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Original Article

The efficacy and safety of domestic and imported rapamycin drug-eluting stents and paclitaxel drug-coated balloons in the treatment of coronary bifurcation lesions

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Abstract: Objective: The study was designed to analyze the efficacy and safety of domestic and imported rapamycin drug-eluting stents (DES) and paclitaxel drug-coated balloons (DCB) in the treatment of coronary bifurcation lesions. Methods: A total of 98 patients with coronary bifurcation lesions treated in our hospital from January 2019 to December 2019 were recruited as the study cohort and divided into four groups according to the different treatment method each patient underwent, including group A (n=25, treated with domestic rapamycin DES), group B (n=21, treated with imported rapamycin DES), group C (n=29, treated with domestic paclitaxel DCB), and group D (n=23, treated with imported paclitaxel DCB). The minimum lumen diameters (MLD), the diameter stenosis rates, the late lumen losses (LLLs), and the incidence of adverse events in each group were compared. Results: The MLD in the four groups were increased immediately after the surgeries and at nine months after the surgeries (P<0.05), and the diameter stenosis rates were decreased (P<0.05). However, there were no significant differences in the MLD or the diameter stenosis rates among the four groups before the surgeries, immediately after the surgeries, or at nine months after the surgeries (P>0.05). The LLLs of groups A and B were significantly higher than the LLLs of groups C and D (P<0.05). Compared with the incidences of major adverse cardiovascular events (16.00% vs. 14.29% vs. 13.79% vs. 17.39%) and the incidences of restenosis (8.00% vs. 4.76% vs. 6.90% vs. 4.35%) in groups A, B, C, and D, there were no significant differences (P>0.05). Conclusion: Domestic and imported rapamycin DES and paclitaxel DCB can effectively improve MLD, reduce the diameter stenosis rate, and have fewer adverse events in the treatment of coronary bifurcation lesions, and domestic and imported paclitaxel DCB have lower LLLs.

Keywords: Rapamycin, drug-eluting stents, paclitaxel, drug-coated balloons, coronary bifurcation lesions

Introduction

A study has shown that about 15%-20% of coronary artery diseases are coronary bifurcation lesions [1]. Coronary artery disease is a common disease in percutaneous coronary intervention (PCI), accounting for about 15%-20% of PCI [2]. Due to its special anatomy and hemodynamics, coronary bifurcation lesion surgery has a low success rate and a high rate of postoperative restenosis and complications. In recent years, drug-eluting stents (DES) have been used in the interventional treatment of coronary bifurcation lesions. Compared with bare metal stents (BMS), the incidence of restenosis of DES has been significantly reduced, and patient prognosis has also been significantly improved after the treatment. However, some problems - such as late thrombosis and late restenosis of the side branches - have not been effectively resolved.

Although the DES double stent surgery has good results immediately after the surgery, the operation is difficult, the radiation dose is relatively large, and the long-term effect is equivalent to that of the single stent surgery. Therefore, there is still a tendency to choose single stent surgery for coronary bifurcation lesions, that is, stent implantation in the main branch [3]. Drug-

coated balloons (DCB) provide a new treatment option for coronary bifurcation lesions. The balloon catheter is used as a drug release carrier to release anti-proliferative drugs into the coronary arteries when the balloon is expanded, which inhibits vascular intimal hyperplasia [4]. Compared with DES, the release of DCB is more uniform, and there is no foreign body implantation, so the incidence of blood vessel formation is relatively low, and the duration of dual antiplatelet therapy is relatively short [5].

Rapamycin can inhibit the proliferation and migration of the endothelial cells, reduce the intimal proliferation after vascular injury, decrease the concentration and duration of the drug acting on the lesion, and reduce the risk of intravascular restenosis [6]. Compared with paclitaxel, rapamycin has the advantages of safety, a wider treatment range, anti-inflammatory effects, and a unique inhibitory effect on the cells [7]. At present, our hospital has rapamycin DES and paclitaxel DCB, and there is still controversy about the choice of treatment for coronary bifurcation lesions. Based on this, this study compared the efficacy and safety of domestic and imported rapamycin DES and paclitaxel DCB in the treatment of coronary bifurcation lesions, in order to provide a reference for the clinical treatment of coronary bifurcation lesions.

