Chapter 25
Newer Advances in Coronary Intervention

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OPTICAL COHERENCE TOMOGRAPHY IN CATH LAB

Optical coherence tomography (OCT) is a high resolution instrument; resolution is equal to microscope, i.e. 10–20 microns. This is used in cardiology for intravascular imaging in cath lab. This is similar to intravascular ultrasound (IVUS). OCT uses fiber optic technology. We have been using OCT in a variety of clinical situations for visualizing plaque characterization, stent apposition, plaque rupture, tissue prolapse (stent), edge dissection, follow-up stent malapposition and stent strut coverage by neointimal hyperplasia. High resolution provided by OCT provides insights into plaque and also vascular response following percutaneous coronary intervention (PCI). Currently available OCT is C7 XR, by using laser, image capture is faster 100 images/sec so it is possible to study 20 mm/sec of vessel. Blood free zone is needed for imaging which is achieved by injecting contrast (contrast is highly viscous so it displaces blood) material at 3–4 mL/sec (Figure 1).

Vulnerable Plaque

Identification of vulnerable plaque can be done by visualizing the thin fibrous cap. OCT due to its high resolution is the only device which can measure the thickness of the cap (Figure 2).

In an observation with statin therapy following myocardial infarction (MI), an increase in thickness of the cap of plaque was observed (measured by OCT), compared to those without statin therapy. Statin therapy therefore stabilizes the plaque.

Plaque and Lipid Content

In patients with acute coronary syndrome (ACS), high lipid content plaques were more compared to stable angina patients. This is detected by OCT, which is superior to IVUS.

Plaque Calcium Content

Calcium detection by OCT is similar to IVUS. High calcium content of the plaque is associated with incomplete stent expansion, malapposition and stent thrombosis.

Figure 1: Normal optical coherence tomography image obtained in a normal left coronary artery

Figure 2: Optical coherence tomography image obtained in an eccentric plaque, showing a lipid-rich soft plaque with a thin fibrous cap
Plaque Rupture
Plaque rupture is defined as discontinuity in fibrous cap, with formation of cavity in athermanous plaque. Plaque erosion is defined as, loss of endothelial continuity, without cavity.

Thrombus Content
Optical coherence tomography can detect thrombus in all ST-segment elevation myocardial infarction (STEMI) patients (100%) and can also identify thrombus not seen by angiography. Occasionally, residual blood in OCT imaging field can give false-positive results.

During Percutaneous Coronary Intervention
Optical coherence tomography in comparison to IVUS can detect stent edge dissection 40 versus 16%, tissue protrusion 58 versus 20% and stent malapposition 47 versus 18%. OCT is a useful tool for risk stratification of PCI. Following implantation, a stent can get covered by regrowth of intima, which is difficult to assess with IVUS, as the thickness of the intimal covering following drug-eluting stent (DES) is less than 100 microns. OCT can assess this neointimal covering of stent due to its high resolution capability. OCT may be used as a guide for assessing duration of dual antiplatelet therapy following DES implantation.

FRACTIONAL FLOW RESERVE
Angiography forms the basis of most revascularization decisions. This approach is perfectly reasonable when the angiogram clearly demonstrates either a severely stenosed coronary artery or a normal one. However, angiography has well-known limitations and the significance of lesions of moderate severity is often difficult to determine based on just the angiogram. This uncertainty may result in inappropriate care with stenting of non-flow-limiting lesions or failure to revascularize significant ones. When confronted with an ambiguous angiogram, additional testing is required to make a confident decision. Myocardial perfusion imaging (MPI) could be used to determine the presence of ischemia in the vascular territory supplied by the suspect artery. Fractional flow reserve (FFR) is physiologically based and describes the ratio of the maximum achievable flow in the presence of a stenosis to the theoretical maximum flow in the same vessel in the absence of a stenosis. It takes into consideration the multiple, complex variables influencing coronary flow including lesion severity, lesion length and collateral flow (Figures 3A to C).

The FFR is defined as the ratio between distal coronary pressure and aortic pressure, both measured simultaneously at maximal hyperemia. Distal coronary pressure is measured with a coronary pressure guidewire. Maximal hyperemia is usually induced by intravenous adenosine, administered at 140 g/kg/min via a central vein or by intracoronary bolus dose. In diffuse or tandem lesions, hyperemic pullback recordings are performed. The unequivocal normal value of 1.0 is well accepted and has been firmly established in humans; although the initial validation studies determined that an FFR of 0.75 most strongly correlated with ischemia, coronary stenoses with FFR between 0.75 and 0.80 have been considered “borderline” and may, in fact, be significant; currently, most clinicians and investigators consider an FFR of 0.80 as “ischemic”. Importantly, revascularization of lesions with nonischemic FFR can safely be deferred, thereby establishing FFR as a valuable tool and important adjunct to angiography in clinical decision making (Figures 4A and B). The FAME 2 trial recently published in New England Journal of Medicine (NEJM), indicates that angioplasty and
stenting along with the best available medications result in better outcomes than medications alone for patients who have significant blockages in their heart arteries, as measured by FFR. It is common practice for physicians to make revascularization decisions in the cath lab after a cursory review of the angiogram. It is frightening to think how many patients undergo unnecessary revascularization procedures or whose symptoms are dismissed as noncardiac because their physician “guessed” the significance of an ambiguous lesion. It is now easy to perform FFR at the time of the procedure, and, unlike conventional single-photon emission computed tomography (SPECT) MPI, it is not influenced by disease in other vessels. With FFR, we can be confident that a lesion requires revascularization. Also the deferral of revascularization based on a nonischemic FFR is safe. We have been regularly using FFR and it is simple ready to use and readily available in the cath lab and has tremendous utility with lots of scientific evidence backing its routine use.

