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Technical Options for Uncrossable Chronic Total Occlusion

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Abstract: It has been estimated that chronic total coronary occlusions (CTO) are encountered in 15 to 20% patients referred for CAG. The benefit of CTO revascularization are well established both in terms of improvement in patients' symptoms as well as improvement in LVEF. We aim in this study to highlight a multitude of techniques that can significantly improve procedural success in this subset of "Uncrossable" CTO lesions. A total number of 436 patients over a period from June 2006 to January 2014 were included. These were patients having either symptomatic angina or documented myocardial ischemia. All patients received loading dose of DAPT Clopidogrel and Aspirin. The lesion was deemed "Uncrossable" if attempts to pass a low profile balloon 1.0 to 1.5 mm were unsuccessful. The failure rate of CTO PCI in our study was 46 cases. In 35 patients coronary guide wire could not able to cross the lesion. The balloon Uncrossable lesions 29 patients. The involved vessels were RCA in 14, LCX in 8 and LAD in 7cases. In 4 patients unable to deploy the stent due to long dissection; small vessels, diffuse disease, unyielding lesions and achieved flow less than TIMI III. We successfully facilitated the balloon and achieved adequate lesion dilatation in 22 patients out of 29 patients. In spite of all these various techniques, in 7 patient lesions were resistant to cross with the balloon. Among seven of these resistant balloon Uncrossable lesion cases, four cases were of LCX lesion, three of RCA lesion and none in case of LAD. The lesion site calcification was invariably present in all patients. The tortuosity at lesion site was noticed in 5, CTO PCI failure were observed in 7 cases. Guide catheters with large size, extra backup, Amplatz and other designed guide catheters provide maximum support. The use of long sheaths, armour guide catheter technique, mother and child technique Guide liner, buddy wire and balloon anchoring including distal anchoring wire technique further provide the strong back up support that is desired when tackling such lesions. In this study we observed Uncrossable lesions in 7.19% cases. The resistant balloon Uncrossable lesions still contributed in 1.59% cases of CTO PCI failure in spite of adaptation of multiple techniques.

Keywords: Chronic Coronary Occlusions (CTO), Dual Antiplatelet Drugs (DAPT), Percutaneous Coronary Intervention (PCI)

1. Introduction

It has been estimated that chronic total coronary occlusions (CTO) are encountered in 15 to 20% patients referred for coronary angiography. [1] The benefits of CTO revascularization are well established both in terms of improvement in patient's symptoms as well as improvement in left ventricular systolic function. The success of CTO revascularization can be attributed to the vast array of hardware that has now become available and also to the vastly enhanced operator expertise. It is however realistic to state that despite the tremendous increase in the rate of successful CTO revascularization, there then comes a subset

of CTO where revascularization attempts fail. The reason for such failures given that other variables remain constant is the inability to cross the CTO lesion. This can be due to a failure to cross the lesion with a guide wire (despite guide wire escalation). The second cause of failure commonly is the failure to cross the lesion with a balloon (i.e. Uncrossable CTO lesion). This can occur despite the successful placement of a wire in the distal true lumen. Instances where the balloon passed could not be dilated also constitute the array of CTO PCI failure. The balloon Uncrossable lesions contributes in 2 to 10% of CTO PCI failure cases. [2] We aim in this study to highlight a multitude of techniques that can significantly improve procedural success in this subset of "Uncrossable" CTO lesions. One major technical development that has allowed a marked improvement in success rates is represented by the manipulation of the subadventitial space to allow successful CTO crossing and recanalization (dissection/re-entry [DR] techniques). [3-5]

2. Material and Methods

Definition: Chronic total occlusion is defined as TIMI 0 flow with known duration of occlusion more than three months. A total number of 436 patients spanning over a period from June 2006 to January 2014 were included in this prospective study. These were patients having either symptomatic angina or documented myocardial ischemia. All patients received loading dose of dual antiplatelet drugs (Clopidogrel and Aspirin), pre procedural unfractionated heparin 100i.u/kg body weight with further doses based on ACT levels checked at 30 minutes interval. The target ACT being above 250 seconds was maintained. The lesion was deemed "Uncrossable" if attempts to pass a low profile balloon 1.0 to 1.5 mm were unsuccessful.

