International Journal of Chinese Medicine
2022; 6(1): 8-14
http://www.sciencepublishinggroup.com/j/ijcm
doi: 10.11648/j.ijcm.20220601.12
ISSN: 2578-9465 (Print); ISSN: 2578-9473 (Online)

Review Article

Comparison of Drug-eluting Balloon Versus Drug-eluting Stent in de Novo Coronary Artery Disease: A Systematic Review and Meta-analysis

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To cite this article:

Cao Mingkun, Yinyuxia, Wang Zhiyong, Zhang Haijun. Comparison of Drug-eluting Balloon Versus Drug-eluting Stent in de Novo Coronary Artery Disease: A Systematic Review and Meta-analysis. *International Journal of Chinese Medicine*. Vol. 6, No. 1, 2022, pp. 8-14. doi: 10.11648/j.ijcm.20220601.12

Received: September 1, 2021; **Accepted**: September 16, 2021; **Published**: January 28, 2022

Abstract: *Background*: Drug- eluting balloon (DEB) and drug- eluting stent (DES) are widely used in cardiovascular interventional surgery. But the long-term safety of DEB is unclear. *Objective*: To compare the efficacy and safety of DEB with DES for the treatment of de novo coronary artery disease (CAD). *Methods*: We conducted a meta-analysis of relevant studies identified in the Pubmed, Embase, and Cochrane Library databases. Random and fixed effects models were used to calculate the relative risks (RR) and standard mean differences (SMD) with 95% confidence intervals. *Results*: Nine studies in 1946 patients were included in this analysis. There was no significant difference in the primary endpoint of major adverse cardiovascular events (MACE) or in the efficacy endpoint of late lumen loss (LLL) between the DEB and DES groups. For follow-up < 12 months, there was no significant difference between DEB and DES for each MACE component, including target lesion revascularization (TLR), stent thrombosis (ST), myocardial infarction (MI), and death. However, a lower risk for MI and death was observed for DEB when the follow-up time was ≥ 12 months. *Conclusion*: DEB is equivalent to DES for the treatment of patients with de novo CAD and appears to represent a safer option for long-term treatment of this patient population.

Keywords: Drug-eluting Balloon, Drug-eluting Stent, De Novo Coronary Artery Disease

1. Introduction

The outcome of a recent meta analysis [1] has raised concerns about the use of paclitaxel drug-coated devices such as DES and DCB in femoropopliteal artery occlusive disease, and in the treatment of peripheral arterial disease and coronary artery disease (CAD) in general. DES is an important part of interventional treatment for occlusive CAD [2, 3] and both clinical studies and real-world data have shown that it can significantly reduce the rate of delayed restenosis or late restenosis compared with bare metal stents (BMS) [4, 5]. However, the there are some challenges for DES, including delayed healing, endothelial dysfunction, need for long-term dual antiplatelet therapy (DAPT), late ST, and persistent restenosis, which can mainly be attributed to the permanent placement of non-degradable stent platforms [6, 7]. These limitations of DES have spurred the developments of the latest advancement in percutaneous coronary interventions (PCI) including bioabsorbable vascular scaffolds (BVS) and DEB. DEB was first indicated for the treatment of in-stent restenosis (ISR) according to ESC/EACTS guidelines on myocardial revascularization (Class IIA, Level B) in 2014 [8]. Soon afterwards, several clinical studies examined the efficiency of DEB for the

treatment of ISR, bifurcation, and small vessel diseases [9, 10]. The benefit of DEB in the treatment of ISR has been demonstrated in several randomized trials. However, compared with DES, the role of DEB in the treatment of de novo lesions remains unclear, as previous studies have been limited by small sample sizes and no unanimous conclusion has been reached. Additionally, evidence for the long-term outcomes of DEB use are insufficient. In the current meta-analysis, we sought to systematically examine the safety and efficiency of DEB in the treatment of de novo CAD and to clarify the potential indications, benefits, and limitations of this treatment strategy.

