Heart Vessels (2016) 31:635–642
DOI 10.1007/s00380-015-0655-3

ORIGINAL ARTICLE

Short- and long-term benefits of drug-eluting stents compared to bare metal stents even in treatment for large coronary arteries

Taiji Yoshida · Kenji Sakata · Yutaka Nitta · Tomio Taguchi · Bunji Kaku · Shoji Katsuda · Masaya Shimojima · Tadatsugu Gamou · Takuya Nakahashi · Tetsuo Konno · Masa-aki Kawashiri · Masakazu Yamagishi · Kenshi Hayashi

Received: 25 July 2014 / Accepted: 27 February 2015 / Published online: 11 March 2015

Abstract Although drug-eluting stents (DES) for percutaneous coronary intervention (PCI) have dramatically reduced the incidence of in-stent restenosis, their deployment for large-size coronary lesions is still controversial because of problems such as late in-stent thrombosis and late catch-up in DES. We aimed to evaluate the long-term outcome beyond 2 years of bare metal stents (BMS) as compared with DES in large vessels. Consecutive 228 patients who underwent PCI with large-size stents (>3.5 mm in diameter) in our hospital were enrolled in this study. The end points of this study are target lesion revascularization (TLR) and occurrence of major adverse cardiac events (MACE) for subject patients. We analyzed 183 patients (152 men, mean age 65.8 ± 10.5 years) whose outcome could be followed up for at least 2 years. At the first 8-month follow-up, clinically driven TLR rate was significantly higher in patients who received BMS than those who received DES (17.2 vs. 2.2 %, $p < 0.05$), although the rate of TLR was not different between the 2 groups beyond 8 months. Thus, overall rate of TLR was higher in BMS than in DES (22.7 vs. 5.4 %, $p < 0.05$). Under these conditions, the higher rate of TLR for BMS was observed in simple as well as complex lesions with or without diabetes, although there were no significant differences in MACE between BMS and DES. Multivariate analysis showed that BMS was an only independent factor of TLR at the 8 month follow-up period [$p = 0.004$, odds ratio 9.58, 95 % confidence interval (2.10–43.8)]. These results demonstrate that the rate of in-stent restenosis in large-size coronary lesions was transiently higher in the first 8 months for patients implanted with BMS compared with DES in which no in-stent thrombosis and TLR beyond 2 years were observed. We suggest using the DES even in large-size coronary lesions in terms of short- and long-term outcomes.

Keywords Coronary intervention · Drug-eluting stent · Bare metal stent · Target lesion revascularization · Long-term prognosis

Drs Yoshida and Sakata have equally contributed to establishing this work.

Electronic supplementary material The online version of this article (doi:10.1007/s00380-015-0655-3) contains supplementary material, which is available to authorized users.

T. Yoshida · Y. Nitta · T. Taguchi · B. Kaku · S. Katsuda
Department of Cardiology, Toyama Red Cross Hospital, Toyama, Japan

T. Yoshida · K. Sakata · M. Shimojima · T. Gamou · T. Nakahashi · T. Konno · M. Kawashiri · K. Hayashi
Division of Cardiovascular Medicine, Kanazawa University Graduate School of Medicine, 13-1 Takara-machi, Kanazawa 920-8641, Japan

M. Yamagishi (✉)
Division of Cardiovascular Medicine, Kanazawa University Graduate School of Medicine, 13-1 Takara-machi, Kanazawa, Ishikawa 920-8640, Japan
e-mail: myamagi@med.kanazawa-u.ac.jp

Introduction

The use of drug-eluting stents (DES) has dramatically reduced in-stent restenosis compared with bare metal stents (BMS) in percutaneous coronary intervention (PCI) [1–4]. A higher rate of in-stent restenosis in BMS than that in DES is associated with small vessel diameter, long lesion, and diabetes, among other factors [5–7]. Under these conditions, the advantage of DES in small-size coronary arteries has been shown in several studies [8–10].

In contrast, it remains controversial whether we should choose DES even for large-size coronary lesions that are >3.5 mm in diameter, because the DES has unsolved problems such as late or very late stent thrombosis [11–14] and late catch-up phenomenon. So far, some studies have analyzed the clinical outcome of DES and BMS in large-size coronary arteries, but follow-up periods in these studies seem too short to conclusively address the problem [15–18]. Although recent studies demonstrate that clinical outcomes were not significantly different between BMS and DES in large-vessel lesions [19, 20], few data exist regarding the impact of stent type on clinical outcomes in terms of both short- and long-term prognoses. Particularly, it is important to determine the use of stents in the left main coronary lesions [21]. Therefore, we analyzed the clinical data of patients who underwent stent implantation in large-size coronary lesions using DES or BMS, and evaluated the clinical outcomes over a 2-year follow-up.

