dual antiplatelet therapy was available in 97.0% of patients at 1 year after the index procedure. Dual antiplatelet therapy was maintained in 87.9% and 63.4% of patients at 6 months and 1 year, respectively. Only 2 patients had discontinued clopidogrel at the time of the ST. Four patients died from early ST; however, no cardiac death occurred in patients who experienced late or very late ST. The incidence of definite or probable ST was not significantly different between the 1-stent and 2 stent group during the follow-up period (0.7% vs 0.7%, P=0.99).

Independent Predictors of MACE

Multivariate analysis using the Cox hazard model revealed that stent length in the MV (hazard ratio (HR) 1.02, 95% confidence intervals (CI) 1.001 to 1.03, P=0.03), the use of paclitaxel-eluting stents (HR 1.98, 95%CI 1.34–2.92, P=0.001) and final kissing ballooning (HR 2.01, 95%CI 1.29–3.13, P=0.002) were independent predictors of MACE (Table 5).

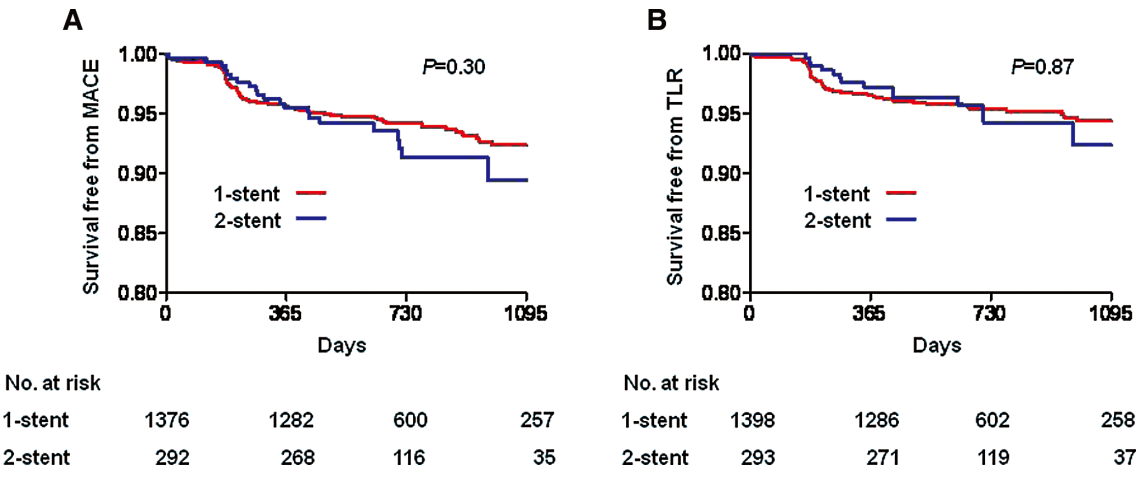

Figure. Kaplan–Meier curves for survival free of (**A**) major adverse cardiac event (MACE) and (**B**) target lesion revascularization (TLR).

Table 5. Independent Risk Factors for MACE and TLR

	HR (95%CI)	P value
MACE		
Final kissing ballooning	2.01 (1.29–3.13)	0.002
Use of paclitaxel-eluting stent	1.98 (1.34–2.92)	0.001
Stent length in the main vessel	1.02 (1.001–1.03)	0.03
TLR		
Final kissing ballooning	3.09 (1.84–5.16)	<0.001
Use of paclitaxel-eluting stent	2.28 (1.45–3.59)	<0.001
Stent length in the main vessel	1.02 (1.01–1.04)	0.01
Stent diameter in the main vessel	0.42 (0.20–0.89)	0.02

HR, hazard ratio; CI, confidence interval. Other abbreviations see in Table 4.

Acute coronary syndrome and stent diameter in the MV had a borderline statistical significance (HR 1.49, 95%CI 0.99–2.25, P=0.06 and HR 0.57, 95%CI 0.31–1.08, P=0.08, respectively). True bifurcation, whether 2-stent technique vs 1-stent technique was used, and SB angiographic success were not significant predictors of the MACE. Final kissing ballooning was not an independent risk factor for MACE in the 2-stent group (HR 0.47, 95%CI 0.16–1.35, P=0.16), but increased risk significantly in the 1-stent group (HR 1.79, 95%CI 1.17–2.74, P=0.007). Independent predictors of TLR were stent diameter and length in the MV (HR 0.42, 95%CI 0.20–0.89, P=0.02 and HR 1.02, 95%CI 1.01–1.04, P=0.01, respectively), use of paclitaxel-eluting stent (HR 2.28, 95%CI 1.45–3.59, P<0.001) and kissing ballooning (HR 3.09, 95%CI 1.84–5.16, P<0.001).