2. Method

2.1. Literature Search Strategy

We searched the Embase, PubMed, and Cochrane Library databases up to 19 October 2019 to identify potential studies in any language using the following key words: "drug coated balloon" OR 'drug eluting balloon" AND "drug coated stent" OR "drug eluting stent". All included studies had been approved by an ethics and institutional review committee. The present analysis was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

2.2. Selection Criteria and Data Extraction

The inclusion criteria were (1) randomized controlled trial (RCT) or observational study; (2) patients with de novo CAD; and (3) patients treated with DEB and DES. Exclusion criteria were (1) patients with stent restenosis; (2) intervention of DEB plus BMS; (3) incomplete endpoint data; and (4) systematic review or meta-analysis studies.

2.3. Quality Assessment

We evaluated the quality of randomized trials using the Cochrane Collaboration risk-of-bias tool. [11] The evaluation included randomization and allocation concealment, blinding of participants and researchers, blinding of outcome assessments, reporting on dropouts, and selective reporting (Table 1). The quality of observational studies was evaluated using the Newcastle–Ottawa Scale (NOS). [12]

2.4. Endpoints

The primary endpoint was MACE, which included safety outcomes such as TLR, MI, death, ST. The secondary endpoint and efficacy outcome was LLL (calculated as the difference of in-stent minimal lumen diameter [MLD] between measurements immediately after the procedure and at follow-up). Target ST was defined as new angiographically verified coronary occlusion in a previously treated lesion. The components of MACE in each study are listed in Table 2. Death was defined as all-cause death. Where data on all-cause death were not available, the most appropriate available endpoint (e.g. cardiac death) was used.

2.5. Data Synthesis and Analysis

We conducted the meta-analysis using R software (version 3.4.4, "meta" package; R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/). The relative risk (RR) and 95% confidence interval (CI) were calculated for categorical variables and standard mean difference (SMD) with 95% CI for continuous variables. I^2 represented heterogeneity among studies, with $I^2 > 50\%$ considered as heterogeneity. We performed sensitivity analyses to identify reasons for variability. If the reason for variability could not be determined, a random effects model was used; otherwise, a fixed effects model was used. Egger tests were used to assess publication bias, with values of $P < 0.05$ considered statistically significant.

3. Results

3.1. Characteristics of Included Studies

Out of a total of 2553 potential studies screened, 9 studies including 1946 patients were eligible for inclusion. [13–22] Figure 1 shows the screening process for studies. Among the included 9 studies, there were 6 RCTs and 3 observational studies. All included patients had de novo CAD. The main endpoints were specified for all included trials, with follow-up durations of 1–36 months. Table 1 shows the characteristics of the included studies.

