

**Review Article**

**An Evolutionary Appraisal of the Efficacy of Coronary Artery Stents relevant to the Treatment of Coronary Heart Diseases**

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**Abstract**

Cardiovascular heart disease is one of the leading healthcare problems in this present era and need much care to prevent from this problem. The main reason for this problem is the accumulation of fats or plaque that blocks coronary arteries of heart which in turn resist the flow of blood to the heart walls and cause serious complications. The advancement in biomedical engineering and fabrication technology along with implantation technique made it possible and convenient to minimize the problems of coronary heart diseases. Small medical implantable device such as coronary stent which is a mesh like tube structure is one such emerging and stunning application which could be implanted in coronary artery with desirable yield and controllability. In this paper we have reviewed about causes of heart arteries blockage due to atherosclerosis and stenosis, about coronary stents implantation technique and different types of coronary stents available in present scenario.

**Keywords:** Coronary Heart Disease; Coronary Artery Stents; Atherosclerosis; Restenosis; Percutaneous Transluminal Coronary Angioplasty

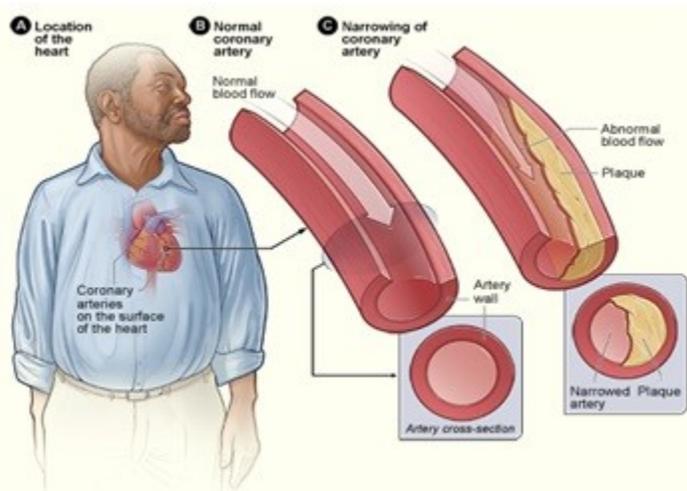
**1. Introduction**

Mainly atherosclerosis is main reason for the origin of coronary heart disease (CHD) where below the endothelium there is development of deposits of plaque which ultimately cause resist or reduce to the heart the flow of oxygen rich blood as well as also cause blood vessels narrowing as shown in figure 1. The artery reopening and by a stent the back push of vessel walls of the plaque are the most important methods for treatment of CHD<sup>1</sup>. Clinical reports revealed that at the present decade a main worldwide health care dilemma is cardiovascular disease. The basis for formation of thrombus at the arterial walls is the buildup of cholesterol, fats etc that slender the lumen vessels and also caused blockage of arteries<sup>2</sup>.

Narrowing of blood vessels due to atherosclerotic as shown in vascular disease possess a pain in severe cases upon tissue breakdown due to the formation of fatty plaques and restriction of blood movement to the tissues<sup>3</sup>. In order to deal with this trouble, the coronary stent is the well thought capable and helpful device<sup>2</sup>. Arteries narrowing (stenosis) which

delivers blood to the heart tissue characterize the coronary heart disease which apparently it leads to myocardial infarction and angina. Coronary heart disease treatment over the years now utilize the percutaneous coronary intervention (PCI) which is now a stunning substitute to surgical revascularization and medical therapy<sup>4</sup>.

**Figure 1: (A) Shows the location of the heart in the body. (B) Shows a normal coronary artery with normal blood flow. The inset image shows a cross-section of a normal coronary artery. (C) Shows a coronary artery narrowed by plaque<sup>5</sup>.**



## 2. Historical background

The angiography was first introduced by Charles Theodore Dotter and Melvin P. Judki in 1964, whereas the first balloon coronary angioplasty was performed by Andreas Grüntzig after thirteen years of first angioplasty, which step forward for the treatment of coronary intervention<sup>6</sup>. A variety of metallic stents design have been introduced and developed by researchers to enhance the performance of vascular stents after the beginning of the idea of these stents<sup>7</sup>. A new era of coronary artery was open in 1977 by Gruentzig introduced successfully the process of percutaneous transluminal coronary balloon angioplasty in structure lesion. In this method the structure lesion broadens when balloon dilates which in turn blood flow get improves<sup>8</sup>.