Methods

Patients and treatments

The study protocol was approved by the medical ethics committee of the Toyama Red Cross Hospital. Consecutive patients who underwent PCI in the Toyama Red Cross Hospital with large stents with a diameter of >3.5 mm were enrolled from January 2004 to December 2007. Indications for PCI included stable angina or acute coronary syndrome with elective or emergent procedures. Among them, we analyzed patients whose outcome was followed up for at least 2 years after intervention. Patients with both BMS and DES of diameter of >3.5 mm during this follow-up period were excluded from this study. The patients with large stent in a bypass graft were also excluded in the present study.

Device selection of guidewires, balloon catheters, and coronary stents was made at the discretion of the PCI operator. During PCI with DES or BMS, a bolus infusion of heparin (200 U/kg) was administered to maintain an activated clotting time of more than 200 s. Intravascular ultrasound was used at the operator's discretion. As a standard, dual antiplatelet therapy with aspirin 100–200 mg and clopidogrel 50–75 mg or ticlopidine 200 mg was employed [22]. The duration of dual antiplatelet therapy was at least 12 months.

Clinical follow-up, definitions, and outcome

Patients were evaluated clinically during a follow-up period by visits to outpatient clinics. In patients who did not show up at the outpatient clinic, we mailed questionnaires to them to inquire about any post-PCI events, medications, and other relevant information. The initial follow-up coronary angiography was commonly performed at 8 months after stent implantation. Additional coronary angiography was performed when patients had chest pain, or when the attending cardiologists recommended it as needed for the particular lesion type or clinical background of the patient.

Procedural success was defined as residual stenosis of <25 %. Binary restenosis was defined as stenosis of >50 %. We investigated patients' backgrounds and characteristics such as sex, age, smoking, the presence of obesity (BMI > 25), hypertension (blood pressure > 140/90 mmHg or use of hypotensive drug), hypercholesterolemia (total cholesterol > 220 mg/dl or low-density lipoprotein cholesterol > 140 mg/dl or use of cholesterol lowering medicine), diabetes mellitus (hemoglobin A1c determined by the JDS (Japan Diabetes Society) method > 6.5 %, or use of hypoglycemic medication), and lesion characteristics [23]. Then, we evaluated the occurrence of target lesion revascularization (TLR) and major adverse cardiac events (MACE) defined as cardiac death and nonfatal myocardial infarction. TLR was defined as clinically driven TLR performed when the patient had ischemic symptoms, ischemic electrocardiographic changes at rest, or positive stress test results. In addition, even in the absence of clear ischemia, revascularization for stenosis of ≥70 % which the operator clinically judged an indication of PCI was also considered clinically driven TLR. Cardiac death was defined as any death without a clear noncardiogenic cause. An incidence of in-stent thrombosis in the 2 groups was evaluated according to Academic Research Consortium definitions [24].

Statistical analysis

Continuous variables were expressed as mean ± SD and were compared using Student's t test and analysis of variance. Categorical data were compared using the χ^2 test or Fisher's exact test. Cumulative incidences of TLR were estimated by the Kaplan–Meier method and compared with the log-lank test. Logistic regression analysis was used to assess independent predictors of TLR. Variables with $p < 0.2$ by univariate analysis were included in multivariate logistic regression analysis model. The p values were two sided, and a $p < 0.05$ was considered statistically significant. All data analyses were performed using StatMate IV software (ATMS Institute, Tokyo, Japan).

Results

Among consecutive 228 patients who underwent PCI with large stents, 183 patients (152 men, mean age 65.8 ± 10.5 years) and 238 lesions were eligible to enter our study (Fig. 1). The mean follow-up period was 3.8 ± 1.2 years. Administration of dual antiplatelet therapy