Information and methods

General information

A total of 98 patients with coronary bifurcation lesions treated in our hospital from January 2019 to December 2019 were recruited as the study cohort and divided into four groups according to the different treatment methods, including group A (n=25), group B (n=21), group C (n=29), and group D (n=23). Inclusion criteria: ① Patients with coronary bifurcation disease confirmed using coronary angiography, and ② Patients between 18 and 80 years old. Exclusion criteria: ① Patients with severe calcification or acute myocardial infarction, ② Patients with persistent atrial fibrillation, ③ Patients with severe renal failure, heart failure, or other organ dysfunction, ④ Patients with malignant tumors or a survival time less than one year, ⑤ Patients unable to be treated with DCB or DES, ⑥ Patients who were intolerant to the dual antiplatelet therapy, and ⑦ Patients who were lost to follow-up or who withdrew from the study. This study was approved by the Ethics Committee of The Third Affiliated Hospital of Nanchang University. The patients and their families were informed of the study, and they signed the informed consent forms.

Methods

Group A was implanted with Paclitaxel DCB (Orchid & Dhalia) from Beijing Acotec Scientific Co. Ltd, and group B was implanted with Paclitaxel DCB (SeQuentPlease) from B. Braun Melsungen AG Germany. Before the surgeries, 200 μg of nitroglycerin was injected intravenously into the coronary artery. The diameter of each DCB was 0.8-1.0 of the diameter of the blood vessel. Adhering expansion was carried out for at least 45 seconds. When the DCB was expanded, a nominal pressure of 7-8 atm was used. The DCB had to cover the length of the pre-treated neck and 2-3 mm beyond the edges of both sides. Within two minutes of opening the DCB, it was delivered to the lesion and released. Dual antiplatelet therapy (100 mg/d aspirin + 75 mg/d clopidogrel) was used after the surgeries for at least six months, after which 100 mg/d aspirin was used for the long-term.

Group C was implanted with rapamycin DES (Nano) from Beijing LEPU Medical, and group D was implanted with rapamycin DES (Xience Xpedition series) from Abbott, USA. A stent of appropriate length was selected according to the length of each patient's blood vessel. The surgeons determined the opening or the precise positioning of the bifurcation during the surgery. According to the stent adhesion, the appropriate pressure was selected for expansion, and the surgeons decided whether to use non-compliant balloon expansion and the expansion pressure based on the actual situation of the patients. Criteria for successful surgery: there was no obvious stenosis in the postoperative angiography, no occlusion of the branch vessel opening, no thrombosis or intimal tearing, and the blood flow of the thrombolysis in the myocardial infarction (TIMI) of the main branch and branch vessel was grade 3. After the surgeries, dual antiplatelet therapy was used for 12 months, after which aspirin was used long-term.

Observation indices

The quantitative results of the coronary angiography before the surgeries, immediately after

Table 1. Comparison of the baseline data among the four groups ($\bar{x}\pm s$; *n*, %)

