

in a patient with very severely compromised renal function and to minimise the use of contrast in PCI (18, 19).

Optical Coherence Tomography (OCT)

OCT gives an image resolution 10 times greater than IVUS and is also easier and faster to set up and use. It reconstructs the vessel wall image by using infrared light. This light-based OCT technology can penetrate 2-3 mm inside the vessel wall. OCT is far better than IVUS for determining the vessel's luminal diameter and cross-sectional area. OCT can depict plaque morphology with a sensitivity close to that of histology. It can also assess calcium thickness, lipid, thrombus, fibroatheroma, plaque rupture, stent strut neointimal thickness and apposition, and edge dissections. It requires the use of contrast injection and may not be suitable in the case of patients with severe renal dysfunction (18, 19).

Based on restenotic tissue structure in the cross-sectional images captured by OCT, the patterns are categorised into (20):

1. Homogeneous intima: uniform optical properties of restenotic tissue showing no focal variations in the backscatter pattern
2. Heterogeneous intima:
 - a. Type 1 – Thin-cap fibroatheromas (TCFA)-like pattern: the presence of an area with marked signal attenuation with a diffuse border and fibrous cap thickness at the thinnest part $\leq 65 \mu\text{m}$ and an angle of lipidic tissue $\geq 180^\circ$
 - b. Type 2 – Layered pattern: restenosis tissue consists of concentric layers with different optical properties (a thick high scattering layer and a low scattering layer with a stent strut)
 - c. Type 3 – Patchy pattern: patchy and highly echolucent regions throughout the layers
 - d. Type 4 – Speckled pattern: restenotic tissue consists of a heterogeneous speckled band.

Management of In-Stent Restenosis

The treatment of ISR remains a challenging clinical problem. Clinicians should carefully consider choosing the best type of

treatment based on the original stent problem to prevent the possibility of another recurrence.

Drug-Eluting Stent (DES)

Most previous studies consistently demonstrated relatively poor outcomes in patients treated for DES-ISR compared with BMS-ISR (21). In a meta-analysis assessing the treatment of DES-ISR, repeat DES implantation showed decreased target revascularisation and superior antirestenotic efficacy compared with angioplasty alone. DES implantation exhibited similar performance in both ISR types (BMS-ISR or DES-ISR) (1, 22).

A large meta-analysis was conducted to clarify which strategy is the best treatment modality for ISR. The study involved 27 trials with a total of 5,923 patients at 6 months to 1-year follow-up. Repeat stenting with everolimus-DES (EES) which is classified as second-generation DES was found to be statistically superior to all other modalities (23). The RIBS III trial (Restenosis Intrastent: Balloon Angioplasty Versus Elective Stenting) suggested that the use of second-generation and limus-type DES was associated with better angiographic outcomes although further studies with larger sample sizes would be required (21).

Nonetheless, the debate regarding whether to use a DES eluting the same or a similar type of drug (homo-DES approach) versus a switch to a different type of drug (hetero-DES approach) has continued. The hypothesis of the switch approach benefit is based on the possibility that it might overcome drug resistance or polymer-related problems (4). Furthermore, the RIBS III trial assessed the impact of selecting a different DES for the treatment of ISR. This study showed that, in patients with DES ISR, the use of a different DES yielded superior clinical and angiographic long-term results compared with those seen with other therapeutic modalities (21).

However, a potential drawback of DES implantation is that another layer of a stent is implanted, which can lead to ensuing therapeutic challenges in the event of ISR recurrence (22).

Drug-Coated Balloon (DCB)

DCB offers the advantage of avoiding the implantation of an additional metallic layer

when treating ISR, and is recommended by the European Society of Cardiology guidelines as a treatment option (Class I, Level of Evidence: A) (24).

DCB has a potential role in the treatment of DES-ISR by avoiding the placement of another layer of the stent and providing favourable results. DCB can be particularly suitable for clinical situations where it is not applicable to add another layer of the stent (i.e., multiple previous stent layers, the presence of a major side branch) or for bleeding events, and can be particularly suited to clinical situations where the mechanism of ISR is stent maldeployment (4, 5, 25).

DCB was ranked as the second most effective treatment for ISR based on meta-analyses conducted by Siontis et al (23). No significant difference in the risk of all-cause death, myocardial infarction, or target lesion thrombosis between treatments of DCB and DES was observed (8.7% vs. 7.5%; HR: 1.13; 95% CI: 0.65 to 1.96). However, DCB angioplasty showed a slightly better performance in BMS-ISR compared with DES-ISR in some studies (4, 22).

Furthermore, in DES-ISR, there was a borderline numerical trend toward a decreased risk after DCB angioplasty compared with DES implantation (9.5% vs. 13.3%; HR: 0.69; 95% CI: 0.47 to 1.00) (22, 26).

In recent years, sirolimus DCBs have also been developed, and a comparison of a novel SCB with a crystalline coating showed similar angiographic outcomes in the treatment of both coronary de novo disease and ISR compared with a clinically proven PCB (27, 28).

Plain Old Balloon Angioplasty (POBA)

POBA is one of the initial treatments that has been used in patients with ISR. The procedure consistently shows satisfactory acute results and a very low occurrence of complications. The use of high-pressure balloons in ISR is most important for mechanical causes. It can be used for stent underexpansion with noncompliant balloons with a high pressure of approximately 40 atm. However, one of the limitations of POBA is that the acute gain is short-lived, and subacute tissue re-intrusion back to the lumen tends to occur within minutes of the last balloon inflation. The proce-