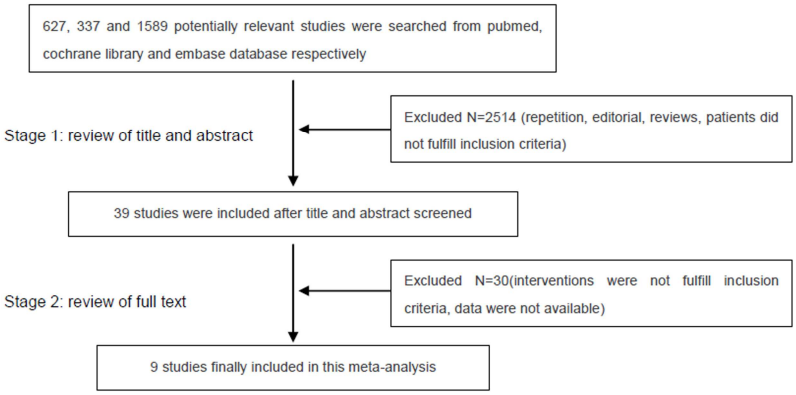

Figure 1. *The screening process for studies.*

Table 1. *Characteristics of included studies.*

Study Year	Design	Intervention	Patients	Age, year	Reference diameter, mm	Setting	Primary endpoint (follow-up, mts)	MACE (follow-up, mts)
Ali et al 2011	randomised	SeQuent™ Please DEB	45	62.9±8.1	2.78±0.32	CAD in diabetics	In-segment LLL (9)	TLR, MI, ST, cardiac death (9)
		Taxus™ Liberté™, IN.PACT Falcon DES	39	58.4±9.8	2.75±0.30			
BELLO 2012, 2015	randomised	IN.PACT Falcon DEB	90	64.8±8.5	2.15±0.27	small vessel de novo CAD	in-stent/ (in-balloon) LLL (6)	death, MI, TLR (6, 12, 24, 36)
		Taxus Liberte´ DES	92	66.4±9.0	2.26±0.24			
PICCOLETO 2010	randomised	Dior DEB	28	68±9	2.45±0.28	small vessel de novo CAD	per cent diameter stenosis (6)	death, Q-wave MI, TLR (9)
		Taxus Libertè DES	29	67±10	2.36±0.25			
Sinaga et al 2016	observational	SeQuent Please DEB	172	61.0±11.8	2.22±0.30	small vessel de novo CAD	Not mention	Death, MI, revascularization (12)
		Resolute Integrity, Xience Biomatrix DES	163	61.2±10.7	2.44±0.18			
Gobić et al 2017	randomised	SeQuent PleaseDEB	37	54.3±10.6	2.61±0.49	STEMI	LLL and MACE (6)	cardiac death, reinfarction, TLR, ST (6)
		Biomime DES	38	56.6±13.2	3.04±0.46			
Her et al 2018	observational	SeQuent Please DEB	54	57.6±9.5	2.7±0.4	Single-vessel de novo CAD	Not mention	cardiac death, MI, TLR, TVR, ST (12)
		Newer-generation DES	54	58.9±10.4	2.8±0.4			
Jeger et al 2018	randomised	SeQuent Please DEB	382	67.2±10.3	2~3	small vessel de novo CAD	MACE (12)	cardiac death, non-fatal MI, TVR (12)
		Xience/ Taxus Element DES	376	68.4±10.3				
Nishiyama et al 2016	randomised	SeQuent Please DEB	30	67.30±11.12	2.88±0.57	chronic CAD	Not mention	Not mention
		Xience Prime/Xpedition, Abbott Vascular DES	30	70.63±8.97	2.72±0.64			
Sim et al 2018	observational	SeQuent Please/Neo, In.Pact Falcon DEB	87	58.1±11.9	1.88±0.38	very small vessel de novo CAD	occurrence and time to TLF (1, 6, 12)	cardiac death, MI, TLR (1, 6, 12)
		Xience Xpedition SV/Alpine, Resolute Onyx DES	200	61.3±11.2	1.95±0.21			

3.2. Safety Endpoints

MACE There was no significant difference in risk for MACE between the DEB and DES subgroups (<12 months: RR, 0.92; 95% CI, 0.58–1.45; ≥ 12 months: RR, 0.80; 95% CI, 0.60–1.07). *TLR* The incidence of TLR was similar for both the DEB and DES subgroups (<12 months: RR, 0.96; 95% CI, 0.53–1.76; ≥ 12 months: RR, 0.80; 95% CI, 0.52–1.24). *MI* There was no significant difference in the rate of MI between DEB and DES in the < 12 months follow-up subgroups (RR, 0.42; 95% CI, 0.13–1.37). However, when the follow-up time was ≥ 12 months, the rate of MI in the DEB group was significantly lower than that in the DES group (RR, 0.55; 95% CI, 0.33–0.92; P=0.023). *ST* There was no significant difference in ST rate between the DEB and DES subgroups (<12 months: RR, 0.51; 95% CI, 0.13–2.00; ≥ 12 months: RR, 0.25; 95% CI, 0.01–4.68).

Death There was no significant difference in death rate between the DEB and DES < 12 months follow-up subgroups (RR, 0.82; 95% CI, 0.34–1.98). However, DEB was associated with a significantly lower death rate than DES at ≥ 12 months of follow-up (RR, 0.45; 95% CI, 0.25–0.82; P=0.009).

3.3. Efficiency Endpoints

LLL DEB was associated with a lower incidence of LLL compared with DES (SMD, −0.44; 95% CI, (−0.91)–0.03)) although the difference was not statistically significant.