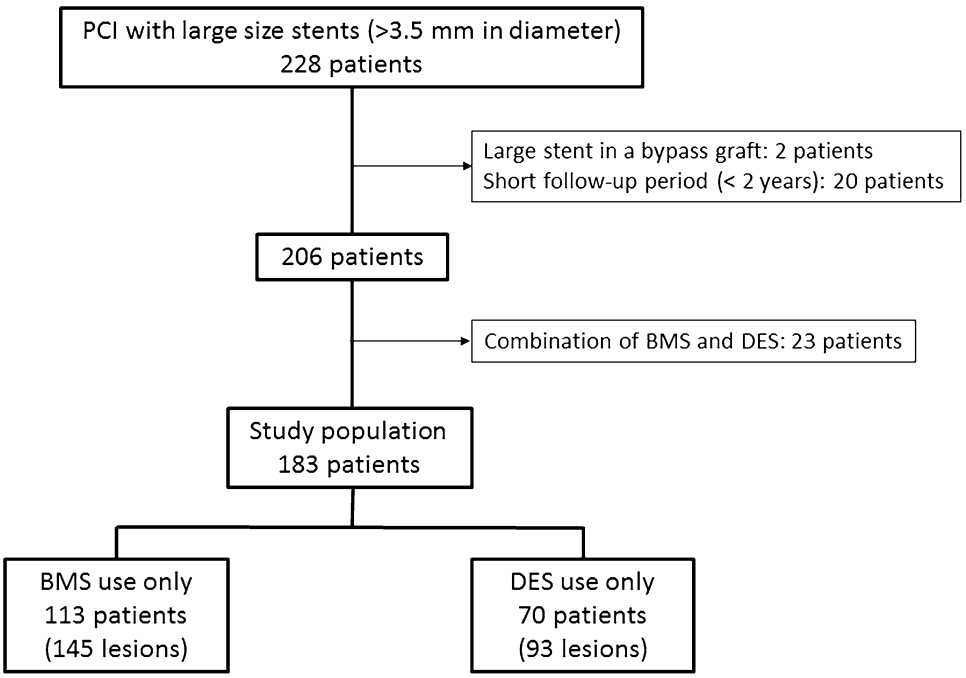

Fig. 1 Patient flowchart of this study population. *PCI* percutaneous coronary intervention, *BMS* bare metal stent, *DES* drug-eluting stent

Table 1 Baseline patient characteristics

	All patients ($n = 183$)	BMS group ($n = 113$)	DES group ($n = 70$)	p value
Age (years)	65.8 ± 10.5	65.5 ± 10.8	66.2 ± 10.0	0.656
Male (%)	152 (83.1)	94 (83.2)	58 (82.9)	0.954
Obesity (%)	83 (45.4)	48 (42.5)	35 (50.0)	0.320
Current smoker (%)	51 (27.9)	34 (30.1)	17 (24.3)	0.395
Hypertension (%)	133 (72.7)	78 (69.0)	55 (78.6)	0.159
Diabetes (%)	60 (32.8)	32 (28.3)	28 (40.0)	0.102
Hypercholesterolemia (%)	90 (49.2)	54 (47.8)	36 (51.4)	0.632
Acute coronary syndrome (%)	69 (37.7)	59 (52.2)	10 (14.3)	<0.05

BMS bare metal stent, *DES* drug-eluting stent

with aspirin and clopidogrel or ticlopidine was confirmed in all patients.

Baseline characteristics

The baseline characteristics of the enrolled patients are shown in Table 1. The frequency of acute coronary syndrome was significantly higher in the BMS group than in the DES group. There were no significant differences in the presence of diabetes, hypertension, active smoking, and obesity between the 2 groups. The lesions and stent characteristics are shown in Table 2. There were no significant differences in lesion types between the 2 groups. The mean diameter of BMS was greater than that of DES. In the DES group, sirolimus-eluting stents (Cypher, Johnson and Johnson, USA) accounted for 89.2 %, and paclitaxel-eluting stents (Taxus, Boston Scientific, USA) for 10.8 %. In the BMS group, Driver stents (Medtronic, USA) accounted for 31.0 %, Multi-link ZETA stents (Abbott, USA) for 13.8 %, and Multi-link VISION (Abbott, USA) for 13.1 %.

Angiographic results

The rate of TLR in each period is shown in Fig. 2. TLR in the first 8-month follow-up period was significantly higher in the BMS group than in the DES group. Between the next 8 and 24 months, the rate of TLR was not significantly different between the 2 groups. Therefore, in a period of over 2 years after stent implantation, the overall TLR rate was higher in the BMS group than in the DES group (22.7 vs. 5.4 %; $p = 0.0004$). Interestingly, irrespective of lesion type, the TLR rate was significantly higher in the BMS group than in the DES group (19.4 vs. 3.1 % for types A and B1 lesions; $p = 0.04$, and 23.7 vs. 6.6 % for

Table 2 Lesion and stent characteristics

	BMS group ($n = 145$ lesions)	DES group ($n = 93$ lesions)	p value
Acute coronary syndrome (%)	75 (51.7)	15 (16.1)	<0.05
AHA/ACC type (%)			
A	2 (1.4)	2 (2.2)	
B1	29 (20.0)	30 (32.3)	0.176
B2	86 (59.3)	46 (49.5)	
C	28 (19.3)	15 (16.1)	
De novo lesion (%)	134 (92.4)	86 (92.4)	0.987
Stent diameter (mm)	3.7 ± 0.2	3.5 ± 0	<0.05
Stent length (mm)	17.1 ± 4.7	18.0 ± 2.6	0.084
Follow-up period (years)	4.0 ± 1.3	3.6 ± 1.0	<0.05