In 1980s first biodegradable stent was introduced which named Duke stent. This stent was made by using strands of woven poly l-lactic acid (PLLA) polymer. In human the Igaki-Tamai stent was first biodegradable stent that has zigzag helical coil design implanted<sup>7</sup>. The introduction of stenting in 1993 appreciably minimizes the rates of complications related to procedure of balloon angioplasty. The complications that are mitigate by stents includes intimal dissection, vessel wall elastic recoil, decreases rates of angioplasty restenosis and closure of acute and subacute vessel<sup>4</sup>.

## 3. Stenosis and Restenosis

Coronary stenosis is a form of an abnormal condition same as shown in figure.1, in which the arteries of heart becomes narrowed or tapered due to accumulation or backed up by means of materials like cholesterol or fat. Stenosis does not allowed the flow of blood to walls of the heart. When there is constriction of arteries the heart's normal function severely affects and become fatal. One of the general techniques for treatment of cardiac vessels stenosis is Percutaneous Transluminal Coronary Angioplasty (PTCA) that utilizes intercession of stent. In the body a stent is introduce into a natural passage that give mechanical help and support to the vessel that is diseased and ultimately work against an induced diseased that caused localized flow constraint. This stent usually broaden the wall of vessels and compact the plaque subsequent to position into an artery. The vital pro is that they do not need open heart surgery<sup>2</sup>. Due to effective foreword and progress of coronary stents into the medical practice of several years of attempts has made it possible to triumph over these problems<sup>9</sup>.

Restenosis is the blood vessel re-narrowing that decreases the size of lumen which as a result after intravascular procedure restricts the flow of blood. Restenosis is mostly described and characterize by remodeling of vessel and intimal hyperplasia. Restenosis results as a combination of mechanical reaction as well as biological response to percutaneous

coronary intervention (PCI)<sup>4</sup>. The problems of restenosis and closure of vessel in early plain old balloon angioplasty (POBA) treatment was encountered by the introduction of coronary stent treatment that was in 1986 implanted by for the first time. This stent was named Wall sent which was self expanding bare metal stent<sup>6</sup>.

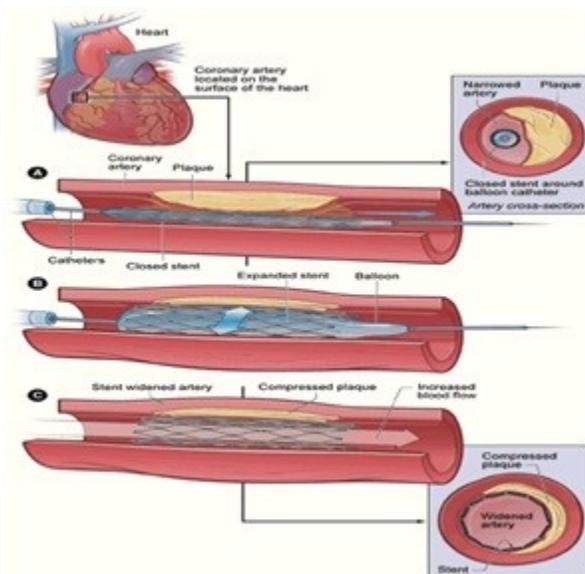
#### 4. Stents

In the last decade for the treatment of cardiovascular heart disease stents are now considered one of the most essential intravascular implants<sup>9</sup>. Stents are structures of arrangement of mesh like cylindrical which at the location of narrowing vessel expanded radially in order to stabilize vascular patency<sup>1</sup>. These devices have characteristics of tiny sized, a kind of a metal, circular spongy scaffolding design which widened section that is active after it is grafted into coronary vessel that is stenosed. The method for the treatment of coronary heart disease to dilate the lumen of coronary arteries is the Percutaneous Transluminal Coronary Angioplasty (PTCA)<sup>9</sup> as shown in Figure 2.