3.4. Quality Assessment

The quality assessment of randomized trials is presented in Table 2. The quality scores for the observational studies (Sinaga et al., 13 Her et al., 14 and Sim et al. 15) were 7, 8, and 8 respectively.

Table 2. *Quality assessment of randomized studies included in the meta-analysis.*

Study	Randomization/allo-cation concealment	Blinding of participants /researchers	Blinding of outcome assessment	Incomplete outcome data	Selective reporting
Ali et al [16]	L	U	U	L	L
BELLO et al [17, 18]	L	L	H	L	L
PICCOLETO et al [19]	L	H	L	L	L
Gobić et al [20]	L	U	U	L	L
Jeger et al [21]	L	L	U	L	L
Nishiyama et al [22]	L	L	U	L	L

H=high risk of bias, L=low risk of bias, U=unclear risk of bias.

3.5. Sensitivity Analysis

A sensitivity analysis was conducted at endpoints when $I^2 >$ 50%. For LLL, we sequentially eliminated one study at a time and observed that the study of Gobić et al. [20] had a strong influence on heterogeneity. We did not eliminate this study, however, because of the low number of studies included in the analysis.

3.6. Publication Bias

The Egger test showed no evidence of significant publication bias between the groups with respect to MACE (P=0.739) and LLL (P=0.500).

3.7. RR and 95% CI for MACE

The RR for MACE (0.92 vs 0.80), ST (0.51 vs 0.25), and TLR (0.96 vs 0.80) showed no statistically significant difference between DEB and DES. However, RR showed a downward trend with extended follow-up time. For follow-up < 12 months, the safety data for MI and death were similar between DEB and DES, but DEB was associated with a lower risk for MI and death when the follow-up time was ≥ 12 months. (Figure 2)