BMS bare metal stent, *DES* drug-eluting stent

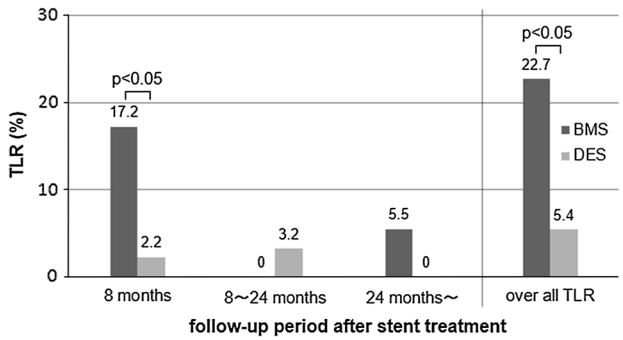

Fig. 2 Target lesion revascularization in each follow-up period. *BMS* bare metal stent, *DES* drug-eluting stent, *TLR* target lesion revascularization

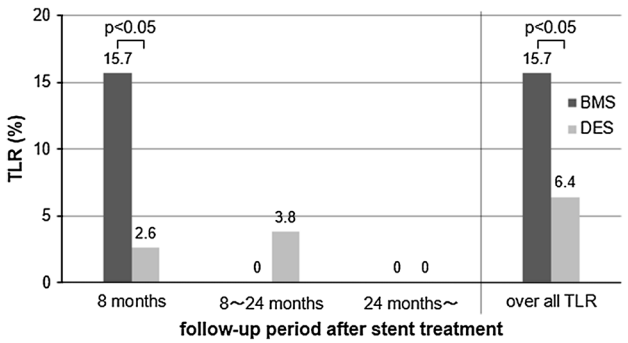

Fig. 4 Target lesion revascularization in non-acute coronary syndrome in each follow-up period. *BMS* bare metal stent, *DES* drug-eluting stent, *TLR* target lesion revascularization

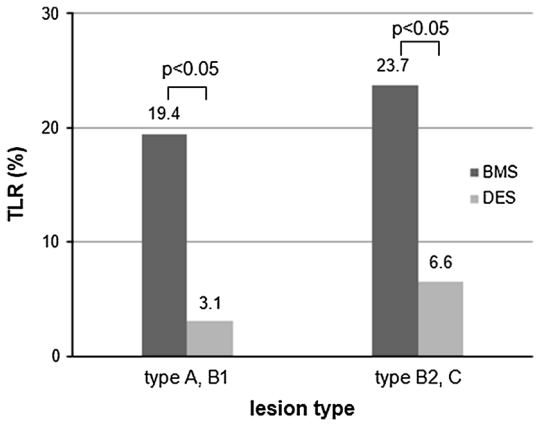

Fig. 3 Target lesion revascularization in each lesion type. *BMS* bare metal stent, *DES* drug-eluting stent, *TLR* target lesion revascularization

types B2 and C lesions; $p = 0.005$) (Fig. 3). Furthermore, in subgroups with or without diabetes, TLR rate was also significantly different between the BMS and DES groups (28.3 vs. 2.9 % for the presence of diabetes; $p = 0.003$, and 20.2 vs. 6.8 % for the absence of diabetes; $p = 0.023$). On the other hand, when subgroup analysis was performed in short lesion (stent length < 18 mm without stent overlap), there was a trend toward higher TLR rate in the BMS group compared with the DES group (16.7 vs. 4.5 %; $p = 0.054$).

Because it is possible that the higher TLR rate for the BMS group in the early phase could be due to a higher number of patients with acute coronary syndrome, the same analysis was performed in patients who did not have ACS. Under these conditions, the TLR rate was also significantly higher in the BMS group than in the DES group at the 8-month follow-up (15.7 vs. 2.6 %; $p = 0.005$) and overall for the entire follow-up period (15.7 vs. 6.4 %; $p = 0.0001$) (Fig. 4). There were no statistical differences in TLR between BMS and DES in patients with ACS due to shortage of TLR.

Long-term clinical outcomes

Cumulative incidence of TLR was significantly lower in the DES group than the BMS group ($p < 0.001$) (Fig. 5). There were no significant differences in the incidence of MACE between the BMS and DES groups (3.5 vs. 2.9 %; $p = 0.80$). However, 2 patients suffered from very late

