JAMA Cardiology | Review

Drug-Coated Balloons for the Treatment of Coronary Artery Disease
A Review

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IMPORTANCE Drug-coated balloon (DCB) angioplasty has emerged as an alternative to drug-eluting stent (DES) implantation for percutaneous coronary intervention (PCI) in patients with coronary in-stent restenosis (ISR) as well as de novo coronary artery disease.

OBSERVATIONS DCBs are balloons coated with antiproliferative agents and excipients, whose aim is to foster favorable vessel healing after appropriate lesion preparation. By providing homogeneous antiproliferative drug delivery in the absence of permanent foreign body implantation, DCBs offer multiple advantages over DES, including preservation of vessel anatomy and function and positive vessel remodeling. As such, DCBs have become appealing for treatment of ISR, small-vessel disease, long lesions, simplification of bifurcation procedures, and treatment of diffuse distal disease after recanalization of chronic total occlusions. In addition, patients with high bleeding risk, diabetes, and acute coronary syndrome might also stand to benefit from DCB angioplasty.

CONCLUSIONS AND RELEVANCE Although commercially available in numerous countries now for more than a decade, DCB only recently obtained US Food and Drug Administration approval for the treatment of coronary ISR. Moreover, preliminary results from newer generation devices tested in different clinical scenarios have raised the interest of the international community. Accordingly, an up-to-date review is timely particularly with the anticipated wave of research on the matter. Herein, this review encompasses DCB technologies, their worldwide usage, details on relevant indications, and key procedural aspects of DCB angioplasty.

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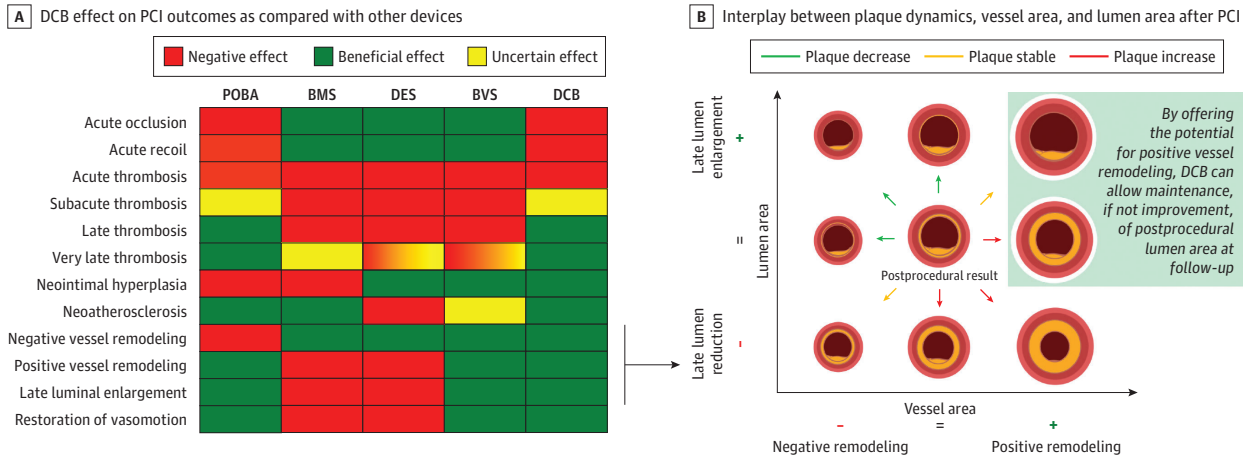
Percutaneous coronary intervention (PCI) with drug-eluting stent (DES) implantation is the most common revascularization strategy for patients with coronary artery disease (CAD).[1,2] DES implantation gives an immediate, stable result, and mitigates the risk of major adverse cardiac events. However, a strategy entailing universal DES implantation holds limitations: (1) stents inhibit positive vascular remodeling and pulsatile function in the treated vessel segment, (2) a 2% yearly accrual rate in adverse events, increasing in the presence of long stents or those with diabetes,[3] (3) stent and device delivery across a stent can be very complex in tortuous anatomies, (4) the consequences of suboptimal stent implantation can be catastrophic, and (5) in-stent restenosis (ISR) can be very difficult to treat. In these settings, drug-coated balloon (DCB) angioplasty has emerged as an alternative approach for certain subsets of patients.[4-7] By providing homogeneous antiproliferative drug delivery with no foreign body implantation, DCBs offer a cage-free option and may accelerate arterial healing, preserve normal vessel anatomy and function, and offer the potential for positive vessel remodeling (**Figure 1**). Specifically, DCB angioplasty may be preferred for the following scenarios: (1) ISR, (2) small-vessel disease, (3) long lesions, (4) bifurcation lesion side branches, and (5) treatment of diffuse distal disease after recanalization of chronic total occlusions.

Additional clinical factors that might support DCB angioplasty include high-bleeding risk, diabetes, or acute coronary syndromes (ACS). Herein, we provide a review of DCB technologies, their worldwide usage, details on relevant indications, and key procedural aspects of DCB angioplasty.