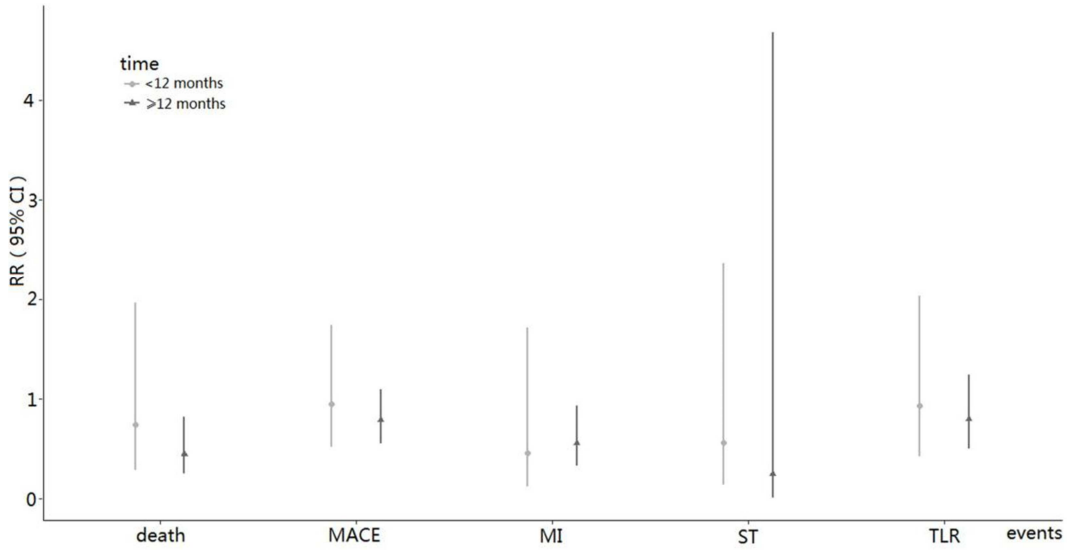

Figure 2. *The RR and 95% CI.*

4. Discussion

This meta-analysis was conducted to evaluate the safety and efficacy of a DEB-only strategy in the treatment of de novo CAD. The main findings are summarized as follows: 1) DEB-only usage demonstrated an efficacy equivalent to DES usage in treating de novo CAD; 2) the analysis of short-term follow-up (<12 months) data showed that there was no significant difference between DEB and DES with respect to the rate of MACE, TLR, MI, ST, and death; 3) a reduced risk for MI and death (MI: RR, 0.55; 95% CI, 0.33–0.92; P=0.023; death: RR, 0.45; 95% CI, 0.25–0.82; P=0.009) was observed for DEB compared with DES for follow-up ≥ 12 months. However, larger trials are needed to confirm these findings. At present, DES implantation remains the first choice for the treatment of CAD. [2, 3, 23, 24] Despite significant advances in DES technology, a limitation of DES use is its permanent foreign stent platform and coating which may lead to chronic inflammation, late stent thrombosis, ISR, and stent strut fracture. In clinical practice, almost 5% of patients treated with DES experience ISR, and the rate of MACE is approximately 10%–20% in this patient population. Furthermore, prolonged DAPT is typically required in these patients and may lead to the gastrointestinal bleeding. In specific patients with complex vessel lesions such as small vessel disease and bifurcation lesions, or with diabetes as a comorbidity, a higher incidence of MACE was observed. Compared with DES, DEB had a greater contact area and delivered higher paclitaxel doses (300–600 μg/mm^2), thus ensuring more uniform drug delivery to the vascular wall. Furthermore, the shorter endothelial healing time associated with DEB can reduce the duration of DAPT from 12 months to 3 months and lower the risk of bleeding and thrombosis. [25] The effectiveness of DEB compared with standard DES use has been confirmed in the treatment of ISR [26-28]. For patients with de novo CAD, particularly small vessel disease and bifurcation lesions, the choice of therapeutic method remains unclear. Kleber et al. [29] and Nakatani et al. [30] have highlighted that limitations such as acute elastic recoil can restrict the application of DEB. However, other studies have shown promising results for DEB. Ali et al., [16] Sinaga et al., [13] the PICCOLETO trial, [19] and Jeger et al. [21] reported no statistically significant difference between DEB and DES for MACE; Sinaga et al., [13] Nishiyama et al., [22] and Her et al. [14] indicated similar TLR rates; and similar rates of LLL and death were reported by Nishiyama et al. [22] and Her et al., [14] respectively. Moreover, the results of the BELLO trial [17, 18] favoured DEB, reporting a lower LLL at 6 months of follow-up and a lower MACE rate at 36 months of

follow-up compared with DES. Given the inconsistencies in the outcomes of previous studies, we analysed the relevant research to determine whether DEB was superior to DES in the treatment of de novo CAD. Although several studies on de novo CAD have been reported, few have taken follow-up time into account. In the current meta-analysis, patients with small vessel disease, non-small vessel disease, STEMI, diabetes, and other forms of de novo CAD were included, meaning that the population was representative of de novo CAD in general. In addition, the analysis was based on subgrouping by follow-up duration, meaning that the short- and long-term effects of DEB and DES could be compared. In general, this study may provide references for DEB use in de novo CAD.

Given that DES represents the current mainstay of de novo CAD treatment, it is important to evaluate newer methods such as DEB against DES. In the current meta-analysis, the efficacy and short-term safety of DEB was shown to be non-inferior to that of DES in the treatment of de novo CAD. Both DEB and DES contain an anti-proliferative agent and late or very late thrombosis as the limitation of DES, so it is not surprising that the short-term efficiency of DEB is similar to that of DES. Some studies have compared acute elastic recoil in DEB plus BMS compared with DES and demonstrated equivalence between the two strategies. [31–33] Therefore, acute elastic recoil may not be the cause of any clinical difference between DEB and DES. However, Gobić et al. [20] reported that DEB was superior to DES with respect to LLL. In the present analysis, we identified heterogeneity in LLL in the study by Gobić et al., which may be attributable to the inclusion of subjects with STEMI presenting less than 12 hours from symptom onset and with a worse prognosis than patients with regular MI. The first study on DEB use for the treatment of STEMI [34] reported good outcomes, indicating that DEB may represent the most effective intervention for this condition. From a long-term perspective, DEB was superior to DES for with respect to the incidence of MI and death. One explanation for this result is that DES is a foreign material, and the stimulation to the body and cardiovascular system may increase over time. Delayed healing and endothelial dysfunction of DES may lead to thrombosis and subsequent MI or death, although further pre-clinical research is needed to clarify the mechanism responsible for this effect. In general, we have observed that DEB tended to be superior to DES over a longer follow-up duration, although most of the differences between the two treatments were not statistically significant. But there was a study showed a different result: they found DEB had no significant difference compared with DES at long-term follow-up. [35] Therefore, further studies with longer follow up are required to verify the superior long-term safety profile of DEB compared with DES.