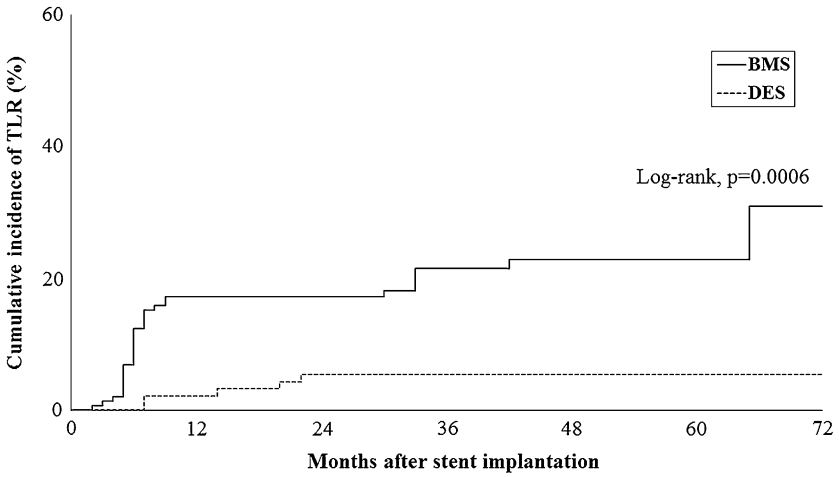

Fig. 5 Cumulative incidence of target lesion revascularization. *BMS* bare metal stent, *DES* drug-eluting stent, *TLR* target lesion revascularization

Table 3 Factors related to target lesion revascularization at around 8 months

	Odds ratio	95 % CI	*p* value
Univariate analysis			
Men	1.20	0.38–3.76	0.75
Obesity	1.14	0.50–2.59	0.75
Smoking	1.36	0.57–3.26	0.49
Hypertension	0.71	0.30–1.71	0.45
Diabetes	0.84	0.35–2.05	0.71
Hypercholesterolemia	0.95	0.42–2.16	0.91
Bare metal stent	9.66	2.21–42.2	0.0004
Acute coronary syndrome	1.98	0.87–4.50	0.10
Type B2 or C lesion	2.19	0.72–6.70	0.17
Multivariate analysis			
Bare metal stent	9.58	2.1–43.8	0.004
Acute coronary syndrome	0.97	0.39–2.40	0.95
Type B2 or C lesion	2.00	0.61–6.61	0.25

CI confidence interval

stent thrombosis in the BMS group, although there were no patients with such events in the DES group. One patient had elective gastroduodenal endoscopy with 1 week discontinuation of dual antiplatelet therapy at 2.8 years after stent implantation. In another patient, stent thrombosis occurred at 5.5 years after stenting while receiving aspirin.

Predictors of target lesion revascularization

Multiple logistic regression analysis, including BMS, acute coronary syndrome, and complex lesion (type B2 or C lesion), as covariates, confirmed that BMS was independently associated with TLR at the 8-month follow-up [$p = 0.004$, odds ratio 9.58, 95 % confidence interval (2.10–43.8)] (Table 3). In the present study, the incidence of ACS was more frequently found in BMS, thus resulting in some bias for the results. After excluding ACS, BMS was again found to be an independent factor for TLR (Supplemental Table).

Discussion

In this study, we compared the short- and long-term results over 2 years between BMS and DES in lesions requiring large coronary stents >3.5 mm in diameter. Overall, TLR rates were significantly higher in the BMS group than in the DES group, although there were no significant differences in the incidence of MACE between the two groups. Interestingly, the incidence of short-term TLR, transiently observed within 8 months after stent implantation, was higher in the BMS group than in the DES group. These results demonstrate that we should choose DES even in a large-size coronary artery >3.5 mm in diameter.

A series of previous studies showed no significant differences in the rate of TLR and MACE between BMS and DES in patients requiring large coronary stents [15–18]. However, follow-up periods in these studies seemed to be relatively short to support their conclusions, because the late catch-up phenomenon and very late stent thrombosis could occur more than 1 year after stent implantation. In this study, the mean follow-up period in all patients was 3.8 ± 1.2 years. Under these conditions, the TLR rates were higher in BMS than in DES in the initial 8 months of follow-up, thus yielding overall higher TLR in BMS-implanted lesions.

Recent studies reported that there was no difference in TLR between BMS and DES in large coronary lesions [19, 20]. In this point of view, our results might be explained by the protocol in which follow-up coronary angiography at 8 months was routinely performed. Especially in diabetic patients, TLR might be even higher in BMS than in DES as reported by a previous study [4].

It might be important that the benefit from DES may differ between men and women [25]. In our study, there was no significant difference in gender between the BMS and DES group, although most patients were of male gender. However, we would suggest performing a further study to compare the advantage of DES in Japanese men and women.

Importantly, two patients suffered from very late stent thrombosis in the BMS group. Generally, BMS is superior to DES in terms of stent thrombosis. A previous study reported that the rate of stent thrombosis was 0.34 % at 30 days, 0.54 % at 1 year, and 0.77 % at 2 years after DES implantation in a Japanese cohort [14]. Another study reported that an increase in inflammatory cytokines in the late phase after implantation of DES was shown and this might result in abnormal wound healing [26], although the use of DES could suppress the excessive intimal proliferation in accordance with out-stent plaque suppression [27]. Nonetheless, late or very late stent thrombosis may occur in the BMS group in case of large coronary arteries as in our cases and another study [28]. Positive remodeling and rupture of neoatherosclerosis in-stent segment might have been associated with late or very late BMS thrombosis [29]. Moreover, in our cases, BMS thrombosis occurred in patients with diabetes, and long lesion required multiple overlapped stents. From these results, these conditions could promote stent thrombosis not only in DES, but also in BMS in large coronary arteries.