DCB Technologies

The DCB concept was introduced in 2000 after the demonstration that paclitaxel prevents neointima formation in rabbits after balloon angioplasty.[7] DCBs are usually semicompliant balloons coated with a pharmacologically active, lipophilic matrix layer including the antiproliferative drug and an excipient.[8] Compared with DES, DCB have a higher concentration of drug on the balloon surface. However, the absence of a polymer necessitates a technology that provides for rapid drug uptake during balloon inflation and sustained release within the vessel wall to prevent neointimal hyperplasia. The role of specific drugs and excipients is

Figure 1. Drug-Coated Balloon (DCB) Effect as Compared With Other Devices and Vessel Remodeling Scenarios After DCB



DCB effect on PCI outcomes as compared with other devices. Interplay between plaque dynamics, vessel area, and lumen area after percutaneous coronary intervention (PCI). A comparison of potential PCI outcomes according to the type of device adopted is presented on the left. The impact of different vessel remodeling scenarios on residual lumen area is depicted on the right. Relative changes in vessel area (vessel remodeling) and plaque burden determine lumen area. The possibility to avoid late lumen reduction or gain late lumen enlargement with DCB derives from the potential positive vessel remodeling in absence of permanent stent implantation. BMS indicates bare metal stent; BVS, bioresorbable vascular scaffold; DES, drug-eluting stent; POBA, plain balloon angioplasty.

key to achieving this, and the observed absence of a DCB class effect derives from the diverse pharmacokinetic properties of tested devices.[9]

Antiproliferative Drugs

Paclitaxel is the most widely used antiproliferative drug in DCB technologies because of its lipophilicity and efficient cellular uptake.[10] It decreases smooth muscle proliferation, migration, and formation of extracellular matrix in the vessel wall (ie, neointima formation) by irreversibly binding to the β subunit of tubulin, halting microtubule disassembly and inhibiting cell-cycle progression.

In contrast, sirolimus, the most commonly used limus-based analogue in DES, is a cytostatic agent with wide therapeutic range acting via the formation of a complex with an intracellular cytosolic protein that binds to and reversibly inhibits mammalian target of rapamycin, inhibiting vascular smooth muscle cell cycle progression from the G1 to S phases.[10] Although less lipophilic than paclitaxel, the effectiveness and safety of limus-based DES has prompted the development of novel DCB technologies including sirolimus. Additional analogues have been proposed and tested in preclinical settings.

Concerns about paclitaxel toxicity leading to an increased risk of mortality in patients treated with DCB for peripheral artery disease have largely been quelled,[11] and no signal of excess mortality has been described to date after DCB treatment of CAD. Also, concerns about coronary artery aneurysm formation after paclitaxel DCB angioplasty have been disproven.[12]

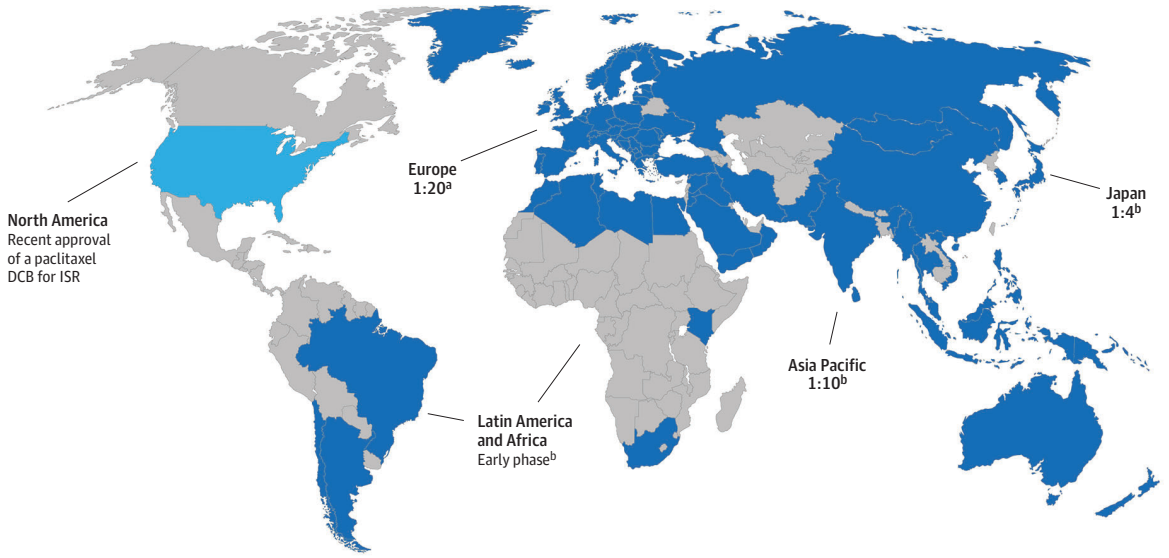
Excipients

The concept of a long-lasting biological effect despite a short contact time was first explored with a DCB using iopromide, a radiography contrast agent, as an excipient to paclitaxel.[7,10] It then became clear that one or more excipients plus the active substance were necessary to achieve efficient delivery of the antiproliferative drug and thereby promote the clinical effectiveness of DCBs. In addition, factors such as coating morphology affect drug transfer and tissue persistence as well as drug and particle loss in blood such that different coating variants and dosages might have different safety and efficacy profiles.[10,13-15] More specifically, crystalline formulations of both paclitaxel and sirolimus DCBs appear to be more efficacious, demonstrating higher stability and drug retention compared with the amorphous form at the expense of higher downstream particulate generation post-DCB angioplasty.[16] Although this latter observation has raised concerns about possible slow-flow or periprocedural myocardial infarction, no evidence of jeopardized clinical safety has been observed so far. Available DCB technologies and their different drug-excipient combinations are shown in eTable 1 in the Supplement.