Discussion

In the present study, we investigated real-world practice patterns, long-term clinical outcomes and predictors of adverse outcomes after DES implantation for coronary bifurcation lesions using the largest, dedicated registry data to date. This observational study demonstrated that the majority of lesions were treated with 1-stent strategies and that the overall outcomes after DES implantation were favorable in real-world experience. The long-term clinical outcomes were similar between the 1-stent and 2-stent groups. Independent predictors of MACE were stent length in the MV, stent type and kissing ballooning.

Real-World Registry

Several randomized studies provided valuable insights on treatment strategy and stent technique for bifurcation lesions.[1,4,5] However, practice patterns in real-world experiences might not be adequately reflected by these randomized trials as they consisted of small to medium sample sizes, had a follow-up period of 6–12 months, and collected limited data regarding long-term clinical outcomes. Some of these previous studies focused on 2-stent technique,[10,11] which limits generalization of these study results to real-world patients undergoing PCI on bifurcation lesions considering that 1-stent technique is used predominantly currently. A limited number of studies using real-world data have been reported. However, these studies were not based on registries dedicated to bifurcation lesions and had a sample size inadequate to identify prognostic factors by multivariate analysis, and some of these registry studies reported mixed results with the use of bare-metal stents and DES.[6,7] To date, there has been no dedicated bifurcation registry data reflecting real-world practice patterns with a large sample size. Therefore, we constructed a multicenter registry dedicated to bifurcation lesions treated solely with DES in order to investigate long-term clinical outcomes and predictors of MACE in a real-world practice. Our registry is the largest one ever reported regarding bifurcation lesions and had an excellent follow-up rate.

Overall Clinical Outcomes

One of the main findings of the present study is that long-term clinical outcomes after DES implantation for coronary bifurcation lesions are very promising. During the follow-up period with median of nearly 2 years, the rate of MACE was 6.4% and the incidence of ST was 0.7%, somewhat lower than reported by previous studies. There are several possible explanations for the lower rates of MACE and ST found in our study. First, most lesions were treated with a simple conservative strategy or 1-stent technique in our study. Several randomized trials have demonstrated that complex stenting strategies are no better than simple strategies when treating bifurcation lesions.[4,5] Second, the definition of MACE differs between several previous studies and ours. While periprocedural MI was not included in studies that reported a relatively low MACE rate, such as the present study and the Nordic bifurcation study,[4] it was included in several studies reporting a relatively high MACE rate, such as the SIRIUS bifurcation study[1] and the CACTUS trial (Coronary bifurcations: Application of the Crushing Technique Using Sirolimus-eluting stent).[5] Even in studies reporting a relatively high MACE rate, MI rarely occurred after hospital discharge. In our study, cardiac enzymes were not measured systematically, making it difficult to pick up true peak levels. Therefore, we did not include periprocedural MI in our definition of MACE. Third, prolonged use of thienopyridine might partly explain the relatively low incidence of MACE and ST in the present study. The dual antiplatelet therapy was maintained in 87.9% and 63.4% of patients at 6 months and 1 year, respectively: this is somewhat higher than in the e-Cypher registry which reported 40.3% of patients with dual antiplatelet therapy at 1 year.[12] Clopidogrel therapy was recommended for only 3–6 months and the actual rate of patients on dual antiplatelet therapy was not reported in bifurcation lesion studies conducted before concerns about the safety of DES raised.[1,13,14] Fourth, systematic angiographic follow-up was not performed in this registry. This prevented the 'oculostenotic reflex', which, in turn, prevented inflation of TLR rate. Finally, ethnic differences might contribute to differences between the current and previous studies. The TLR rate at 1 year after sirolimus-eluting stent was only 1.4% in the recent ZEST trial (Park SJ et al, presentation at the late breaking clinical trial session of the American College of Cardiology 58th Annual Scientific Session and i2 Summit), and incidence of definite/probable ST was only 0.91% at 2 years in the j-Cypher registry.[15,16] Regardless of the cause of variance between the current and previous studies, our registry demonstrates favorable long-term clinical outcomes following DES implantation for the treatment of coronary bifurcation lesions in a real-world practice.