Groups		Group A (n=25)	Group B (n=21)	Group C (n=29)	Group D (n=23)	F/χ^2	*P*
Age (year)		58.66±8.55	59.15±10.02	58.33±9.45	59.14±10.34	0.044	0.988
Gender	Male	13 (52.00)	11 (52.38)	15 (51.72)	12 (52.17)	0.135	0.713
	Female	12 (48.00)	10 (47.62)	14 (48.28)	11 (47.83)		
BMI (kg/m^2)		25.55±3.21	26.44±2.99	26.61±3.74	25.37±2.35	0.969	0.411
PCI history		14 (56.00)	12 (57.14)	17 (58.62)	14 (60.87)	0.038	0.845
Myocardial infarction		13 (44.83)	9 (42.86)	14 (48.28)	11 (47.83)	0.165	0.684
Hypertension		13 (52.00)	12 (57.14)	15 (51.72)	14 (60.87)	0.165	0.684
Diabetes		8 (32.00)	6 (28.57)	9 (31.03)	6 (26.09)	0.041	0.839
Smoking		9 (36.00)	8 (38.1)	10 (34.48)	9 (39.13)	0.031	0.861
CCS classification	Grade I	9 (36.00)	7 (33.33)	10 (34.48)	8 (34.78)	1.056	0.304
	Grade II	13 (52.00)	11 (52.38)	16 (55.17)	14 (60.87)		
	Grade III	2 (8.00)	2 (9.52)	2 (6.9)	2 (8.7)		
	Grade IV	1 (4.00)	1 (4.76)	1 (3.45)	1 (4.35)		
Medina type	1,1,1	20 (80.00)	16 (76.19)	22 (75.86)	18 (78.26)	0.341	0.559
	1,1,0	3 (12.00)	3 (14.29)	4 (13.79)	3 (13.04)		
	1,0,1	2 (8.00)	2 (9.52)	3 (10.34)	2 (8.7)		
Target vessel	LAD	21 (84.00)	17 (80.95)	24 (82.76)	19 (82.61)	0.140	0.708
	LCX	4 (16.00)	4 (19.05)	5 (17.24)	4 (17.39)		

Note: LAD is the anterior descending branch, and LCX is the circumflex branch.

the surgeries, and at nine months after the surgeries were recorded, including the minimum lumen diameters (MLD), the target reference vessel diameters (RVD), and the diameter stenosis rates = (RVD-MLD)/RVD × 100%; late lumen loss (LLL) nine months after the surgeries, the restenosis rate (after the interventional treatment, the coronary angiography showed that the blood vessel diameter re-narrowed ≥ 50%), and the incidence of major adverse cardiovascular events (MACE) during the 1-year follow-up were recorded.

Statistical methods

The statistical analysis of the data was processed using SPSS 22.0. The count data were expressed as (n, %) and χ^2 tests were used. The measurement data were expressed as $\bar{x}\pm s$. One-way analyses of variance (ANOVA) were used for the comparisons between multiple groups, and LSD-t tests were used for the pairwise comparisons between groups. For the comparisons at different time points, the variance analysis of repeated measurement data was used to analyze the inter-group differences and the time differences of the measured values at each time point, and LSD-t tests were performed afterwards. The statistical graphs were plotted using GraphPad Prism 8. $P<0.05$ was considered statistically significant.

Results

Baseline data

There was no significant difference among the four groups in terms of the baseline data, such as age, gender, body mass index (BMI), PCI history, myocardial infarction, hypertension, diabetes, smoking, Canadian Cardiovascular Society (CCS) angina pectoris classification, Medina type, or target vessel ($P>0.05$) (**Table 1**).

MLD and the diameter stenosis rates

Repeated measurements showed that the MLD and diameter stenosis rates were significantly different in terms of their time-points and inter-group interactions ($P<0.05$). The LSD-t tests afterwards showed that the MLD of the four groups were increased immediately after the surgeries and at nine months after the surgeries compared with their pre-surgery levels ($P<0.05$), and the diameter stenosis rate was decreased compared with its pre-surgery rate ($P<0.05$). However, there was no significant dif-

Table 2. Comparisons of the four groups' MLD at different time points (mm; $\bar{x}\pm s$)

Groups	Number of patients	Before surgery	Immediately after surgery	9 months after surgery
Group A	25	0.39±0.13	2.82±0.29[a]	2.48±0.46[a]
Group B	21	0.42±0.14	2.78±0.32[a]	2.26±0.53[a]
Group C	29	0.45±0.15	2.77±0.34[a]	2.45±0.53[a]
Group D	23	0.38±0.12	2.76±0.31[a]	2.41±0.44[a]
F		$F_{\text{time point}}$=3453.946, $F_{\text{interaction}}$=0.946, $F_{\text{inter-group}}$=0.433		
P		$P_{\text{time point}}$<0.001, $P_{\text{interaction}}$=0.464>0.05, $P_{\text{inter-group}}$=0.730>0.05		

Note: Compared with before the surgeries, [a]*P*<0.05.