Contemporary Worldwide DCB Usage

Since the introduction of coronary DCB over 15 years ago, the technology has become increasingly used in clinical practice worldwide. Although treatment of ISR is the only indication for DCB angioplasty in North America, newer devices and a wider experience in the treatment of de novo lesions has contributed to heterogeneous distribution and adoption of this technology. The ratio of DCB to DES PCI performed ranges from 1:20 in Europe to 1:10 in the Asia Pacific region and up to 1:4 in Japan (**Figure 2**).[17] The penetration of different DCB types varies by country. For example, the SeQuent Please paclitaxel DCB (B. Braun Medical Inc) is registered in more than 50 countries with a worldwide market share of greater than 50%, while more than 115 000 Magic Touch sirolimus DCBs (Concept Medical) have been used in coronary arteries across over 75 countries as of September 2023. In the US, the Agent DCB (Boston

Figure 2. Paclitaxel-Coated Balloon Usage Across the World



World distribution of a paclitaxel drug-coated balloon (DCB):drug-eluting stent (DES) ratio for percutaneous coronary intervention (PCI). The map outlines the penetration of a paclitaxel DCB (SeQuent Please [B. Braun]) usage across the globe. Usage of DCB vs DES for PCI is expressed as DCB:DES ratio. Figure readapted from B. Braun Melsungen AG. EUCOMED indicates European database on medical devices; ISR, in-stent restenosis.

[a]EUCOMED-Data Europe, 2022.

[b]EUCOMED-Data, 2022 & Internal Data B. Braun Melsungen AG.

Scientific) is the first commercially approved DCB. The recent acquisition of MedAlliance by Cordis and the ongoing SELUTION DeNovo trial in de novo coronary lesions may further boost DCB penetration if positive.[18]

When To Use DCB

Coronary Artery ISR

The largest supporting evidence for DCB PCI has accrued in ISR.[1] After the first randomized clinical trial (RCT) showing superior angiographic results at 6 months with paclitaxel-iopromide DCB vs balloon angioplasty for treatment of bare metal stent (BMS) ISR,[19] other studies followed in the context of both BMS and DES ISR, confirming angiographic superiority of DCB vs balloon angioplasty.[20-22] Recently, clinical superiority of a paclitaxel-acetyltributylcitrate DCB (AGENT [Boston Scientific]) vs balloon angioplasty at 1 year among patients with 1- and 2-layer BMS or DES ISR led to the US Food and Drug Administration approval of DCB for treatment of ISR.[23]

Angiographic noninferiority of paclitaxel DCB vs DES has been suggested in BMS and DES ISR.[24,25] However, other studies in patients with DES ISR demonstrated inferior angiographic and clinical outcomes with paclitaxel DCB vs DES.[26-28] Such modification of DCB effect according to BMS or DES ISR may be related to (1) different pathologies, (2) DES ISR might be at higher risk of recurrent events given the failure of a first drug to inhibit restenosis, and (3) the adoption of older generation paclitaxel DCB.

A nanoencapsulated liquid formulation of sirolimus delivered by a porous balloon (Virtue [Caliber Therapeutics]) was the first among newer-generation sirolimus DCB technologies to be tested in ISR, and 6-month in-segment late lumen loss (LLL) was similar to that reported for paclitaxel DCB.[29] Additional promising results at up to medium-term follow-up for such technologies in ISR come from a combined analysis of 2 parallel RCTs evaluating crystalline sirolimus DCB[30] and from an observational cohort study assessing a sirolimus-phospholipid nanocarrier DCB.[31,32] An ongoing noninferiority trial comparing a new biolimus A9 DCB with a standard paclitaxel DCB for the treatment of coronary ISR is underway.[33]