In the present study, TLR was higher in BMS than in DES for simple lesions as well as in complicated lesions in large coronary arteries, suggesting BMS implantation in large coronary arteries might be inferior to DES in every type of lesion. Furthermore, we previously reported that in terms of PCI for the left main coronary, which should be the largest vessel in the coronary tree, the incidence of TLR was much greater with BMS for complex lesions than that with DES for simple lesions [21]. A previous study had shown that atherosclerotic progression of neointimal proliferation inside a BMS was observed with intravascular ultrasound over the long term, and this would be the potential for adverse clinical events [30]. A higher inflation pressure and/or greater balloon size for post-dilatation may be responsible for excessive neointimal proliferation, possibly contributing to higher incidence of TLR in BMS in the larger coronary arteries. Therefore, DES may be superior to BMS in terms of neointimal suppression even in large coronary lesions.

There remain several limitations in the present study. First, the number of patients enrolled in this study was relatively small. However, clearly significant differences were observed in the overall TLR rates between BMS and DES in the early phase after implantation into large coronary artery lesions. Second, the retrospective and non-randomized study design implies some degree of selection bias. However, it should be noted that the outcome was demonstrated in consecutive patients in our hospital, and so these results might reflect a real-world population. A future large-scale trial will be necessary to confirm any definitive conclusions on this subject. Third, we presented only stent size instead of vessel size or plaque volume which might be related to the occurrence of TLR [27]. However, even under these conditions, there was significant difference in TLR in early phase after stent implantation. Fourth, the present study consisted of patients treated with first-generation stents. However, the present results provide an important clinical implication regarding the selection of the next-generation stents.

Conclusion

The present study demonstrates that even in coronary lesions requiring large-size stents, the rate of TLR in DES was significantly reduced compared with BMS in the early phase after stent implantation, and that there was no increased risk of unfavorable prognosis associated with DES during the follow-up period beyond 2 years. We would suggest that DES might be encouraged in the treatment of even large-size coronary lesions, if patients do not have any associated diseases that would preclude the use of these stents.

Conflict of interest We have no conflict of interest to declare.

References

1. Morice MC, Serruys PW, Sousa JE, Fajadet J, Ban Hayashi E, Perin M, Colombo A, Schuler G, Barragan P, Guagliumi G, Molnàr F, Falotico R (2002) A randomized comparison of a sirolimus-eluting stent with a standard stent for coronary revascularization. N Engl J Med 346:1773–1780
2. Moses JW, Leon MB, Popma JJ, Fitzgerald PJ, Holmes DR, O'Shaughnessy C, Caputo RP, Kereiakes DJ, Williams DO, Teirstein PS, Jaeger JL, Kuntz RE (2003) Sirolimus-eluting stents versus standard stents in patients with stenosis in a native coronary artery. N Engl J Med 349:1315–1323
3. Stone GW, Ellis SG, Cox DA, Hermiller J, O'Shaughnessy C, Mann JT, Turco M, Caputo R, Bergin P, Greenberg J, Popma JJ, Russell ME (2004) A polymer-based, paclitaxel-eluting stent in patients with coronary artery disease. N Engl J Med 350:221–231
4. Uchiyama K, Ino H, Hayashi K, Fujioka K, Takabatake S, Yokawa J, Namura M, Mizuno S, Tatami R, Kanaya H, Nitta Y, Michishita I, Hirase H, Ueda K, Aoyama T, Okeie K, Haraki T, Mori K, Araki T, Minamoto M, Oiwake H, Konno T, Sakata K, Kawashiri M, Yamagishi M, Heart Research Group of Kanazawa (2011) Impact of severe coronary disease associated or not associated with diabetes mellitus on outcome of interventional treatment using stents: results from HERZ (Heart Research Group of Kanazawa) analyses. J Int Med Res 39:549–557

