Vascular Restoration Therapy: Method to Improve Performance of Fully Bioabsorbable Vascular Stent to Replace Current Metallic Drug Eluting Stent

Yunbing Wang
Abbott Vascular, 3200 Lakeside Drive, Santa Clara, CA 95054

Statement of Purpose: Coronary artery disease (CAD) is by far the leading causes of death in the world. The treatment of CAD is complex and often involves invasive coronary intervention. The newest and most promising minimally invasive intervention is metallic drug eluting stent (DES) approved by FDA in 2003 [1]. A DES is a small expanded drug coated metallic scaffold where the scaffold functions to offer support to arteries and the drug is released to prevent restenosis. Currently, all metallic DESs are made from biostable metals, which stay in the vessels permanently after implantation and make any further non-invasive screening or re-intervention more difficult, and could cause sudden death due to the formation of late thrombosis [2]. The development of a bioabsorbable stent would obviate the permanent metal implant in vessel, allow late expansive luminal and vessel remolding, and leave only healed native vessel tissue after the full absorption of the stent. Consequently, it would reduce the risk of potential long-term complications and of late thrombosis, and would facilitate non-invasive diagnostic MRI /CT imaging.

Since early 1980s, a lot of work on bioabsorbable stent development has been done in both academic and industrial area. Unfortunately, so far, most bioabsorbable stent projects developed by various companies and institutes are still in bench testing or preclinical study stage, since some basic questions such as principles of material selection, stent design and processing condition selection, and degradation profile control have not yet been well answered.

At Abbott Vascular, we have worked on bioresorbable scaffold (which was once called BVS bioabsorbable stent) development since 1988, and recently have successfully developed a method to prepare bioabsorbable stent whose near-term performance is totally competitive to current metallic DES, which could be used to replace metallic DES for coronary artery disease treatment.

Methods: Based on our recent studies and various data generated from bench testing and preclinical studies, we set up a new concept for bioabsorbable stent design and found a new method to prepare stent based on the principle of this new concept. This concept is that the bioabsorbable stent design should meet a totally different set of performance criteria compared with regular metallic DES design. The lifecycle of a biabsorbable stent should be divided into three phases: (1) revascularization of blocked vessel within around 3 months after stent implantation; (2) restoration of reopened vessel from the fourth months to around 10 months; (3) resorption of bioabsorbable stent. During the first phase, the bioabsorbable stent's performance should mimic that of a metallic DES. In another word, it should have high acute radial strength, minimum of acute recoil, good deliverability, and therapeutic agent delivered to abluminal tissue at a controlled rate. During the second phase, the bioabsorbable stent should gradually lose radial strength, deposit cellular matrix over struts, and allow the vessel to respond naturally to physiological stimuli. In the third phase, the stent should become discontinuous structure and be absorbed in a benign fashion.

In order to meet the proposed new design concept, we selected a special spider type structure stent design (Figure 1), chose PLLA as backbone material and made it with high crystallinity and chain orientation through special control of thermal processing conditions. Everolimus drug was blended with amorphous PDLLA material at 1:1 ratio and sprayed onto PLLA backbone for a controlled drug release.

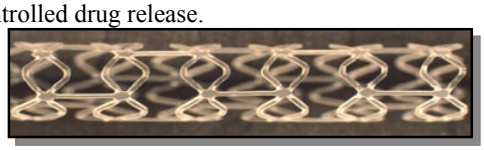

Fig. 1. Spider type design of BVS bioresorbable scaffold

Results: The testing results showed that BVS has similar radial strength to metallic DES and can maintain it for more than 3 months. Preclinical data showed that the scaffold totally disappeared after 3 years (Figure 2). Clinical data showed that no late thrombosis had been observed up to 3 years (at this time point the scaffold had been totally disappeared), and the original diseased vessel had regained vasomotion function. Early this year, a large scale clinical trial with 1000 patient enrollment had been initiated.

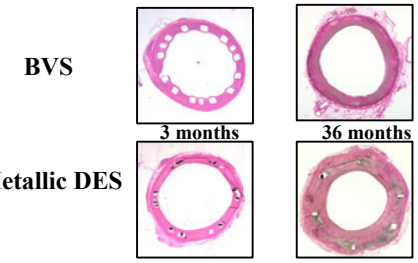

Fig.2 Preclinical results of BVS up to 3 years

Conclusions: Bioabsorbable stent which matches near-term performance of metallic DES but absorbs into the body on longer scales can be successfully prepared through a special stent pattern design, material selection, material morphology and degradation profile control. The clinical trial results using bioabsorbable stent prepared by this new method has shown great safety and efficacy, which showed that it could be superior to current metallic DES and could bring a new revolution to vascular disease treatment – this revolution would be called as Vascular Restoration Therapy.

References:

1. Indolfi C, et al. Trend Cardivasc. Med., 2003, 13, 142
2. Finn AV, et al. Circulation, 2007, 115, 2434