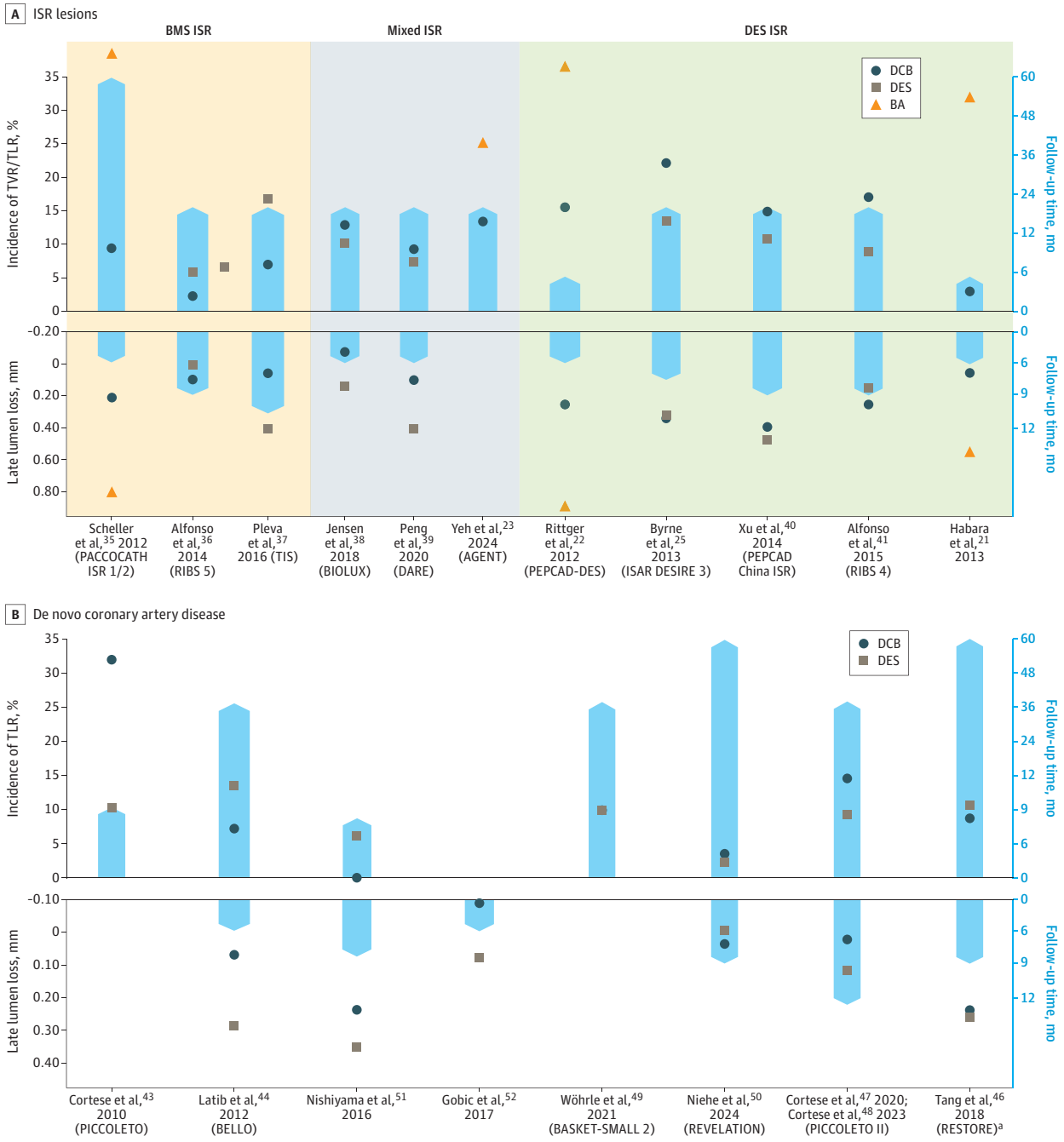
Some believe that initial treatment with DCB may be preferred compared with DES in for first occurrence of ISR, reserving an additional DES layer for subsequent recurrences after DCB treatment. DCB PCI instead of repeat DES is particularly attractive in patients with BMS ISR, multiple prior stent layers, ISR in small vessels, or relevant side branches emerging from the failed stent.[8,34] Alternatively, repeat DES may be a preferred treatment for DES ISR in a large vessel where an additional stent layer will not exact a large penalty. **Figure 3**A provides details on clinical and angiographic outcomes from RCTs evaluating treatment of ISR with DCB.[21-23,25,35-41] Ultimately, large-scale trials of DCB vs DES with long-term follow-up of at least several years are required to determine the optimal approach to DES ISR.

Small Vessels

In de novo CAD, the largest experience with DCB has been in small vessels, usually defined as 2.75 mm or less.[42] Small-vessel lesions have higher rates of restenosis after DES, and the theoretical advantages of DCB vs DES in this context rely on the fact that there is no obligate luminal reduction by stent struts.

A total of 5 RCTs have been conducted comparing outcomes of 5 different paclitaxel DCB vs DES in small coronary arteries (Figure 3B).[43-52] In the first study, a paclitaxel-dimethylsulphoxide DCB (Dior I [Eurocor GmbH]) characterized by very rapid drug elution

Figure 3. Clinical and Angiographic Outcomes From Randomized Clinical Trials Comparing Drug-Coated Balloons (DCBs) to Drug-Eluting Stents (DES) or Balloon Angioplasty (BA)