A number of studies on the clinical use of DEB for treating de novo CAD are currently underway to identify optimal indications, further improve patient prognosis, and evaluate the clinical effect of DEB using intraluminal imaging. The efficacy of DEB in the treatment of ISR has been established in several clinical trials [36–38] and its use is recommended in European guidelines. [39] However, the role of DEB in PCI for de novo CAD remains unclear.

This meta-analysis had some limitations. First, the analysis was based on multiple studies, and observational studies were not omitted. Furthermore, although the included studies featured follow-up durations ranging from 1 to 36 months, we only explored the efficiency of DES and DEB at < 12 months and ≥ 12 months because of the small sizes of follow-up duration subgroups. The results may therefore represent a limited basis for reference, meaning that larger, multi-centre, randomized trials with longer follow-up durations are required. Second, we focused on the intervention type and did not distinguish between the composition and delivered drug type for DES and DEB. Further detailed subgroup studies are thus needed to evaluate these factors.

5. Conclusion

For follow-up < 12 months, there was no significant difference between DEB and DES for each MACE component, including target lesion revascularization (TLR), stent thrombosis (ST), myocardial infarction (MI), and death. However, a lower risk for MI and death was observed for DEB when the follow-up time was ≥ 12 months. It was proved that the safety and efficacy of DEB was similar to that of DES for follow-up < 12 months. However, a lower risk for MI and death was observed for DEB when the follow-up time was ≥ 12 months. DEB was superior to DES during long-term follow-up (≥12 months). Therefore, both DEB and DES may represent appropriate first-line treatment for patients with de novo CAD, with DEB as the first choice for patients who are ineligible for DES implantation, particularly those with small-vessel CAD and STEMI.

References

[1] Katsanos K, Spiliopoulos S, Kitrou P, et al (2018) Risk of Death Following Application of Paclitaxel-Coated Balloons and Stents in the Femoropopliteal Artery of the Leg: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Journal of the American Heart Association 7: e011245.

[2] Stone GW, Ellis SG, Cannon L, et al (2005) Comparison of a polymer-based paclitaxel-eluting stent with a bare metal stent in patients with complex coronary artery disease: a randomized controlled trial. Jama 294: 1215-1223.

[3] Bangalore S, Kumar S, Fusaro M, et al (2012) Short- and long-term outcomes with drug-eluting and bare-metal coronary stents: a mixed-treatment comparison analysis of 117 762 patient-years of follow-up from randomized trials. Circulation 125: 2873-2891.

[4] Lasala JM, Cox DA, Lewis SJ, et al (2009) Expanded use of the TAXUS Express Stent: two-year safety insights from the 7,500 patient ARRIVE Registry programme. EuroIntervention: journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology 5: 67-77.

[5] Kirtane AJ, Ellis SG, Dawkins KD, et al (2008) Paclitaxel-eluting coronary stents in patients with diabetes mellitus: pooled analysis from 5 randomized trials. Journal of the American College of Cardiology 51 (7): 708-715.

[6] Chang M, Park DW (2014) Optimal Duration of Dual Antiplatelet Therapy After Implantation of Drug-Eluting Stents: Shorter or Longer? Cardiol Ther 3: 1-12.

[7] Hung MJ, Hsu KH, Chang NC, Tsimikas S, Hung MY (2015) Prevalence of coronary artery spasm after stent placement and its association with inflammation. International journal of cardiology 179: 252-255.

[8] Costa F, Ariotti S, Valgimigli M, Kolh P, Windecker S (2015) Perspectives on the 2014 ESC/EACTS Guidelines on Myocardial Revascularization: Fifty Years of Revascularization: Where Are We and Where Are We Heading? Journal of cardiovascular translational research 8: 211-220.