Table 3. Comparison of the diameter stenosis rates of the four groups at different time points (%; $\bar{x}\pm s$)

Groups	Number of patients	Before surgery	Immediately after surgery	9 months after surgery
Group A	25	77.35±13.65	9.42±2.87[a]	13.03±3.58[a]
Group B	21	78.85±13.63	9.95±2.56[a]	12.24±3.79[a]
Group C	29	78.68±13.39	9.58±2.13[a]	12.51±3.13[a]
Group D	23	78.28±13.01	9.66±2.97[a]	12.46±3.04[a]
F		$F_{\text{time point}}$=1577.190, $F_{\text{interaction}}$=0.335, $F_{\text{inter-group}}$=0.023		
P		$P_{\text{time point}}$<0.001, $P_{\text{interaction}}$=0.918>0.05, $P_{\text{inter-group}}$=0.995>0.05		

Note: Compared with before the surgeries, [a]*P*<0.05.

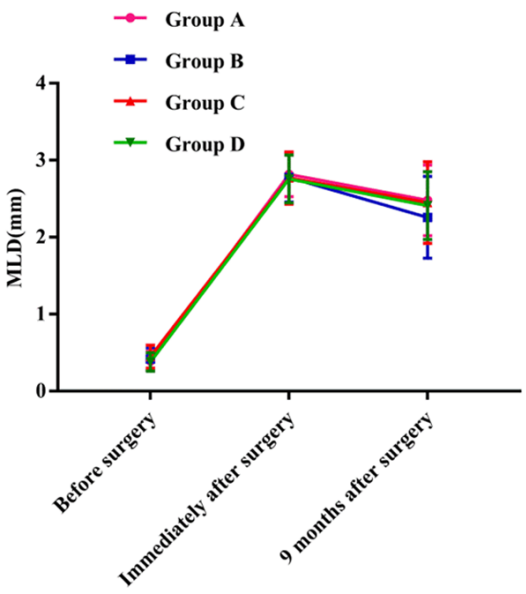

Figure 1. Comparisons of the four groups' MLD at the different time points. This figure shows that the differences in the four groups' MLD before the surgeries, immediately after the surgeries, and at nine months after the surgeries were not significant (*P*>0.05).

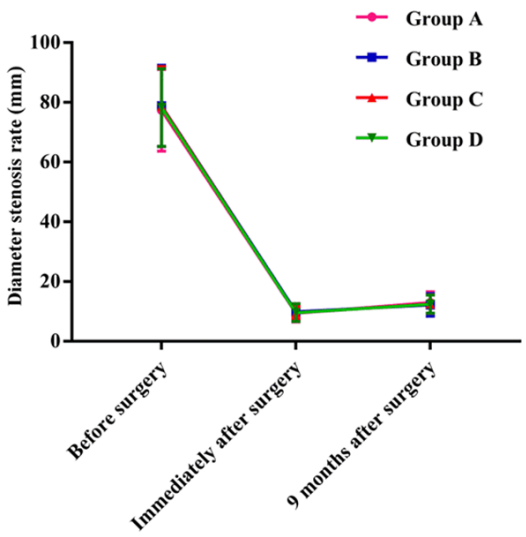

Figure 2. Comparison of diameter stenosis rates in the four groups at the different time points. This figure shows that the differences in the four groups' diameter stenosis rates before the surgeries, immediately after the surgeries, and at nine months after the surgeries were not significantly different (*P*>0.05).

ference in the MLD or the diameter stenosis rate before the surgeries, immediately after the surgeries, or at nine months after the surgeries (*P*>0.05) (**Tables 2** and **3**; **Figures 1** and **2**).