A, In-stent restenosis (ISR) lesions. B, De novo coronary artery disease. AGENT indicates A Clinical Trial to Assess the Agent Paclitaxel-Coated Percutaneous Transluminal Coronary Angioplasty (PTCA) Balloon Catheter for the Treatment of Subjects With ISR; BASKET-SMALL, Basel Kosten Effektivitäts Trial–DCBs vs DES in Small Vessel Interventions; BELLO, Balloon Elution and Late Loss Optimization; BIOLUX, Clinical Performance of the Pantera LUX Paclitaxel-Releasing Balloon vs the Drug-Eluting Orsiro Hybrid Stent System in Patients With ISR—a Randomized Controlled Trial; BMS, bare metal stent; DARE, Drug-Eluting Balloon for In-Stent Restenosis; ISAR DESIRE 3, Intracoronary Stenting and Angiographic Results: DES ISR—3 Treatment Approaches; PACCOCATH ISR 1/2, Treatment of ISR by Paclitaxel-Coated PTCA Balloons; PEPCAD China ISR, A Prospective, Multicenter, Randomized Trial of Paclitaxel-Coated vs Paclitaxel-Eluting Stent for the Treatment of DES ISR; PEPCAD-DES, Treatment of DES ISR With SeQuent Please Paclitaxel-Eluting PTCA Catheter; PICCOLETO, Drug-Eluting Balloon Efficacy for Small Coronary Vessel Disease Treatment; PICCOLETO II, Drug-Eluting Balloon Efficacy for Small Coronary Vessel Disease Treatment II; RESTORE, Assess the Efficacy and Safety of RESTORE Paclitaxel Eluting Balloon vs RESOLUTE Zotarolimus-Eluting Stent for the Treatment of Small Coronary Vessel Disease; REVELATION, Revascularization With Paclitaxel-Coated Balloon Angioplasty vs DES in Acute Myocardial Infarction; RIBS 4, Restenosis Intra-Stent of DES: Drug-Eluting Balloon vs Everolimus-Eluting Stent; RIBS 5, Restenosis Intra-Stent of Bare Metal Stents: Paclitaxel-Eluting Balloon vs Everolimus-Eluting Stent; TIS, Treatment of ISR; TLR, target lesion revascularization; TVR, target vessel revascularization.

[a]Indicates 5-year data were presented at Transcatheter Cardiovascular Therapeutics 2022.

(tissue concentration of 0.3 µg/g at 48 hours) and a coating technology including a roughened balloon surface rather than a proper matrix was found to be inferior to a paclitaxel DES in terms of 6-month percentage diameter stenosis. The proportion of patients undergoing predilation before DCB angioplasty was 25% and was identified as a possible factor contributing to unsatisfactory angiographic and clinical results.[47] When compared with the same DES, a paclitaxel-urea DCB (IN.PACT Falcon [Medtronic]) demonstrated lower 6-month LLL (mean [SD], 0.08 [0.38] mm vs 0.29 [0.44] mm) but a larger percentage diameter stenosis.[44] Subsequent studies later demonstrated similar follow-up percentage diameter stenosis,[46,47] and the tendency for DCB to yield smaller LLL and similar net lumen gain in the presence of larger percentage diameter stenosis and smaller minimum lumen diameter became evident (Figure 1).[53] The only RCT comparing DCB (paclitaxel-iopromide SeQuent Please DCB [B Braun]) and DES (everolimus-eluting or paclitaxel-eluting stent) in terms of a primary clinical end point in small coronary arteries demonstrated noninferiority of DCB to DES, with a similar incidence of major adverse cardiac events at 12 months. Such results were replicated by other RCTs comparing paclitaxel-shellac Restore DCB (Cardionovum) vs zotarolimus-eluting stent[46] and paclitaxel-dextrane Elutax SV DCB (Aachen Resonance) vs everolimus-eluting stent.[47] DCB were later shown to be noninferior to DES in terms of major adverse cardiac events at up to 5-year follow-up, with an observed incidence of approximately 10% to 15% in most DCB groups.[48] Finally, a signal for a lower risk of target vessel occlusion was observed with DCB.[48,53]

Comparative data between different DCB technologies are scant in small vessels. Promising clinical safety and efficacy was reported at 1-year follow-up after phospholipid nanocarrier sirolimus DCB in 1 large cohort study[31]; nonetheless, the same DCB failed to demonstrate noninferiority compared with paclitaxel-iopromide DCB in terms of 6-month net lumen gain (mean [SD], 0.25 [0.40] vs 0.48 [0.37] mm; *P* for noninferiority = 0.17) in a recent RCT.[54,55] On the other hand, randomized evidence has shown treatment with crystalline sirolimus DCB is noninferior to paclitaxel-iopromide DCB with regard to 6-month LLL, although negative LLL was still less frequent after crystalline sirolimus DCB (32% vs 60%; *P* = .02).[56] Although adequately powered trials are required, a DCB first strategy with DES reserved for suboptimal procedural results or subsequent restenosis may be preferred in small-vessel CAD.

Long Lesions

Promising evidence from observational studies has been accumulating for DCB angioplasty in long lesions, and data from RCTs are under way.[18,57] This is particularly attractive in scenarios involving severe tortuosity, numerous side branches, or, in case of PCI failure that are amenable to downstream coronary artery bypass graft surgery with a left internal mammary artery providing improved survival (ie, left anterior descending artery).[8] A hybrid approach combining proximal DES implantation and distal DCB angioplasty can also be used to limit total stent length. Older data supporting a hybrid DCB-DES and a DES-only approach[58] have been recently corroborated by cohort studies including mostly sirolimus DCB, with mean reference vessel diameter of 3.0 mm and up to 80% DCB-only approach.[59-61] Favorable outcomes were reported at 12-month follow-up from an all-comer registry of 562 lesions (60% ≥3.0 mm in diameter) with a 1.4% incidence of target lesion revascularization in chronic coronary syndromes.[62] Furthermore, data from a cohort study conducted in patients undergoing left anterior descending artery PCI showed an 80% reduction in risk of target lesion failure at 2-year follow-up in patients undergoing hybrid DCB-DES vs DES-only approach.[61] The same concept was recently explored in the setting of multivessel CAD, with promising results at 2-year follow-up when compared with a DES-only approach.[63] Further prospective, randomized studies assessing whether reduction in the number and overall length of DES implanted translates into improved long-term clinical outcomes by reducing stent-related events are eagerly awaited.[18]

Procedure Simplification

Additional potential indications have emerged from the need to simplify treatment of complex and diffuse disease and from deeper acknowledgment of the importance of preserving vessel remodeling.