[9] Siontis GCM, Stefanini GG, Mavridis D, et al (2015) Percutaneous coronary interventional strategies for treatment of in-stent restenosis: a network meta-analysis. The Lancet 386: 655-664.

[10] Byrne RA, Joner M, Alfonso F, Kastrati A (2014) Drug-coated balloon therapy in coronary and peripheral artery disease. Nature reviews Cardiology 11: 13-23.

[11] Higgins JP, Altman DG, Gotzsche PC, et al (2011) The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ (Clinical research ed) 343: d5928.

[12] Wells GA, Shea B, O'Connel D, et al. NewCastle-Ottawa Quality Assessment Scale –Cohort Studies. Available at: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp.

[13] Sinaga DA, Ho HH, Watson TJ, et al (2016) Drug-Coated Balloons: A Safe and Effective Alternative to Drug-Eluting Stents in Small Vessel Coronary Artery Disease. Journal of interventional cardiology 29: 454-460.

[14] Her AY, Kim YH, Garg S, Shin ES (2018) Impact of paclitaxel-coated balloon versus newer-generation drug-eluting stent on periprocedural myocardial infarction in stable angina patients. Coronary artery disease 29: 403-408.

[15] Sim HW, Ananthakrishna R, Chan SP, et al (2018) Treatment of Very Small De Novo Coronary Artery Disease With 2.0 mm Drug-Coated Balloons Showed 1-Year Clinical Outcome Comparable With 2.0 mm Drug-Eluting Stents. The Journal of invasive cardiology 30: 256-261.

[16] Ali RM, Degenhardt R, Zambahari R, et al. (2011) Paclitaxel-eluting balloon angioplasty and cobalt-chromium stents versus conventional angioplasty and paclitaxel-eluting stents in the treatment of native coronary artery stenoses in patients with diabetes mellitus. EuroIntervention: journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology 7 Suppl K: K83-92.

[17] Latib A, Colombo A, Castriota F, et al (2012) A randomized multicenter study comparing a paclitaxel drug-eluting balloon with a paclitaxel-eluting stent in small coronary vessels: the BELLO (Balloon Elution and Late Loss Optimization) study. Journal of the American College of Cardiology 60: 2473-2480.

[18] Latib A, Ruparelia N, Menozzi A, et al (2015) Long-term (3-year) follow-up of the balloon elution and late loss optimisation (BELLO) study. JACC Cardiovasc Interv 8: 1132-1134.

[19] Cortese B, Micheli A, Picchi A, et al (2010) Paclitaxel-coated balloon versus drug-eluting stent during PCI of small coronary vessels, a prospective randomised clinical trial. The PICCOLETO study. Heart (British Cardiac Society) 96: 1291-1296.

[20] Gobić D, Tomulić V, Lulić D, et al (2017) Drug-Coated Balloon Versus Drug-Eluting Stent in Primary Percutaneous Coronary Intervention: a Feasibility Study. American journal of the medical sciences 354: 553-560.

[21] Jeger RV, Farah A, Ohlow MA, et al (2018) Drug-coated balloons for small coronary artery disease (BASKET-SMALL 2): an open-label randomised non-inferiority trial. The Lancet 392: 849-856.

[22] Nishiyama N, Komatsu T, Kuroyanagi T, et al (2016) Clinical value of drug-coated balloon angioplasty for de novo lesions in patients with coronary artery disease. International journal of cardiology 222: 113-118.

[23] Sabate M, Raber L, Heg D, et al (2014) Comparison of newer-generation drug-eluting with bare-metal stents in patients with acute ST-segment elevation myocardial infarction: a pooled analysis of the EXAMINATION (clinical Evaluation of the Xience-V stent in Acute Myocardial INfArcTION) and COMFORTABLE-AMI (Comparison of Biolimus Eluted From an Erodible Stent Coating With Bare Metal Stents in Acute ST-Elevation Myocardial Infarction) trials. JACC Cardiovascular interventions 7: 55-63.