LLLs

Compared with group C [(0.37±0.12) mm] and group D [(0.35±0.11) mm], the LLLs of group A

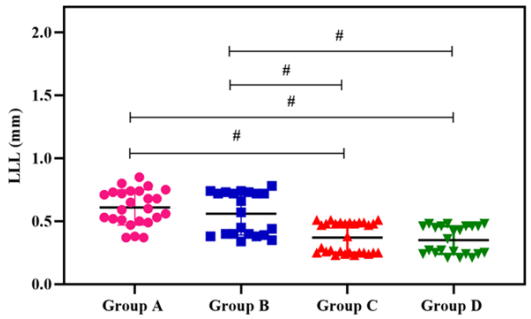

Figure 3. Comparison of the four groups' LLLs. This figure shows that the LLLs in groups A and B were significantly higher than the LLLs in groups C and D ($P<0.05$). $^{\#}P<0.05$.

[(0.61±0.14) mm] and group B [(0.56±0.17) mm] were significantly higher ($P<0.05$) (**Figure 3**).

The incidence of adverse events

Compared with the incidences of MACE (16.00% vs. 14.29% vs. 13.79% vs. 17.39%) and the incidences of restenosis (8.00% vs. 4.76% vs. 6.90% vs. 4.35%) among groups A, B, C, and D, there was no significant difference ($P>0.05$) (**Table 4**).

Discussion

The most commonly-used standard treatment for coronary bifurcation lesions is sent placement in the main branch of the vessel, and sent placement on the side branches when necessary, safe treatments that have a good clinical effectiveness. However, there is no standard treatment method for coronary bifurcation lesions of the distal main branch. The main reason is that the distal main branch lesions are mostly small blood vessels and orifice lesions. It is difficult for the stent to be accurately fixed, and it is prone to plaque displacement. Therefore, the treatment plan needs to be formulated according to the actual situation of each patient. Rapamycin is a new type of coating drug for DES. It is a fat-soluble macrolide antibiotic with a strong immunosuppressive effect. It can bind to FKBP12 and inhibit the activity of the protein kinase of the target of rapamycin (TOR), and it can enhance the activity of P27 and hinder the transformation of the cell cycle from the G1 phase to the S phase, thereby inhibiting the migration and proliferation of the smooth muscle cells (VSMC), and ultimately and effectively preventing restenosis in the stent [8-11].

DCB spreads the drug evenly on the surface of the balloon, delivers the drug to the lesion through the catheter, and expands the balloon coated with the anti-VSMC proliferation drug, releases drugs to the lesions of the vascular wall in a short time, and allows the tissue to absorb the drugs, thus playing a role in the treatment of the bifurcation lesions [12-14].

This study compared domestic (Nano from Beijing LEPU Medical) and imported (Xience Xpedition series from Abbott, USA) rapamycin DES, domestic (Orchid & Dhalia from Beijing Acotec Scientific Co. Ltd) and imported (SeQuentPlease from B. Braun Melsungen AG Germany) paclitaxel DCB in the treatment of coronary bifurcation lesions. The results showed that the MLD of the four groups was increased, and the diameter stenosis rates of the four groups were decreased immediately after the surgeries and at nine months after surgeries. However, there were no significant differences in the MLD or diameter stenosis rates of the four groups before the surgeries, immediately after the surgeries, or at nine months after the surgeries. The results of the study showed that the four methods of domestic and imported rapamycin DES, and domestic and imported paclitaxel DCB for the treatment of coronary bifurcation lesions can effectively reduce MLD and the diameter stenosis rate, and the treatment effect is significant. Cai et al. [15] reported that DES has a better effect on reducing the diameter stenosis rate than DCB, which was somewhat different from this study, and this may be caused by the small sample size included in this study. LLL is an indicator used to evaluate intimal hyperplasia [16]. In this study, the LLLs of groups A and B were significantly higher than the LLLs of groups C and D. The results of the study showed that paclitaxel DCB is better than rapamycin DES at inhibiting intimal hyperplasia, and both the domestic and imported paclitaxel DCB have the same effect. This can be attributed to the fact that the balloon is placed on the lesion after the drug application, and then it is expanded and its pressure is increased to tear apart the diseased blood vessels and the vascular intima, allowing the drug to combine with the subunits of cell tubulin, causing microtubule