DEDICATED BIFURCATION STENT TECHNOLOGY

We are now using the new dedicated, especially designed stent to clear the stenosis that is formed in the coronary artery involving two branches. Bifurcation lesion means, there is a blockage in a site where the blood vessel divides into two and is more challenging to treat. Two branches of the blood vessel have narrowing. If a balloon angioplasty is performed in one, there are chances of the other branch closing. Conventionally, one or two stents are placed and there are chances of recurrence in the side branch. There are several types of bifurcation stents available. We use the advanced Nile Pax stent (dedicated bifurcation stent) (Figure 5) which is shaped in such a way to remove narrowing from both the branches and has to be inserted through two wires to place it simultaneously in both branches (Figures 6A and B).

These stent has several advantages. It covers both branches and is drug coated, helps in accessing both branches of the artery for future treatment, if required. Also the quantity of dye used and the duration of the procedure is much less.

NEWER DEVICES IN PRIMARY ANGIOPLASTY IN ACUTE MYOCARDIAL INFARCTION

The best form of life-saving treatment one can offer for acute MI is primary angioplasty which is the opening up of the occluded blood vessel within the first 12 hours. The newer devices and techniques available for primary PCI in acute MI has been highly successful in opening the blocked artery and improving long-term outcome. In the process of removing the thrombus, very often the thrombus aspiration catheter is introduced into the blood vessel and the thrombus is removed using manual suction which improves blood flow. However, despite removing the major portions of the thrombus, some minor particles can distally embolize into the blood vessel and can obstruct the coronary microcirculation.

ClearWay Catheter

The ClearWay therapeutic perfusion catheter acts as a low-pressure irrigating system for localized perfusion of therapeutic agents into the coronary vasculature. It is a microporous balloon mounted on a 2.7 F RX catheter and will not burst or tear during use. Fluid gently weeps through the pores with no high pressure jetting. It inflates and infuses fluid at low pressure (1–4 atm) and does not damage the internal elastic lamina of vessel during inflation and infusion. Pressure at the balloon surface during infusion is nearly zero relative to blood pressure. Balloon inflation causes occlusion of the vessel, providing a better drug contact with the thrombus, without dilution by blood flow. This increases concentration and residence time of the therapeutic agent, which leads to a greater reduction in thrombolysis in myocardial infarction (TIMI) thrombus burden score, a hallmark of this catheter system. This ClearWay catheter system (Figures 7A to C) is described as occlusion, containment and infusion (OCI) therapeutics allowing site specific, localized drug delivery across any coronary lesion. The potential disadvantage of the traditional methods (passing through guide catheter) is that greater than 50% of the drug will be washed away in systemic circulation and remaining
Acute Myocardial Infarction Specific Stents

**MGuard Stent**

The MGuard Coronary stent presents a novel combination of a coronary stent merged with an ultra-thin mesh wrapped around the stent (Figure 8). The sleeve is designed to expand seamlessly when the stent is deployed, without affecting the structural integrity of the stent, and to prevent plaque detachment during and postprocedure. The MGuard Coronary stent provides long-acting embolic protection, without adding complexity in deliverability. It is designed for primary PCI in acute MI patients who have thrombus in the blood vessel. MGuard possesses a unique micronet technology that traps blood clot material and allows healthy vessel healing. Available clinical data shows that MGuard is a practical, safe and effective stent for thrombotic lesions. Recent MGuard for acute ST-elevation reperfusion (MASTER) trial has shown significant ST-segment resolution with MGuard stent in acute MI. The advantages of this stent are that it can be deployed fast and no pretreatment or special device is required, is less bulky than thrombectomy devices and the enduring effect of the mesh is permanent. MGuard stent system traps the thrombus and fragile plaque during deployment and has been shown to have high procedural success with low rates of clot dislodgment into distal branches during deployment.

**“ABSORB” BIORESORBABLE VASCULAR SCAFFOLD**

This is a new revolution in interventional cardiology after the introduction of metallic DESs. The new ABSORB biodegradable vascular scaffolds are everolimus-eluting and provide transient vessel support with drug-delivery capability, without the long-term limitations of the metal, presently in DESs.

This novel technology also overcomes many safety concerns associated with metal stent and possibly also has more clinical benefits. In particular, the scaffold provides lumen support for up to 6–12 months and then is completely bioresorbed, eliminating the permanent metal typical of the metal stents.

Initial studies with this scaffold in a small number of patients have shown very promising results with good clinical outcome up to 5 years follow-up. The highlight of this device is the late lumen enlargement and restoration of a normal vasoreactivity. Further ongoing randomized trials would evaluate the efficacy and safety of this device in a large population.

It was recently launched in India for commercial use and our initial experience is very good. Our experience has reinforced the need for adequate coronary bed preparation (Predilatation prior to deployment of the scaffold) which ensures good stent apposition with the vessel wall. We deployed the first stent in a 51-year-old male diabetic with positive stress test. Coronary angiogram showed double vessel disease. LAD was stented using BVS. Right artery FFR was done and was not significant. This new stent disappears over 12–18 months. Important aspect is that dual antiplatelet drugs need not be given for a long time as the stent disappears and, therefore, reduces the long-term bleeding risk and the lowers bleeding risk in case of future emergency or elective surgery. It also helps in creating
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BIBLIOGRAPHY


Figures 9A to D: Absorb bioresorbable vascular scaffold. (A and B) After implantation; (C and D) After resorption

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