Bifurcations

Coronary bifurcation lesions are targets in approximately 20% PCI procedures and are challenging in terms of procedural complexity and increased long-term adverse cardiac events. By avoiding 2 stents, DCB of bifurcation lesion side branches facilitates positive vessel remodeling in the side branch. Small observational studies have assessed a strategy of provisional DES implantation in the main vessel combined with DCB angioplasty in the side branch.[64] Restore (Cardionovum) and Magic Touch (Concept Medical) DCBs were recently evaluated in true bifurcation lesions, and 1-year follow-up was promising for both technologies.[65,66] A DCB-only approach may be contemplated as well after adequate lesion preparation and might be attractive in scenarios such as Medina class 0,1,1 bifurcation lesions.[67] Nonetheless, well-powered prospective studies are currently lacking, and whether cutting or scoring angioplasty before DCB is preferred for ostial side branch lesions remains to be established.[68]

Chronic Total Occlusions

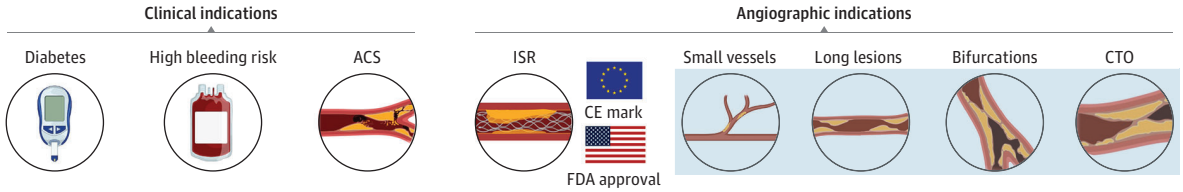
The rationale behind DCB angioplasty in chronic total occlusions is avoidance of extensive stenting by either a DCB-only approach or a hybrid combination of DES implantation in the occluded segment and DCB angioplasty in the distal, often diffusely diseased and negatively remodeled vessel. Underestimation of distal vessel size is common, and such strategies can mitigate the risk of stent undersizing and promote positive vessel remodeling.[69] Results from 2 recent prospective registries suggest that chronic total occlusion revascularization with DCB angioplasty is safe, reduces total stent length and is associated with lower risk of clinical events at 1-year follow-up when compared with DES implantation.[70] Randomized trials are awaited.

Other Clinical Indications

Attractive clinical scenarios for DCB angioplasty theoretically include the following: (1) patients at high bleeding risk, (2) patients with diabetes, given their increased risk of recurrent events after stenting and high prevalence of small vessel CAD, and (3) ACS, where proper vessel size might be underestimated, particularly during acute ST-segment elevation myocardial infarction (**Figure 4**).

Per expert opinion, the recommended duration of dual antiplatelet therapy (DAPT) in patients undergoing DCB angioplasty for stable de novo lesions is 4 weeks.[6,71] The absence of a permanent foreign body makes interruption of antithrombotic agents more appealing than with DES, especially in patients treated for ACS, be it discontinuation for an upcoming surgery or cessation for

Figure 4. Potential Applications of Drug-Coated Balloon (DCB) Angioplasty



Clinical and angiographic indications suitable for DCB angioplasty are depicted. The only angiographic indication currently holding both Conformité Européenne (CE) mark and US Food and Drug Administration (FDA) approval is in-stent restenosis (ISR). The dimmed angiographic indications represent possible additional indications; differently from small vessel disease, prospective randomized data supporting these indications is not available as of today. ACS indicates acute coronary syndrome; CTO, chronic total occlusion.

protracted high bleeding risk. Shortening DAPT duration to only 2 weeks might be considered in patients at very high bleeding risk. Additionally, data suggest a good safety profile of DCB angioplasty on single antiplatelet therapy.[62] Whether these considerations hold true irrespective of the type of DCB is unknown. Also, data on the interplay of antiplatelet agents, anticoagulants, and DCB are lacking.

The beneficial effect of DCB angioplasty among patients with diabetes was highlighted by a post hoc report, which demonstrated a lower risk of angiographic restenosis and lower in-segment LLL among patients with diabetes treated with paclitaxel-urea DCB vs paclitaxel-eluting stent.[72] Diabetic status also did not affect 1-year clinical performance of a phospholipid nanocarrier-sirolimus DCB in the largest prospective cohort study including patients undergoing DCB angioplasty.[73] Furthermore, when compared with DES, a paclitaxel-iopromide DCB had lower risk of target vessel revascularization among patients with diabetes.[49]

The risk of stent undersizing in the setting of ACS supports a DCB angioplasty approach. A paclitaxel-iopromide DCB was noninferior to stent implantation at short-term follow-up after non–ST-segment elevation MI. Also, randomized data comparing DCB and DES in patients with ST-segment elevation myocardial infarction suggest similar long-term clinical outcomes (ie, 5 years) between paclitaxel–butyryl-tri-hexyl citrate DCB and sirolimus- or everolimus-eluting stents.[50] Such results were corroborated by a recent propensity-matched cohort study comprising 1139 patients treated with a DCB strategy vs new-generation DES with a median follow-up of 3 years.[74] Also, lower risks of cardiac death and MI were evident with DCB vs DES among patients with ACS involving small vessels.[75] A list of important RCTs on DCB over the last decade is provided in eTable 2 in the Supplement. Key ongoing RCTs are summarized in eTable 3 in the Supplement.