Table 4. The MACE and restenosis incidences in the four groups (*n*, %)

Groups	Number of patients	MACE			Restenosis
		Angina pectoris	Heart failure	Total MACE	
Group A	25	3 (12.00)	1 (4.00)	4 (16.00)	2 (8.00)
Group B	21	2 (9.52)	1 (4.76)	3 (14.29)	1 (4.76)
Group C	29	3 (10.34)	1 (3.45)	4 (13.79)	2 (6.9)
Group D	23	3 (13.04)	1 (4.35)	4 (17.39)	1 (4.35)
χ^2		0.071	0.692	0.064	0.247
P		0.790	0.405	0.800	0.619

dysfunction, thereby exerting the anti-vascular intimal hyperplasia effect [17, 18]. Paclitaxel is the most-commonly used drug for DCB coatings, as it can reduce the proliferation of the neointimal membrane and inhibit cell proliferation. It not only has the characteristics of tissue retention and high lipophilicity, it can also quickly pass through the cell membrane and bind to the subunits of the cell tubulin, thus inhibiting cell proliferation, division, and migration [19, 20]. This study also analyzed the incidence of restenosis and MACE and followed up the patients for 1 year at 9 months after the surgeries. The results showed that there were no significant differences in the incidences of MACE (16.00% vs. 14.29% vs. 13.79% vs. 17.39%) or the incidences of restenosis (8.00% vs. 4.76% vs. 6.90% vs. 4.35%) in groups A, B, C, and D. Studies have shown that rapamycin DES can effectively reduce the incidence of MACE and restenosis [21, 22]. DCB is not implanted with a stent foreign body, which can reduce the inflammatory reaction of the intima and greatly reduce the incidence of thrombosis. The duration of the dual antiplatelet therapy after DCB is shorter than it is with DES, and it can reduce the risk of bleeding [23-25]. Therefore, the above four methods for treating coronary bifurcation lesions have low incidences of restenosis and MACE, and they are safe.

In summary, the four methods of domestic and imported rapamycin DES and domestic and imported paclitaxel DCB for the treatment of coronary bifurcation lesions can effectively improve MLD, reduce the diameter stenosis rate, and have fewer adverse events and higher therapeutic effects and safety. The domestic and imported paclitaxel DCB have lower LLLs. Therefore, for the clinical treatment of coronary artery bifurcation lesions, domestic rapamycin DES and paclitaxel DCB can be as safe and reliable as imported rapamycin DES and paclitaxel DCB, so patients can choose the appropriate treatment method according to their actual situations. However, this study's cohort was relatively small, so there may be some data bias. In addition, the study lacked intravascular ultrasound imaging data, so further study cannot be carried out. Therefore, further studies with large study cohorts and intravascular ultrasound data are needed to verify our conclusions.

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Disclosure of conflict of interest

None.

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References

[1] Fan Z, Liu X, Zhang P, Gu J, Ye X and Deng X. Transfer of low-density lipoproteins in coronary artery bifurcation lesions with stenosed side branch: numerical study. Comput Math Methods Med 2019; 2019: 5297284.

[2] Chang CF, Chang KH, Lai CH, Lin TH, Liu TJ, Lee WL and Su CS. Clinical outcomes of coronary artery bifurcation disease patients underwent culotte two-stent technique: a single center experience. BMC Cardiovasc Disord 2019; 19: 208.