5. Mehran R, Dangas G, Abizaid AS, Mintz GS, Lansky AJ, Satler LF, Pichard AD, Kent KM, Stone GW, Leon MB (1999) Angiographic patterns of in-stent restenosis: classification and implications for long-term outcome. Circulation 100:1872–1878
6. Elezi S, Dibra A, Mehilli J, Pache J, Wessely R, Schömig A, Kastrati A (2006) Vessel size and outcome after coronary drug-eluting stent placement: results from a large cohort of patients treated with sirolimus- or paclitaxel-eluting stents. J Am Coll Cardiol 48:1304–1309
7. Wykrzykowska JJ, Serruys PW, Onuma Y, de Vries T, van Es GA, Buszman P, Linke A, Ischinger T, Klauss V, Corti R, Eberli F, Wijns W, Morice MC, di Mario C, van Geuns RJ, Juni P, Windecker S (2009) Impact of vessel size on angiographic and clinical outcomes of revascularization with biolimus-eluting stent with biodegradable polymer and sirolimus-eluting stent with durable polymer the LEADERS trial substudy. JACC Cardiovasc Interv 2:861–870
8. Ardissino D, Cavallini C, Bramucci E, Indolfi C, Marzocchi A, Manari A, Angeloni G, Carosio G, Bonizzoni E, Colusso S, Repetto M, Merlini PA (2004) Sirolimus-eluting versus uncoated stents for prevention of restenosis in small coronary arteries: a randomized trial. JAMA 292:2727–2734
9. Schampaert E, Cohen EA, Schlüter M, Reeves F, Traboulsi M, Title LM, Kuntz RE, Popma JJ (2004) The Canadian study of the sirolimus-eluting stent in the treatment of patients with long de novo lesions in small native coronary arteries (C-SIRIUS). J Am Coll Cardiol 43:1110–1115
10. Puymirat E, Mangiacapra F, Peace A, Sharif F, Conte M, Bartunek J, Vanderheyden M, Wijns W, de Bruyne B, Barbato E (2011) Long-term clinical outcome in patients with small vessel disease treated with drug-eluting versus bare-metal stenting. Am Heart J 162:907–913
11. McFadden EP, Stabile E, Regar E, Cheneau E, Ong AT, Kinnaird T, Suddath WO, Weissman NJ, Torguson R, Kent KM, Pichard AD, Satler LF, Waksman R, Serruys PW (2004) Late thrombosis in drug-eluting coronary stents after discontinuation of antiplatelet therapy. Lancet 364:1519–1521
12. Daemen J, Wenaweser P, Tsuchida K, Abrecht L, Vaina S, Morger C, Kukreja N, Jüni P, Sianos G, Hellige G, van Domburg RT, Hess OM, Boersma E, Meier B, Windecker S, Serruys PW (2007) Early and late coronary stent thrombosis of sirolimus-eluting and paclitaxel-eluting stents in routine clinical practice: data from a large two-institutional cohort study. Lancet 369:667–678
13. Kastrati A, Mehilli J, Pache J, Kaiser C, Valgimigli M, Kelbaek H, Menichelli M, Sabaté M, Suttorp MJ, Baumgart D, Seyfarth M, Pfisterer ME, Schömig A (2007) Analysis of 14 trials comparing sirolimus-eluting stents with bare-metal stents. N Engl J Med 356:1030–1039
14. Kimura T, Morimoto T, Nakagawa Y, Tamura T, Kadota K, Yasumoto H, Nishikawa H, Hiasa Y, Muramatsu T, Meguro T, Inoue N, Honda H, Hayashi Y, Miyazaki S, Oshima S, Honda T, Shiode N, Namura M, Sone T, Nobuyoshi M, Kita T, Mitsudo K (2009) Antiplatelet therapy and stent thrombosis after sirolimus-eluting stent implantation. Circulation 119:987–995
15. Steinberg DH, Mishra S, Javaid A, Slottow TL, Buch AN, Roy P, Okabe T, Smith KA, Torguson R, Xue Z, Pichard AD, Satler LF, Kent KM, Suddath WO, Waksman R (2007) Comparison of effectiveness of bare metal stents versus drug-eluting stents in large (> or =3.5 mm) coronary arteries. Am J Cardiol 99:599–602
16. Yan BP, Ajani AE, New G, Duffy SJ, Farouque O, Shaw J, Sebastian M, Lew R, Brennan A, Andrianopoulos N, Reid C, Clark DJ (2008) Are drug-eluting stents indicated in large coronary arteries? Insights from a multi-centre percutaneous coronary intervention registry. Int J Cardiol 130:374–379
17. Yang YJ, Kang S, Xu B, Chen JL, Qiao SB, Qin XW, Yao M, Chen J, Wu YJ, Liu HB, Yuan JQ, You SJ, Li JJ, Dai J, Gao RL (2008) Short- and long-term outcomes of single bare metal stent versus drug eluting stent in nondiabetic patients with a simple de novo lesion in the middle and large vessel. J Transl Med 6:42
