Contemporary management of complex higher-risk and indicated patients: perspectives from China

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Complex higher-risk and indicated patients (CHIPs) refers to patients with severe coronary artery disease (CAD) needing revascularization. However, these patients are at an increased risk for this procedure.[1] The CHIP population is attracting much interest in the field of interventional cardiology, since it was introduced in 2016 by Kirtane *et al*,[1] and the optimal treatment strategies for this population were fiercely discussed in almost every interventional forum at home and abroad. First of all, a comprehensive risk assessment must be conducted to determine which patients with CAD should undergo revascularization based on clinical presentation, functional tests, and anatomic characteristics. Percutaneous coronary intervention (PCI) might be a beneficial option when complete revascularization can be achieved, especially for patients are either inoperable or at higher surgical risk.[2,3] To treat these high-risk patients safely and effectively with PCI, well-trained interventionalists exhibiting both technical and cognitive skills are needed.

According to the European Bifurcation Club, main-vessel (MV) stenting with a proximal optimization technique and provisional side-branch (SB) stenting (known simply as provisional stenting strategy) are the preferred approaches for most bifurcation lesions.[4] However, when a two-stent strategy is required, it is technical challenge to choose and perform an appropriate technique. The DK-CRUSH strategy proposed by Prof. Shao-Liang Chen is an evidence-driven option to achieve a reliable final kissing inflation compared to other two-stent strategies. Importantly, the DK-CRUSH strategy is superior to the provisional stenting strategy as shown in the DKCRUSH-V randomized trial that analyzed target lesion failure at a 1-year follow-up.[5] In addition, Prof. Yu-Jie Zhou proposed the active transfer of plaque (ATP) technique, which is completed by actively transfer the plaque from the SB to the MV by pre-dilating a balloon in the SB, and then fix the plaque by releasing the stent in the MV. In China Interventional Therapeutics Conference 2019, Prof. Zhou's team reported 1-year clinical outcomes of the ATP trial (NCT02768116), which prospectively enrolled 284 patients with unprotected distal left main bifurcation lesions in six Chinese centers. And preliminary results showed no significant difference between patients who were randomized to the ATP technique or the provisional stenting strategy group in terms of primary endpoint target lesion revascularization (3.6% *vs.* 1.4%, $P = 0.280$), while the APT technique reduced both the risk of side branch compromise (1.4% *vs.* 6.9%, $P = 0.020$) and SB stent implantation (2.1% *vs.* 7.6%, $P = 0.032$).

The success rate of PCI for chronic total occlusion (CTO) increased because of advances in techniques and strategies. However, these techniques and strategies are not fully in compliance with our clinical practice. In 2018, the Chinese CTO Club proposed the strategy for CTO PCI, which differs from the hybrid algorithms in North America and Europe, as well as Asia-Pacific algorithm. The Chinese CTO Club algorithm emphasizes dual coronary injection, careful assessment of CTO angiographic parameters and the rational use of antegrade, retrograde and antegrade dissection re-entries or intra-vascular ultrasound (IVUS)-guided PCI techniques. In addition, future studies are required to identify the subset of patients that can most benefit from CTO PCI, compared with guideline-directed medical therapy (GDMT).

In-stent restenosis (ISR) is becoming more prevalent in contemporary catheterization laboratory. In this clinical scenario, second generation drug-eluting stent (DES) and drug-coated balloons (DCBs) are recommended by current guidelines.[6] However, implantation of a new DES is worrisome in recurrent and refractory ISR,[7] whereas the concept of "leave nothing behind" using DCB is attracting

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much more attention as a therapeutic strategy. Generally, before DCB treatment, that lesion must be prepared using non-compliant or cutting balloons. However, sometimes require an aggressive pre-treatment using excimer laser coronary atherectomy (ELCA) or rotational atherectomy (RA), in particular when intra-coronary imaging uncovers a severe stent under-expansion due to heavy calcification.[8,9] In our clinical experience, the photomechanical role of ELCA while simultaneously using contrast injection is potentially helpful for plaque modification in cases of heavy calcification,[10,11] but this is a high-risk procedure that should be used cautiously with small profile catheters.

Intra-coronary imaging is indispensable for the management of ISR to provide mechanistic insights, guide treatments, and optimize results from procedures.[6,12] Similarly, it is also important to identify and evaluate lesion calcification, which is often underestimated by angiography. In particular, optical coherence tomography can provide detailed information on calcium distribution (as well as IVUS) and thickness, which may indicate enhanced lesion preparation before stent implantation.[13] RA is the most widely used device to achieve sufficient calcium ablation, while some lesion subsets (eccentric calcium) may favor orbital atherectomy. However, when a stiff rotawire fails to pass a heavily calcified lesion, ELCA can be used to create a channel for rotawire passing and completing RA.[14] To overcome the disadvantages of rotational and orbital atherectomy with regard to guidewire bias and higher risk of atheromatous embolization, a coronary intra-vascular lithotripsy (IVL) catheter was introduced that contains multiple lithotripsy emitters enclosed in a balloon. More recently, the feasibility of coronary IVL for modification of heavily calcified plaques was established in a prospective multi-center, single-arm pilot study that achieved a 95% clinical success rate and a 95% rate of patients not experiencing major adverse cardiac events after 30-day of treatment.[15]

Notably, complex interventions are not equal to higher-risk interventions. The procedural risk comes from not only complex coronary anatomy, but also a patient's comorbidities and adverse hemodynamics. In the worst-case scenario, cardiogenic shock complicating acute myocardial infarction is associated with in-hospital mortality of 65%.[16] Prof. Zhou proposed a renewed and integrated emergency rescue model termed "PIE-2R," which includes **p**acing management, circulatory support (IABP/Impella, and VA **E**CMO), **r**espiration management, and **r**evascularization. According to our experience, the success of the "PIE-2R" model relies on a multidisciplinary heart team for patient risk evaluation and decision making, both timely and complete revascularization using advanced circulatory and respiratory support, and finally dedicated peri-procedural management.

Although there have been large developments improving the characterization and risk-stratification of CHIP, as well as with revascularization modalities and techniques, present research demonstrates that these patients are least likely to be revascularized, even by using a less invasive percutaneous approach.[17,18] One reason for this is because there is a lack of expertise using excellent techniques and technologies. A second reason stems from a confused revascularized indication for these patients, more specifically, patient sub-groups that are labeled as being high-risk by interventionalists. This cognition overestimates the potential risks of procedural complications suggesting poor clinical outcomes, while underestimates the anticipated benefits that a patient might see with intervention.

To improve the current situation for using these procedures on CHIPs, a dedicated and case-based curriculum for training interventionalists is essential. This curriculum must focus on appropriately evaluating and identify candidates, how to treat them safely and skillfully and understanding the rationale and goals of revascularization. In addition, because CHIP are almost excluded from the majority of clinical trials, it is obvious that additional studies must be completed to demonstrate both short and long-term clinical benefits of revascularization compared to GDMT and the benefits of PCI compared to coronary artery bypass grafting. Also, a more accurate risk model would be helpful to identify and treat the proper subset of patients. This is the only way that interventionalists will be satisfied with the safety and effectiveness of revascularization using the PCI method for CHIPs, which can benefit high-risk patients considerably. In the long-run, this method can achieve a true "higher risk, higher reward" paradigm.

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Conflicts of interest

None.

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