[3] Cui KY, Lyu SZ, Song XT, Yuan F, Xu F, Zhang M, Zhang MD, Wang W, Zhang DF, Dai J, Tian JF

and Wang YL. Long term outcomes of drug-eluting stent versus coronary artery bypass grafting for left main coronary artery disease: a meta-analysis. J Geriatr Cardiol 2018; 15: 162-172.
[4] Megaly M, Rofael M, Saad M, Shishehbor M and Brilakis ES. Outcomes with drug-coated balloons for treating the side branch of coronary bifurcation lesions. J Invasive Cardiol 2018; 30: 393-399.
[5] Tepe G, Micari A, Keirse K, Zeller T, Scheinert D, Li P, Schmahl R and Jaff MR. Drug-coated balloon treatment for femoropopliteal artery disease: the chronic total occlusion cohort in the IN.PACT global study. JACC Cardiovasc Interv 2019; 12: 484-493.
[6] Duvvuri M, Motz K, Murphy M, Feeley M, Ding D, Lee A, Elisseeff JH and Hillel AT. Engineering an immunomodulatory drug-eluting stent to treat laryngotracheal stenosis. Biomater Sci 2019; 7: 1863-1874.
[7] Zhao Y, Du R, Zhou T, Yang D, Huang Y, Wang Y, Huang J, Ma X, He F, Qiu J and Wang G. Arsenic trioxide-coated stent is an endothelium-friendly drug eluting stent. Adv Healthc Mater 2018; 7: e1800207.
[8] Sun H, Wang S and Song M. Long non-coding RNA SENCR alleviates the inhibitory effects of rapamycin on human umbilical vein endothelial cells. Mol Med Rep 2018; 18: 1405-1414.
[9] Kim Y, Park JK, Seo JH, Ryu HS, Lim KS, Jeong MH, Kang DH and Kang SW. A rapamycin derivative, biolimus, preferentially activates autophagy in vascular smooth muscle cells. Sci Rep 2018; 8: 16551.
[10] Uhrin P, Wang D, Mocan A, Waltenberger B, Breuss JM, Tewari D, Mihaly-Bison J, Huminiecki Ł, Starzyński RR, Tzvetkov NT, Horbańczuk J and Atanasov AG. Vascular smooth muscle cell proliferation as a therapeutic target. Part 2: natural products inhibiting proliferation. Biotechnol Adv 2018; 36: 1608-1621.
[11] Farah S. Protective layer development for enhancing stability and drug-delivery capabilities of DES surface-crystallized coatings. ACS Appl Mater Interfaces 2018; 10: 9010-9022.
[12] Iida O, Soga Y, Urasawa K, Saito S, Jaff MR, Wang H, Ookubo H and Yokoi H. Drug-coated balloon vs standard percutaneous transluminal angioplasty for the treatment of atherosclerotic lesions in the superficial femoral and proximal popliteal arteries: one-year results of the MDT-2113 SFA Japan randomized trial. J Endovasc Ther 2018; 25: 109-117.
[13] Kokkinidis DG, Hossain P, Jawaid O, Alvandi B, Foley TR, Singh GD, Waldo SW, Laird JR and Armstrong EJ. Laser atherectomy combined with drug-coated balloon angioplasty is associated with improved 1-year outcomes for treatment of femoropopliteal in-stent restenosis. J Endovasc Ther 2018; 25: 81-88.
[14] Shiraishi J, Koshi N, Matsubara Y, Nishimura T, Shikuma A, Shoji K, Ito D, Kimura M, Kishita E, Nakagawa Y, Hyogo M and Sawada T. Stentless percutaneous coronary intervention using rotational atherectomy and drug-coated balloon: a case series and a mini review. Cardiovasc Revasc Med 2018; 19: 705-711.