18. Na JO, Kim JW, Choi CU, Choi UJ, Shin SY, Lim HE, Kim EJ, Rha SW, Park CG, Seo HS, Oh DJ (2009) Bare-metal stents versus drug-eluting stents in large (≥3.5 mm) single coronary artery: angiographic and clinical outcomes at 6 months. J Cardiol 54:108–114
19. Hsieh MJ, Chen CC, Chang SH, Wang CY, Lee CH, Lin FC, Chang CJ, Hsieh IC (2013) Long-term outcomes of drug-eluting stents versus bare-metal stents in large coronary arteries. Int J Cardiol 168:3785–3790
20. Chan CY, Vlachos H, Selzer F, Mulukutla SR, Marroquin OC, Abbott DJ, Holper EM, Williams DO (2014) Comparison of drug-eluting and bare metal stents in large coronary arteries: findings from the NHLBI dynamic registry. Catheter Cardiovasc Interv 84:24–29
21. Kawashiri MA, Sakata K, Uchiyama K, Konno T, Namura M, Mizuno S, Tatami R, Kanaya H, Nitta Y, Michishita I, Hirase H, Ueda K, Aoyama T, Okeie K, Haraki T, Mori K, Araki T, Minamoto M, Oiwake H, Ino H, Hayashi K, Yamagishi M (2014) Impact of lesion morphology and associated procedures for left main coronary stenting on angiographic outcome after intervention: sub-analysis of Heart Research Group of Kanazawa, HERZ, Study. Cardiovasc Interv Ther 29:117–122
22. Nakamura M, Yamagishi M, Ueno T, Hara K, Ishiwata S, Itoh T, Hamanaka I, Wakatsuki T, Sugano T, Kawai K, Kimura T (2013) Current antiplatelet therapy for Japanese patients with ST elevation acute myocardial infarction: J-AMI registry. Cardiovasc Interv Ther 28:162–169
23. Smith SC Jr, Dove JT, Jacobs AK, Kennedy JW, Kereiakes D, Kern MJ, Kuntz RE, Popma JJ, Schaff HV, Williams DO, Gibbons RJ, Alpert JP, Eagle KA, Faxon DP, Fuster V, Gardner TJ, Gregoratos G, Russell RO, Smith SC Jr (2001) ACC/AHA guidelines for percutaneous coronary intervention (revision of the 1993 PTCA guidelines)—executive summary: a report of the American College of Cardiology/American Heart Association task force on practice guidelines (Committee to revise the 1993 guidelines for percutaneous transluminal coronary angioplasty) endorsed by the Society for Cardiac Angiography and Interventions. Circulation 103:3019–3041
24. Cutlip DE, Windecker S, Mehran R, Boam A, Cohen DJ, van Es GA, Steg PG, Morel MA, Mauri L, Vranckx P, McFadden E, Lansky A, Hamon M, Krucoff MW, Serruys PW, Academic Research Consortium (2007) Clinical end points in coronary stent trials: a case for standardized definitions. Circulation 115:2344–2351
25. Hansen KW, Kaiser C, Hvelplund A, Soerensen R, Madsen JK, Jensen JS, Pedersen SH, Eberli FR, Erne P, Alber H, Pfisterer M, Galatius S, BASKET PROVE Investigators (2013) Improved 2-year outcomes after drug-eluting versus bare-metal stent implantation in women and men with large coronary arteries: importance of vessel size. Int J Cardiol 169:29–34
26. Taguchi I, Yoneda S, Abe S, Toyoda S, Nasuno T, Nishino S, Kageyama M, Tokura M, Ogawa M, Node K, Inoue T (2014) The late-phase inflammatory response after drug-eluting stent implantation. Heart Vessels 29:213–219
27. Tada H, Kawashiri MA, Sakata K, Takabatake S, Tsubokawa T, Konno T, Hayashi K, Uchiyama K, Ino H, Yamagishi M (2012) Impact of out-stent plaque volume on in-stent intimal hyperplasia: results from serial volumetric analysis with high-gain intravascular ultrasound. Int J Cardiol 12:235–239
28. Doyle B, Rihal CS, O'Sullivan CJ, Lennon RJ, Wiste HJ, Bell M, Bresnahan J, Holmes DR Jr (2007) Outcomes of stent thrombosis and restenosis during extended follow-up of patients treated with bare-metal coronary stents. Circulation 116:2391–2398

29. Hasegawa K, Tamai H, Kyo E, Kosuga K, Ikeguchi S, Hata T, Okada M, Fujita S, Tsuji T, Takeda S, Fukuhara R, Kikuta Y, Motohara S, Ono K, Takeuchi E (2006) Histopathological findings of new in-stent lesions developed beyond 5 years. Catheter Cardiovasc Interv 68:554–558

30. Tanaka S, Noda T, Iwama M, Tanihata S, Kawasaki M, Nishigaki K, Minagawa T, Watanabe S, Minatoguchi S (2013) Long-term changes in neointimal hyperplasia following implantation of bare metal stents assessed by integrated backscatter intravascular ultrasound. Heart Vessels 28:415–423