[24] Palmerini T, Biondi-Zoccai G, Riva DD, et al (2012) Stent thrombosis with drug-eluting and bare-metal stents: evidence from a comprehensive network meta-analysis. The Lancet 379: 1393-1402.

[25] Habib A, Finn AV (2015) Endothelialization of drug eluting stents and its impact on dual anti-platelet therapy duration. Pharmacological research 93: 22-27.

[26] DeSilvey DL (2007) Treatment of coronary in-stent restenosis with a paclitaxel-coated balloon catheter. The American journal of geriatric cardiology 16: 115-116.

[27] Scheller B, Hehrlein C, Bocksch W, et al (2008) Two year follow-up after treatment of coronary in-stent restenosis with a paclitaxel-coated balloon catheter. Clinical research in cardiology: official journal of the German Cardiac Society 97: 773-781.

[28] Rittger H, Brachmann J, Sinha AM, et al (2012) A randomized, multicenter, single-blinded trial comparing paclitaxel-coated balloon angioplasty with plain balloon angioplasty in drug-eluting stent restenosis: the PEPCAD-DES study. Journal of the American College of Cardiology 59: 1377-1382.

[29] Kleber FX, Harald R, Klaus B, et al (2013) Drug-coated balloons for treatment of coronary artery disease: updated recommendations from a consensus group. Clinical Research in Cardiology Official Journal of the German Cardiac Society 102: 785-797.

[30] Nakatani M, Takeyama Y, Shibata M, et al (2003) Mechanisms of restenosis after coronary intervention: Difference between plain old balloon angioplasty and stenting. Cardiovascular Pathology 12: 40-48.

[31] Chae IH, Yoon CH (2017) Comparison of Drug-Eluting Balloon Followed by Bare Metal Stent with Drug-Eluting Stent for Treatment of de Novo Lesions: Randomized, Controlled, Single-Center Clinical Trial 32: 933-941.

[32] Clever YP, Cremers B, Speck U, Dietz U, Bohm M, Scheller B (2014) Influence of a paclitaxel coated balloon in combination with a bare metal stent on restenosis and endothelial function: comparison with a drug eluting stent and a bare metal stent. Catheterization and cardiovascular interventions: official journal of the Society for Cardiac Angiography & Interventions 84: 323-331.

[33] Poerner TC, Otto S, Gassdorf J, et al (2014) Stent coverage and neointimal proliferation in bare metal stents postdilated with a Paclitaxel-eluting balloon versus everolimus-eluting stents: prospective randomized study using optical coherence tomography at 6-month follow-up. Circulation Cardiovascular interventions 7: 760-767.

[34] Vos NS, Dirksen MT, Vink M, et al (2014) Safety and feasibility of a PAclitaxel-eluting balloon angioplasty in Primary Percutaneous coronary intervention in Amsterdam (PAPPA): one-year clinical outcome of a pilot study. EuroIntervention: journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology 10: 584-590.

[35] Liu L, Liu B, Ren J, et al (2018) Comparison of drug-eluting balloon versus drug-eluting stent for treatment of coronary artery disease: a meta-analysis of randomized controlled trials. BMC Cardiovasc Disord 18: 46.

[36] Kang IS, Shehata I, Shin DH, et al (2016) Comparison between drug-coated balloon angioplasty and second-generation drug-eluting stent placement for the treatment of in-stent restenosis after drug-eluting stent implantation. Heart and vessels 31: 1405-1411.

[37] Mamuti W, Jiamali A, Rao F, et al (2014) Drug-coated balloon angioplasty for drug-eluting stent restenosis: insight from randomized controlled trials. Annals of medicine 46: 679-683.

[38] Mehilli J, Jochheim D (2015) Paclitaxel-Coated Balloon for Recalcitrant In-Drug-Eluting Stent Restenosis. JACC Cardiovascular interventions 8: 1701-1703.

[39] Windecker S, Kolh P, Alfonso F, et al (2014) 2014 ESC/EACTS Guidelines on myocardial revascularization: The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) Developed with the special contribution of the European Association of Percutaneous Cardiovascular Interventions (EAPCI). European heart journal 35: 2541-2619.