[15] Cai JZ, Zhu YX, Wang XY, Bourantas CV, Iqbal J, Zhu H, Cummins P, Dong SJ, Mathur A and Zhang YJ. Comparison of new-generation drug-eluting stents versus drug-coated balloon for in-stent restenosis: a meta-analysis of randomised controlled trials. BMJ Open 2018; 8: e017231.
[16] Sakamoto Y, Yamawaki M, Araki M, Kobayashi N, Mori S, Tsutsumi M, Honda Y, Hirano K and Ito Y. Comparison of 12-month angiographic outcomes between repeat drug-eluting stent implantation and drug-coated balloon treatment for restenotic lesion caused by stent fracture. Heart Vessels 2019; 34: 1589-1594.
[17] Mitomo S, Jabbour RJ, Mangieri A, Ancona M, Regazzoli D, Tanaka A, Giannini F, Carlino M, Montorfano M, Chieffo A, Latib A and Colombo A. Mid-term clinical outcomes after bailout drug-eluting stenting for suboptimal drug-coated balloon results: insights from a Milan registry. Int J Cardiol 2018; 263: 17-23.
[18] Xu Y, Jia X, Zhang J, Zhuang B, Fu W, Wu D, Wang F, Zhao Y, Guo P, Bi W, Wang S and Guo W. Drug-coated balloon angioplasty compared with uncoated balloons in the treatment of 200 Chinese patients with severe femoropopliteal lesions: 24-month results of AcoArt I. JACC Cardiovasc Interv 2018; 11: 2347-2353.
[19] Elmariah S, Ansel GM, Brodmann M, Doros G, Fuller S, Gray WA, Pinto DS, Rosenfield KA and Mauri L. Design and rationale of a randomized noninferiority trial to evaluate the SurVeil drug-coated balloon in subjects with stenotic lesions of the femoropopliteal artery - the TRANSCEND study. Am Heart J 2019; 209: 88-96.
[20] Milnerowicz A, Milnerowicz A, Kuliczkowski W and Protasiewicz M. Rotational atherectomy plus drug-coated balloon angioplasty for the treatment of total in-stent occlusions in iliac and infrainguinal arteries. J Endovasc Ther 2019; 26: 316-321.
[21] Sun H, Liu CZ, Liu C, Tang M, Cao G, Zhang Q and Gu X. Employing the sirolimus-eluting poly (propylene carbonate) mesh for the prevention of arteriovenous graft stenosis in rats. J Cardiovasc Pharmacol Ther 2019; 24: 269-277.
[22] Kim YH, Her AY, Jeong MH, Kim BK, Lee SY, Hong SJ, Ahn CM, Kim JS, Ko YG, Choi D, Hong MK and Jang Y. One-year clinical outcomes be-

tween biodegradable-polymer-coated biolimus-eluting stent and durable-polymer-coated drug-eluting stents in STEMI patients with multivessel coronary artery disease undergoing culprit-only or multivessel PCI. Atherosclerosis 2019; 284: 102-109.

[23] Boitet A, Grassin-Delyle S, Louedec L, Dupont S, Lamy E, Coggia M, Michel JB and Coscas R. An experimental study of paclitaxel embolisation during drug coated balloon angioplasty. Eur J Vasc Endovasc Surg 2019; 57: 578-586.

[24] Hsieh CA, Chou SH, Chen IC, Jang SJ, Chou HH, Ko YL and Huang HL. Feasibility and mid-term outcomes of drug-coated balloon angioplasty between intermittent claudication and critical limb ischemia in patients with femoropopliteal disease. Acta Cardiol Sin 2019; 35: 308-319.

[25] Liao MT, Lee CP, Lin TT, Jong CB, Chen TY, Lin L, Hsieh MY, Lin MS, Chie WC and Wu CC. A randomized controlled trial of drug-coated balloon angioplasty in venous anastomotic stenosis of dialysis arteriovenous grafts. J Vasc Surg 2020; 71: 1994-2003.