3. Results

The failure rate of CTO PCI was 10.55% 46 cases. The causes of failure were found to be most commonly; coronary guide wire could not cross the lesion, balloon Uncrossable lesions followed by unable to deploy stent due to no satisfactory TIMI (less than TIMI III) flow.

In 35 patients (7.99) coronary guide wire could not able to cross the lesion. The balloon Uncrossable lesions were found in 29 (7.19%) patients. The involved vessels were most commonly RCA in 14 patients (48.27%) followed by LCx in 8 patients (27.58%) and LAD in 7 patients (24.13%). In 4 patients (0.9%) unable to deploy the stent due to long dissection; small vessels, diffuse disease, unyielding lesions and achieved flow less than TIMI III.

The various techniques to increase guiding catheter support and to modify the lesion were considered in balloon Uncrossable lesions. We successfully facilitated the balloon and achieved adequate lesion dilatation in 22 patients (75.86%) out of 29 patients. All the cases of CTO PCI were done with guiding catheters of 7, 8 Fr size with good back up support as per decided as initial strategy. In spite of all these various techniques, in 7 patients (24.12%) lesions were resistant to cross with the balloon. Among seven of these resistant balloon Uncrossable lesion cases, four cases were of LCX lesion, three of RCA lesion and no one case of LAD. The lesion site calcification was invariably present in all patients. The tortuosity at lesion site was noticed in 5 patients (1.45%). The resistant balloon Uncrossable lesions to leading to CTO PCI failure were observed in 7 cases i.e. 1.59% of total cases.

4. Discussion

It is quite essential that a guiding catheter that provides good support is employed for dealing with Uncrossable CTO lesions. Failure to cross a lesion with a low profile balloon is most often due to severe calcification at the occlusion site or a significant tortuosity or as is most often the case a combination of both of these. There are two essential methodologies that address the issue of "Uncrossable Lesions" and attempt to offer solutions for a successful outcome. The first of these looks at improving guide catheter support. To provide variable alternatives to result in a successful revascularization, Guide catheters with large size, extra backup, Amplatz and other specially designed guide catheters provide maximum support. The use of long sheaths, armour guide catheter technique, mother and child technique (5 in 6 or 7 Fr heart rail Terumo catheter), Guide liner (vascular solutions), buddy wire technique and balloon anchoring techniques including distal anchoring wire technique further provide the strong back up support that is desired when tackling such lesions. [6-8] The change of guide catheter to better one and by deep seating it also results in optimization of support. The lesions which are Uncrossable in spite of obtaining good guide backup support are truly uncrossable lesions. These are mostly densely calcific lesions, a cardiologist's nightmare. Various techniques have been described to treat it. The lesions are attempted with low profile over the wire balloon, corsair micro catheter, Tornus micro catheter (Asahi Intec), rotational atherectomy, excimer laser atherectomy and also with the use of Tornus microcatheter with side branch balloon anchoring technique. [9]

The balloon anchoring technique was initially described by Fujita in 2003 as inflation of a balloon in the side branch of a target coronary vessel to facilitate equipment delivery to a target lesion. Distal anchoring is a variation of this technique in which a balloon is inflated distal to or at the target lesion to enhance support for equipment delivery. A modified version of the distal anchor technique was used to cross a balloon-Uncrossable CTO by performing distal balloon inflation on a wire passed into the subintimal space. The distal balloon anchoring in the subintima is also reported to provide back up support for these lesions. [10] The counter movement of wire and balloon should be done during application of anchor balloon techniques.