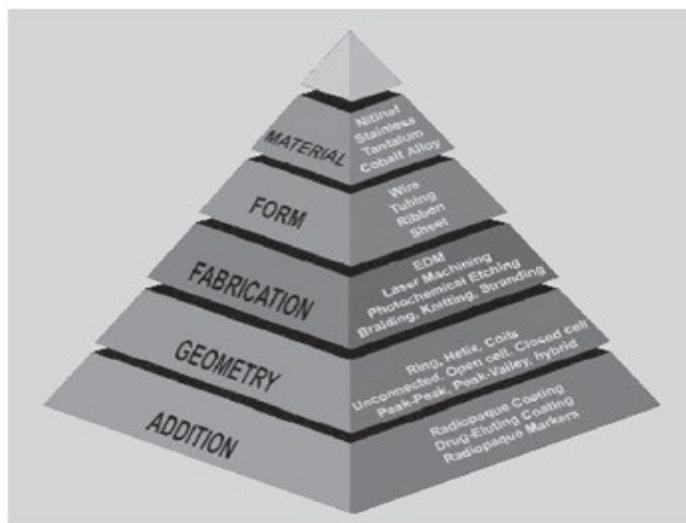
One of the important features in the surgical procedure effectiveness is the expansion of stents which mainly depends on geometry of stent along with huge material non linearity and geometric, deformations and displacements<sup>10</sup>. With entirely mechanical capability and functionality first generation or bare metal stents were developed and designed. After that drug eluting stents that are second generation stents through drugs at local delivery minimize the cause of restenosis which restrain inflammation mainly due to implantation reduced injury<sup>1</sup>.

Stents open previously blocked pathway when insert into vessel lumen where healing takes place to provide a radial to the wall of vascular subsequent to invasive procedure. Usually stents are manufacture from metals and tube of polymer filamentous. They are in range from 1.6 to 3.5 mm and 8 –18 mm or more in diameter and length respectively. In many studies stents have been demonstrated due to its long term and acute benefits over balloon angioplasty<sup>4</sup>. According to several engineering variables stents can be classified that manipulate biocompatibility, characteristics and outcome<sup>12</sup>. The ideal characteristics of stents reported are<sup>12</sup> flexible, trackable, low unconstrained profile, radio-opaque, thromboresistant, biocompatible, reliably expandable, high radial strength, circumferential coverage, low surface area, hydrodynamic compatible<sup>12</sup>.

**Figure 2: Percutaneous Transluminal Coronary Angioplasty (PTCA)<sup>11</sup>**



Requirements of stents varying from application to application due to their mechanical act, form factor and design that perhaps set some restrictions on the advancement of assembly and manufacturing which can be applied on them. Stainless steel and Laser cutting and is widely used for the manufacturing of majority coronary stents forming a mesh like structure<sup>13</sup>. Figure 3 shows the stent design pyramid.