Performing DCB Angioplasty—Technical Considerations and Proposed Algorithm

Lesion Preparation

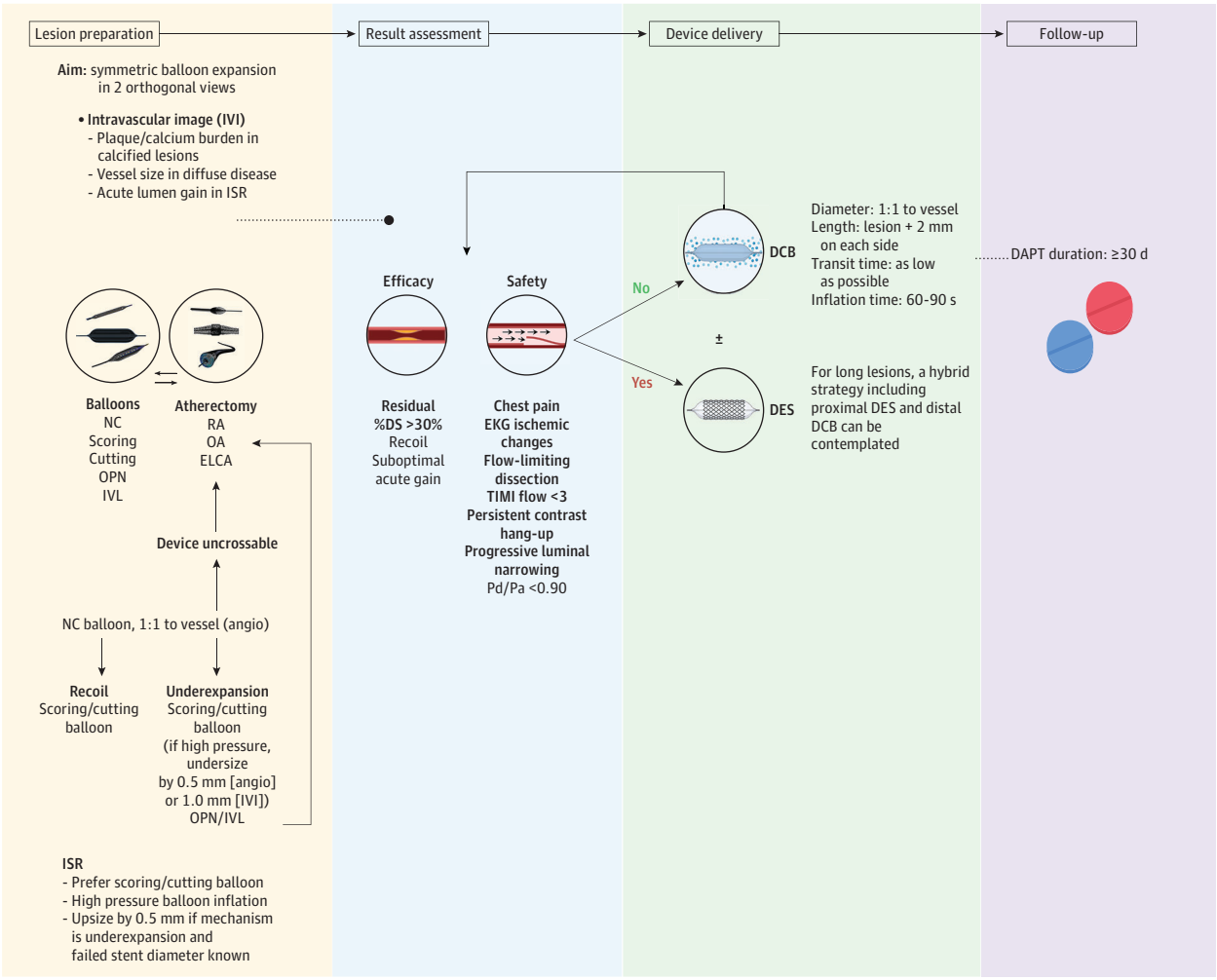
Proper lesion preparation before DCB angioplasty is important (**Figure 5**) as the sole purpose of DCB PCI is 360° antiproliferative drug delivery to the vessel wall. Intravascular imaging might be particularly helpful to assess (1) plaque and calcium burden, (2) lumen gain in specific scenarios (ie, ISR), and (3) vessel size in diffuse disease. Recent evidence supports intravascular ultrasound use during DCB angioplasty in patients at high bleeding risk with de novo CAD; nonetheless, specific criteria for procedural guidance have not been developed yet.[76] Routine predilation of crossable de novo lesions with prolonged inflations of noncompliant balloons with 1:1 balloon to artery diameter ratio by angiography should aim for full balloon expansion in 2 orthogonal fluoroscopic views. Should recoil occur, crossover to angioplasty with long inflations (30-60 seconds) of specialty balloons such as scoring and cutting balloons should be considered. On the other hand, if insufficient balloon expansion is observed due to heavy calcification, noncompliant and specialty balloon inflation should be considered even at high pressure. At first, a prolonged inflation at nominal pressure of scoring or cutting balloon with a 1:1 balloon to artery diameter ratio on angiography should be implemented to promote scoring/cutting plane shift. If high-pressure inflation is considered for nondilatable segments, noncompliant, scoring, or cutting balloon undersizing by 0.5 mm on angiography or 1 mm on intravascular imaging (media to media) should be contemplated to mitigate potential complications related to high pressure inflations (particularly true for scoring and cutting balloons). In more resistant lesions, gradual inflation of a super high-pressure noncompliant balloon and/or intravascular lithotripsy can be attempted. Atherectomy should be considered in recalcitrant or device-uncrossable lesions, particularly when severe calcification is present. Whether a strategy of de novo lesion modification including a low threshold for atherotomy with specialty balloons, intravascular lithotripsy or for atherectomy devices improves diffusion of antiproliferative agents remains to be proven.[77]