Multi wire plaque crushing technique is one of among all which had also proven effectively. The multi-wire plaque

crushing technique is to insert 1-2 wires along with the original wire located in the true lumen of CTO after balloon failure for plaque crushing and then to withdraw the crushing wires to get an enlarged lumen inside the occlusion segment, thus facilitating the passing of the low profile balloon. [11] The seesaw balloon-wire cutting technique is one of the effective and safe techniques to facilitate balloon crossing during CTO interventions. The main process of this technique was to insert two guide wires (guide wire A and guide wire B) into the distal true lumen of CTOs and then to advance two short and low-profile balloons (balloon A and balloon B) over the two guide wires, respectively. Balloon A was first advanced over guide wire A as distally as possible, and then was inflated with high pressure (≥18 atm) to press guide wire B, producing a cutting power to crush the proximal fibrous cap of the CTO. Subsequently, balloon A was withdrawn slightly, and balloon B was advanced as distally as possible and then was inflated to press guide wire A, producing a similar cutting effect to crush the proximal fibrous cap on the other side. The two balloons were progressed alternatively until one of them was able to cross through the occluded segment. [12] The Grenadoplasty is also yet another useful technique for Uncrossable lesion CTO PCI. In Grenadoplasty small (usually 1.20 – 1.50 mm) balloon is advanced as for as possible into the lesion and inflated at high pressure until it ruptures. The balloon rupture can modify the plaque resulting in successful penetration of another balloon. [13] These lesions should be attempted to cross with micro catheters mainly corsair and Tornus. The Tornus catheter should be crossed by counterclockwise rotations and the opposite way during retrieval. Rotational atherectomy is often resorted to in both balloon Uncrossable and dilatation failure lesions. The fundamental step is being able to pass a Rota wire in exchange with the guide wire that has been able to pass the lesion. It is needless to mention that this may not always be feasible. Laser directed atherectomy is another option. [14] More data is required on this front. In extreme cases, such as in balloon failure-to-cross, antegrade Ra might be decisive. Few studies have specifically analyzed the outcomes of this technique in CTO patients, [15, 16] while most of available data on RA concern its use in non-occlusive coronary artery disease [17]. RA is infrequently used in CTO because of the risk of complications or the frequent presence of known contraindications, such as dissection, small distal vessel, or presence of side branches.

Overcoming Uncrossable CTO

i. Guide catheter support

7, 8 Fr Guides: Amplatz, extra backup guides

Long arterial sheaths

Armour guide technique

Deep engagement

Mother and child technique

Guide liner

Anchor wire

Buddy wire

Anchor balloon: side branch, distal target vessel or Subintimal at or below lesion site

ii. Lesion modification Techniques

Tornus or corsair micro catheter

Excimer laser: ablative and acoustic energy

Rotational atherectomy

Seesaw balloon-wire cutting technique

Grenadoplasty

Multi wire plaque crushing technique

Retrograde approach

5. Conclusion

The second most common cause of CTO PCI failure is balloon Uncrossable lesions in spite of successful wire positioning in the distal true lumen. In this study we observed Uncrossable lesions in 7.19% cases. The resistant balloon Uncrossable lesions still contributed in 1.59% cases of CTO PCI failure in spite of adaptation of multiple techniques. The calcification and tortuosity at the lesion site primarily accounts for it. The main principle behind to achieve success in CTO PCI of such lesions is to have a strategy for good guide backup support. Once good guide backup support is achieved and there still remains a difficulty in crossing the lesion, lesion modification should be considered. The various technical options are available to facilitate the balloon across the Uncrossable lesions. The simultaneous and sequential applications of various techniques are used to gain a final successful outcome. We felt Uncrossable lesions in spite of good guide support should be tackled initially corsair microcather followed side branch balloon anchor technique. The utilization of various other above mentioned techniques, Tornus microcatheter and rotational atherectomy should be considered as a last resort as per depending upon operators comfort and experience. The resistant balloon Uncrossable lesions should be treated with optimal drug therapy or coronary artery bypass surgery as depending upon other vessel disease status and myocardium area supplied by these lesions.

Conflict of Interest

All the authors do not have any possible conflicts of interests.

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