Indian Heart Journal xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Indian Heart Journal

journal homepage: www.elsevier.com/locate/ihj

Editorial

Unraveling the mystique of CTO Interventions: Tips and techniques of using hardware to achieve success

ARTICLE INFO

Article history:
Available online xxx

Keywords:
Chronic total occlusion
Percutaneous coronary intervention
Gaia
Sion blue
Fielder
Corsair
Tornus
CrossBoss
Antegrade
Retrograde
STAR technique
Collateral channel
CART
Reverse CART
Externalization

ABSTRACT

The scientific discourse of chronic total occlusions interventions is mired in a technical jargon so confusing that it prevents an average interventional cardiologist from pursuing this field so much so that it has become a domain of a few. This review attempts to simplify this vernacular and present it in a manner that this procedure comes within the scope of a mainstream interventionist.

1. Introduction

Interventions in chronic total occlusion (CTO) represent a niche area of percutaneous coronary interventions (PCI). The essential difference lies in the fact that in CTO PCI the disease lumen is occluded (versus patent in a garden variety of PCI). This difference culminates into not only increased complexity and difficulty but also makes it more prone to complications. This situation has led to an evolution of whole new field of interventional cardiology with specialists dedicated to this procedure particularly adept in retrograde techniques. Furthermore, this has led to development of a new jargon of technical words, "reverse CART," "septal surfing," "externalization," etc, a complete new language associated with CTO intervention which has on one hand added to the mystique of the procedure but on the other hand created confusion in the mind of regular interventionists and taken procedure out of their realm. This review is an attempt to clarify and simplify some of the concepts and techniques so that it is easily understandable by regular interventional cardiologists with the overall aim of increasing the popularity and acceptability of these procedures.

2. How is CTO intervention different from a regular PCI?

The essential difference in CTO intervention versus a "regular PCI" is that the lumen is occluded versus open (though stenosed) in a regular PCI. This singularity entails a whole reworking of the entire PCI strategy in CTO interventions. Procedurally, a regular PCI involves the wiring across the lesion supported by a guide-catheter, followed by balloon dilatation (to prepare bed) or sometimes even no pre-dilatation based on severity of disease and type of lesion, followed by stent implantation. However, during the course of procedure several other techniques may also be used like thrombus extraction, distal protection, rota-ablation depending on individual requirements of the case. On the other hand, CTO intervention involves a complex and difficult wiring, followed by a more extensive preparation of bed. Due to this difference the CTO intervention may be associated with slightly lower efficacy and safety but also increased procedure time and use of contrast. Technique wise the PCI in CTO may be different from usual PCI in several aspects:

1. Wiring is usually the key both in terms of technique as well as the characteristic of the wire used, not only to negotiate the

http://dx.doi.org/10.1016/j.ihj.2017.02.004

occluded lumen but also to be able to deliver several types of devices to accomplish a successful PCI.
2. Improved guide support is required to increase the ability to work with a wire.
3. Preparation of vascular bed by pre-dilatation is absolutely mandatory (again because of occluded lumen).
4. There is no classical modus operandi, if one technique is not successful several other variations in technique may be applied: retrograde, parallel wire etc.
5. In a regular PCI, among all the sensory faculties, vision is the most important sensory input with some tactile feedback. However, in CTO PCI this faculty is seriously limited (CTO intervention is essentially a blind procedure – at least in early part), here the tactile sense is the most important. But for human species sight is the most important sense and this being curtailed is the major limitation of CTO PCI. Thus there could be higher value and requirement of alternate imaging like intra-vascular ultrasound (IVUS).

To summarize, the basic difference between a regular and a CTO PCI is that in a CTO PCI the artery is occluded with no free lumen. But this is not all. This tissue occluding the lumen is of variable consistency, ranging from very soft (micro-channels) to soft (thrombus, proteoglycan, cholesterol clefts) to stiff (collagen or elastin) to very hard (calcium). Table 1 Operationally, to surmount this problem usually more than one wire may be required (chosen according to characteristic of the occlusion) and an individualized strategy has to be worked out. Thus the pre-requisite of a successful CTO PCI involve:

1. Knowing the histology of CTO.
2. Knowing the physical characteristics of the wire and other hardware.
3. Choosing the wire/s or other hardware according to the composition of the occlusion.
4. Knowing how to use the wire/hardware.
5. Choosing the right strategy.

