

Bioabsorbable Stents : Reaching Clinical Reality

Abdul Wadud Chowdhury
Dhaka Medical College

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The use of percutaneously introduced prosthetic devices to maintain luminal integrity of diseased blood vessels was proposed by Dotter and Judkins in 1964, well before the introduction of Coronary Angioplasty by Andreas Gruntzig in 1977.^{1,2} This was followed by use of balloon mounted stent in peripheral arteries by Palmatz et al in 1985 and introduction of first commercially successful stents the “Palmaz-Schatz stent” .^{3,4} Puel and Sigwart were the first to implant a stent in humans in March 1986 .⁵ In 1993 two Landmark trials Belgium Netherland Stent (BENESTENT) Study and North American Stent Restenosis Study (STRESS) established the efficacy of intracoronary stents in reducing the incidence of acute closure and angiographic restenosis .^{6,7} In the early 2000s Percutaneous Coronary Interventions (PCI) reach the third milestone by the advent of drug eluting stents (DES) , where a stent is combined with a drug designed to prevent in-stent restenosis (ISR) through inhibition of smooth muscle cell proliferation.⁸ The restenosis rates were reported at 0 % in highly selective lesions and up to 16 % in a broader range of patients and lesions.⁹⁻¹¹ But later it became obvious that permanent stents per se generate problems though they reduce ISR due to neointimal hyperplasia. These limitations include long term endothelial dysfunction, delayed re-endothelialization, thrombogenicity (late and very late stent thrombosis), permanent physical irritation, chronic inflammatory local reactions, mismatches in mechanical behavior (vasomotion) between stented and nonstented vessel areas, and importantly non permissive or disadvantageous characteristics for later surgical revascularization.¹²

The prospect of a temporary vascular stent, termed ‘Scaffold’ , based on a bioabsorbable / biodegradable material represent an attractive

alternative revascularization modality which offers the acute advantages of a stent while being free of potential long term complications of metal stents. The Igaki-Tamai stent (Igaki Medical Panning Company, Kyoto, Japan), the first absorbable stent implanted in humans is constructed from poly- L-Lactic acid (PLLA). Hydrolysis of bonds between repeating Lactide units produce lactic acid that enters the Krebs cycle and is metabolized to CO₂, and water. The stent was however quite bulky required 8 F guiding catheter and used a cumbersome deployment process.¹³

The first metallic bioabsorbable stent implanted in humans is the magnesium alloy stent studied in the Clinical Performance and Angiographic Results of Coronary Stenting with Absorbable Metal Stents trial. However as these stents were radiolucent and did not have radio-opaque markers so accurate postdilatation and additional stent placement without gap or long overlap become quite a challenge. In addition it did not release any antiproliferative drugs. Consequently, there was high restenosis rate (nearly 50%) at 4 months and high target vessel revascularization rate (45%) at 1 year.¹⁴

The bioabsorbable vascular scaffold (BVS) everolimus eluting stent (Abbot Vascular, Santa Clara, California) is the first bioabsorbable stent to have clinical and imaging outcomes similar to those following metallic drug eluting stent (DES) implantation for 2 years but with the potential advantages of full stent absorption.¹⁵ This stent has a bioabsorbable polymer backbone of PLLA (similar to Igaki-Tamai stent) with polymer coating of poly-D, L- Lactide that contains & controls the release of a proven antiproliferative drug, everolimus. The first generation devices were evaluated in ABSORB Cohort A clinical trial (ABSORB 1.0) and the second generation (ABSORB Revision 1.1) were investigated in ABSORB Cohort B trial.¹⁶ The third generation

is under evaluation. These stents used the original Multi-Link design & have adjacent platinum radio-opaque markers at each end ensuring good fluoroscopic visibility. There was however, an angiographic late loss (LL) of 0.44mm. This was less than LL of bare metal stent (BMS) (>0.8mm) but higher than LL of Xience everolimus eluting stents (LL=0.11). A combination of neointimal hyperplasia (+5.5%) and reduction of device area (-11.8%) as consequence of early bioabsorption and early recoil of the device leading to “scaffold shrinkage” were the main reasons for these findings.¹⁶ The second generation stents however showed much improved results with a reduction in scaffold area of 2.4% and 1.9% with intravascular ultrasound (IVUS) and optical coherence tomography (OCT) respectively.¹⁶ Additionally the hierarchical MACE rate at 1 year (7.1%) was comparable to that observed in the historical series of Xience V metallic everolimus eluting stents.¹⁶

The “liberation” of treated vessel from its “metallic cage” and subsequent reactivation of the physiological process of vasomotion, vascular remodeling and lumen enlargement along with freeing the jailed side branches from stent struts are goals that seem to be the achievable gifts of bioabsorbable vascular scaffold. The main challenges faced by ABSORB BVS are its limited distensibility, and therefore its suitability for implantation in appropriately sized vessels. So a quantitative coronary angiography (QCA) guidance often necessary for its proper implantation.¹⁶ A second headache is that if BVS is over-stretched beyond its designed limits, it can lose some of its radial strength and may possibly fracture.¹⁶ Embolization of partially degraded stent scaffold and difficulties in delivering or deploying the bulky polymer stents particularly through extensively calcified or tortuous vessel are other potential drawbacks of bioabsorbable stents.¹⁷ With improving design and polymer manufacturing process perhaps these limitations will be overcome in near future. Lastly, in developing countries like Bangladesh another important drawback is its high cost. In future, reduction in cost will surely lead to extensive use of these efficacious stents.

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