**Figure 3: Stent design pyramid with different material and construction<sup>12</sup>**

## 5. Coronary stents

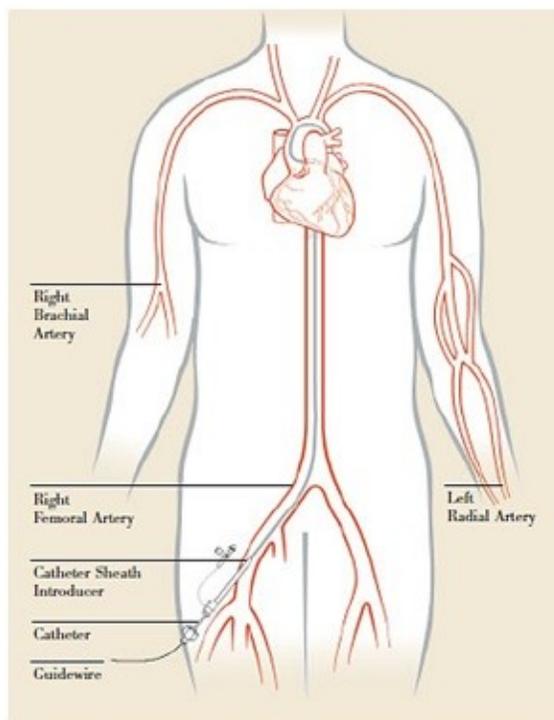
For percutaneous revascularization coronary stents implantation is also a pertinent branch of interventional procedures. The popularity of coronary stenting over balloon angioplasty was due to two important trials that is angiographic restenosis reduction and repetition of interventions require in large coronary arteries and focal lesions. In market there are now many different types of stents made with different designs and materials both for bare metal stents and drug eluting stent<sup>12</sup>. Small tubes like structures of intravascular stents restore perfusion of blood flow that is expanded into stenotic arteries to the downstream tissues<sup>10</sup>. The comparison of stenting with angioplasty has proved that stenting improves the protection of percutaneous coronary intervention as well as the success rate of short term. When considered longer term stenting, the revascularization repetition desire as well as restenosis reduces. Neointimal hyperplasia<sup>14</sup>, remodeling of negative arterial and elastic recoil<sup>15-17</sup> are the three key restenosis pathogenic factors. Furthermore, stents have the capability to counteract and eliminate arterial remodeling and elastic recoil respectively but after stenting the restenosis still due to neointimal hyperplasia<sup>14-18</sup>.

## 6. Coronary stent implantation technique

The coronary stent deployment is similarly carried out through cardiac catheterization procedure of angioplasty in a specialized dedicated room in hospital name as Catheterization Laboratory (CATH LAB). After the initial balloon procedure the coronary stent is placed. The insertion procedure and deployment technique of coronary stent<sup>19</sup> occurred in the following steps.

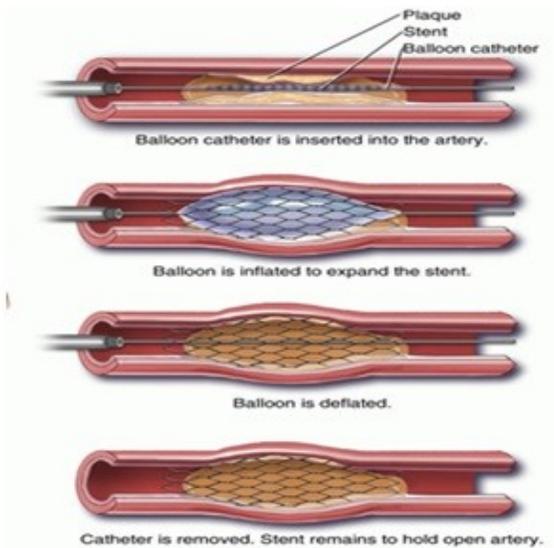
- i. When a local anesthetic administered, in the femoral artery of groin or radial artery of arm a small cut is made and into the artery a catheter sheath introducer is then inserted. Next, a guiding Catheter which is a long and narrow tube is passed to the heart through the sheath as shown in Figure 4.
- ii. Sometimes a contrast dye through the guiding catheter is administered that permits the heart artery to see by the doctors through an x-ray machine named as angiography machine.
- iii. The doctors then through the guiding catheter threads a guiding wire and keep forward advances it to the narrowed artery when on x-ray screen keep observing the arteries.
- iv. Now over the guiding wire balloon catheter is inserted and at the area of blockage positioned it.
- v. Soon the balloon catheter is positioned, the balloon gets expands and against the artery lining the plaque compresses and to the heart blood flow is restored.

**Figure 4: Coronary Stent insertion site<sup>19</sup>**



- vi. Next the coronary stent into the artery is inserted that is mounted on balloon catheter which at area of blockage it is placed as shown in Figure 5.
- vii. The balloon is then inflated once the stent and balloon are positioned. Due to this the stent expands and pressed the inner artery of the wall.
- viii. As once the stent adjust there the balloon catheter is then deflated and along with guiding catheter and guiding wire the balloon catheter is removed. In order to keep the artery open the coronary stent will permanently placed there or removed after some time mainly weeks or months depends on doctors advised.