3. Basic histology of coronary artery

3.1. Normal

Coronary artery is composed of three concentric layers: intima, media and adventitia with a central lumen inside. The intima consists of a lining layer of endothelial cells, a sub-endothelial layer containing connective tissue, and smooth muscle cells. Intima is separated from media by a relatively thick but fenestrated layer of internal elastic lamina (IEL) composed of elastin fibers. The media consists of around 40 layers of circumferentially or helically oriented layer of smooth muscle cells and connective tissue (elastic fibers, collagen, proteoglycans). The medial layer is separated from the adventitial layer by the external elastic lamina (EEL) which is composed of interrupted layers of elastin and is considerably thinner than the IEL. The adventitial layer consists of fibrous tissue (collagen, elastic fibers) that is surrounded by vasa vasorum, nerves, and lymphatic vessels. Surrounding bundles of collagen are oriented primarily longitudinally and relatively loosely.

Table 1
Physical characteristic of histological components of occluded segment.

Consistency	Very Soft	Soft	Firm	Hard
Components of Occlusion				
	Re-canalized lumen Micro-channels	Thrombus Proteoglycans Cholesterol clefts Cells	Collagen Elastin	Calcium

3.2. Atherosclerosis

Atherosclerosis is a disease of the intima and is characterized by physiologic disruption of endothelial lining and accumulation of atherosclerotic plaque which may protrude in both lumen and media. Underlying the diseased intima, medial thickness is generally reduced.

3.3. CTO

The characteristic of CTO is an occluded lumen which is initially composed of fresh thrombus but which soon gets organized into loose tissue segments composed of loose fibrous tissue, proteoglycan, haemosidrin/RBC and inflammatory cells intermingled with re-canalized channels. The intimal layer is initially composed of cholesterol clefts, foam cells, giant cell atherophagocyte, RBC, mononuclear cells but gets converted to collagen, elastin and even calcium. In addition there could be neo-vascular channels.[1,2] There are essentially two types of micro-channels:

1. Endothelialised micro-channels (100–500 μ) – They are essentially re-canalized part of occluded artery, and are a CTO operators delight, easily penetrable by a soft, polymer jacketed wire. They are generally present in a recent CTO, in CTOs with a tapered tip; they run parallel to the occluded parent vesseland may span the entire extent of CTO occlusion.
2. Micro-capillaries (<100 μ) – These capillaries are present in adventitia (vasa-vasorum) and may extend into media and intima. They generally occur in older CTOSs, are common with a blunt tip of CTO, run principally in a radial direction, do not connect proximal and distal caps, and are predisposed to sub-intimal passage Fig. 1.

In addition at both ends of CTO there is accumulation of dense collagen rich fibrous tissue known as fibrous cap. The cap is likely to be stiffer, more extensive proximally as compared to distally because of flow characteristics of an occluded artery.

4. Properties of guidewire in context of CTO PCI

Depending on its construction guidewires have different properties which can be used to an advantage in different situations.[3,4]

4.1. Penetrability

Penetrability is the ability topuncture a lesion, the stiffer the lesion the more penetrability is required; wire in the lumen < micro-channel < lipid plaque < proteoglycan < collagen/elastin < calcium. The penetrability of a wire depends on its:

1. Tip load
2. Tapered tip
3. Wire support (micro-catheter/OTW Balloon, anchoring techniques, child-in-mother catheter)
4. Lateralsupportof the wire

4.2. Pushability

Pushability is the amount of force needed to advance the wire or the ease of advancing the wire once it has penetrated a lesion. Pushability depends on a) the characteristic of the tissue a wire has

Please cite this article in press as: S. Mishra, Unraveling the mystique of CTO Interventions: Tips and techniques of using hardware to achieve success, Indian Heart J (2017), http://dx.doi.org/10.1016/j.ihj.2017.02.004