The same concepts hold true for lesion preparation for ISR, although the following nuances should be acknowledged: (1) scoring or cutting balloon angioplasty should be preferred over noncompliant balloon angioplasty,[78] and (2) high-pressure balloon inflation with 1:1 balloon to artery diameter ratio can be upsized slightly, especially if underexpansion is the underlying mechanism of stent failure.

Result Assessment

Although some of these procedural details might be considered speculative, it is evident that satisfactory lesion preparation before DCB angioplasty, including residual diameter stenosis of 30% or less, is associated with a lower risk of recurrent events.[6,79,80] This should be taken into consideration when comparing results between studies, given that the proportion of patients undergoing lesion preparation varies between 25% and 100%.[23,31,43,47] More importantly, stability of the result is supported by the absence of chest pain, ischemic changes on electrocardiography, persistent contrast hang-up, progressive luminal narrowing, flow-limiting dissection, and Thrombolysis

Figure 5. Technical Considerations for Drug-Coated Balloon (DCB) Angioplasty



Lesion preparation is a key step of a strategy including DCB angioplasty. Result assessment should include both efficacy and safety aspects, and device delivery should follow accordingly. Bail-out stenting or a hybrid strategy including both drug-eluting stent (DES) implantation and DCB angioplasty should be contemplated in specific scenarios. angio indicates angiographic; DAPT, dual antiplatelet therapy; DS, diameter stenosis; EKG, electrocardiogram; ELCA, Excimer later coronary angioplasty; ISR, in-stent restenosis; IVL, intravascular lithotripsy; NC, noncompliant; OA, orbital atherectomy; OPN, OPN super high-pressure noncompliant balloon (SIS Medical AG); Pa, aortic pressure; Pd, resting distal coronary artery pressure; RA, rotational atherectomy; TIMI, Thrombolysis in Myocardial Infarction score.

In Myocardial Infarction grade flow less than 3. When in doubt, preliminary evidence suggests a distal coronary/aortic pressure ratio greater than 0.90 is predictive of favorable evolution of coronary dissections.[59] In cases of an inadequate or unstable result, bail-out stenting should be contemplated with the aim to cover the entire dissection. Of note, the reported proportion of patients requiring bail-out stenting in de novo disease has ranged from 5% to 15%.[31,60,61,81] On the other hand, during treatment of long coronary lesions, an up-front, hybrid strategy entailing proximal segment stenting and DCB angioplasty distally may be an attractive option.

DCB Angioplasty

A DCB with 1:1 balloon to artery diameter ratio and a length at least 2 mm longer than the predilated segment at either end should be selected. Uneventful delivery of the last used (and often bulkiest) balloon can be used as proxy of sufficient support for DCB delivery. Once positioned, the DCB should be inflated to nominal pressures for 60 to 90 seconds to ensure adequate drug delivery. Result assessment should follow similarly to that occurring after lesion preparation. Additional lesion preparation and DCB angioplasty or stent implantation might then follow as needed.

Follow-Up

Postprocedural patient treatment, including assessment for complications and cardiac enzyme monitoring, should follow that after stenting. Generally, same-day discharge is possible in the absence of complications in the immediate 4-hour postprocedural time frame. In the presence of factors suggesting patient or procedural complexity, such as 3 vessels or 3 or more lesions treated, bifurcation lesions or chronic total occlusion target lesions, overnight observation can be planned. Although there is a lack of consensus and limited data on the optimal DAPT duration after DCB angioplasty, we suggest at least 30 days of

DAPT. Considering promising early evidence, single antiplatelet therapy should be reserved for patients at extreme bleeding risk.[82] Further dedicated prospective studies on the matter are eagerly awaited.

Conclusions

The ability to effectively deliver antiproliferative agents to the coronary vessel wall in the absence of a permanent foreign body is appealing in many scenarios. The role of DCB angioplasty has been well established for the treatment of ISR and encouraging data are available for multiple additional scenarios within the PCI panorama including small vessels, long lesions, and bifurcations. DCB safety and efficacy profiles are device specific, and an appropriate lesion preparation strategy should regularly be implemented to optimize DCB outcomes (Figure 5). Ongoing RCTs will determine the optimal role of these novel devices as treatment alternatives for patients with CAD.

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Concept and design: Camaj, Leone, Colombo, Vinayak, Dangas, Kini.
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