One-Stent vs Two-Stent Strategies

There has been paucity of data regarding treatment patterns in real-world practice. In the present study, we report that a simple 1-stent technique was performed in the majority of lesions in a real-world practice. The rate of lesions treated with 1-stent technique in our registry is higher than that reported from several randomized studies[1,5] as well as that from registry data.[6,7] Although differences in baseline characteristics, such as the prevalence of true bifurcation might partly explain difference in the rate of 1-stent technique, temporal change of preference for stent strategy in bifurcation lesions could be reflected.

Several randomized trials and a recent meta-analysis have demonstrated that complex strategies are no better than simple strategies when treating bifurcation lesions.[4,5,17,18] Concordant with previous studies, no difference in MACE rates between the 1-stent and 2-stent group was found in the present study. Our data suggest that most bifurcation lesions can be treated with simple and provisional approach. However, considering the left ascending artery/diagonal lesions and true bifurcation lesions were noted more frequently in the 2-stent group compared with the 1-stent group in the present study, angiographic findings seemed to affect selection of stenting strategies in bifurcation lesions. Two-stent strategy might be required in selected cases with SB of substantial size or complex anatomy.

Predictors of MACE and TLR

Multivariate analysis demonstrated that stent length in the MV, stent type and final kissing ballooning were independent predictors of MACE; stent diameter in the MV was an additional risk factor of TLR. Previous studies reported that the IVUS-measured final minimum stent area and stent length were independent predictors of angiographic restenosis after DES implantation.[19] Although the stent area and length were not assessed by IVUS in the present study, the results that stent diameter and length in the MV were independent predictors of MACE and TLR seemed relevant. Data on comparisons between sirolimus-eluting stents and paclitaxel-eluting stents in bifurcation lesions are scarce. One randomized study reported that restenosis and TLR occurred less frequently in bifurcation lesions treated with sirolimus-eluting stents compared with paclitaxel-eluting stents.[20] Surprisingly, performing kissing ballooning increased the risk of MACE and TLR in 1 stent group of the present study, opposite of what we had predicted. Final kissing ballooning has been reported to be associated with a lower incidence of angiographic restenosis, TLR, MI and ST.[3,5,11] However, the role of final kissing ballooning has been studied mostly after 2-stent strategies including crush stenting in previous studies and data was limited with 1-stent strategies. Considering that most lesions were treated with 1-stent technique in our study, the implications of kissing ballooning might differ according to treatment strategy in bifurcation lesions. Koo et al have suggested that among jailed SB with >75% stenosis, only 37% of lesions were functionally significant.[21] In the present study, treatment strategy of final kissing ballooning might be affected by suboptimal angiographic results. Final kissing ballooning in 1-stent group might increase the SB ostial injury in patients with functionally insignificant stenosis of SB. An adequately powered randomized study would be required to assess the role of final kissing ballooning in the simple stent strategy. Notably, SB angiographic success was achieved only in 64.1% of the treated lesions, but this was not significantly associated with clinical outcomes in our study. In the Nordic study, SB ballooning after MV stenting was only allowed when TIMI flow was less than 3 and was performed in 32% of the simple strategy group, but clinical results were excellent in this subgroup.[4] For SBs of the bifurcation, immediate angiographic result might not be significantly associated with clinical outcomes.

Study Limitations

There are several limitations to our study. First, selection of treatment strategies, stent types and final kissing ballooning were at the discretion of operators. Our findings are subject to selection bias and compounded with unmeasured variables. Second, coronary angiography was analyzed qualitatively, not quantitatively. Detailed quantitative analysis of the angio-

graphic data would be helpful in interpreting our findings and in removing potential confounding effects. Third, although our registry is the largest one reported to date, the number of lesions treated with 2-stent technique was inadequate to perform subgroup analysis. Predictors of MACE might differ according to specific treatment strategies in bifurcation lesions, especially in the case of final kissing ballooning.

Conclusions

In the present study, we investigated the long-term clinical outcomes and predictors of adverse outcomes after DES implantation for the treatment of coronary bifurcation lesions using the data from a large, real-world registry. Simple conservative strategy was used predominantly and the overall outcomes after DES implantation were favorable regardless of 1-stent or 2-stent strategy. Independent predictors of MACE were stent length in the MV, stent type and kissing ballooning. The angiographic success rate in the SB was relatively low; however, this did not have prognostic significance.

Acknowledgements

Name of grants: This work was supported by the Korean Society of Interventional Cardiology, Seoul, Korea.

Clinical Trial Registration Information: clinicaltrials.gov number NCT00851526.

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