**Figure 5: Coronary stent implantation<sup>20</sup>**



## 7. Types of stents

The coronary stents are available in two types based on the expansion modality that is balloon expandable stents and self expandable stents<sup>14</sup>. Through the balloon inflation balloon expandable stents are deformed plastically due to its material characteristics, the stent retain its expanded shape even after the balloon is deflated, excluding the slight recoil formed by deformation. Self expanding stents are developed in expanded shape which is then allow to compressed and restrain in a delivery system, they have the ability to spring back after released from delivery system that is to preset diameter it is self expand<sup>3,12</sup>. Both types of stents have certain pros and cons. Self expanding stents cause placement complication which in turn at deployment cause shortening but in new designs this effect at large degree has been mitigate whereas balloon expandable stents cause high stiffness<sup>3</sup>. The ideal material for balloon expandable stents manufacture should contain low yield stress and high elastic modulus. Balloon expandable stents have small diameter which is mounted on the balloon and at the target site are deployed inside the vessel. On the other hand, self expanding stents functionality depends on the materials elastic properties and these materials must contain high yield stress and low elastic modulus<sup>12</sup>. Nowadays most of the PCI procedures entail a coronary stent and for implantation cardiologists have a wide choice of coronary stents. Most widely coronary stents includes bare-metal stents (BMS) and biodegradable polymers drug eluting stents (DES)<sup>6</sup>.

### 7.1. Bare metal stents

Metal stents presented in both balloon expandable and self expandable. The principle of metal stent expansion is based on the metal plastic deformation larger than its elastic limit. The metals stents used may have many disadvantages, main are thrombogenicity due to its electropositivity, at the site of injury irritates the immunological response, concern of sensitization for those who are metals hypersensitive. Metal stents have the ability to grasp local drug delivery for limited capacity with materials of less thrombogenic that is polymer or biodegradable polymer coating<sup>4</sup>. Early stents that were developed were made from stainless steel and was called bare metal stent (BMS). The body cause inflammatory mediators in combination with immunological response since the foreign objects are recognized by metal stents which in turn cause neointimal hyperplasia<sup>21, 22</sup>. The selections of metals for the preparation of these stents are based on shape memory, elasticity, strength and malleability. The commonly used materials are nitinol alloys, stainless steel and tantalum. The thermal shape memory and superelastic properties of nitinol during the deployment permit stent self expansion<sup>4</sup>.

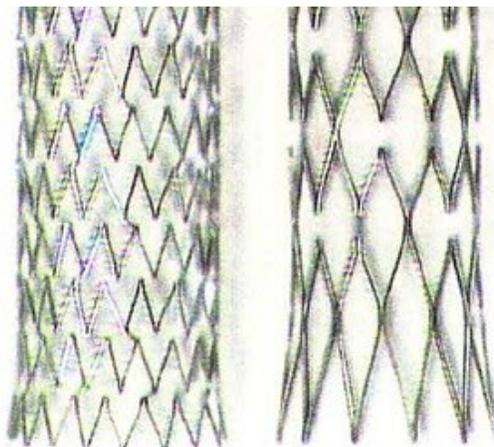
A variety of metallic stents design have been introduced and developed by researchers to enhance the performance of vascular stents after the beginning of the idea of these stents. It has been experienced that after percutaneous coronary intervention (PCI) metallic stents have revealed that intracoronary stenting played an important role in avoiding rapid restenosis and closure of vessel. In-stent restenosis is still remains a main complication regardless of elevated rate of success. Furthermore metallic prosthesis effects for long term are very little known along with problem of compliance mismatch between wall of vessel and the stent. Upon these scarcities consideration is required to improve new metallic stents<sup>7</sup>. Neointimal proliferation and formation after the operation caused the restenosis when the bare metal stent (BMS) used. In order to triumph over the BMS problems, drug eluting stent (DES) is introduced and developed where on metal surface applied drug reducing restenosis. So there is more attention towards the biodegradable materials which overcome the problem of thrombosis and restenosis as drug is released by material of stent<sup>8</sup>.

#### 7.1.1. Cobalt - Chromium alloy stent

Due to In-Stent Restenosis (ISR) rates and relationship between struts thickness the material of choice in recent years is cobalt-chromium alloys for the design of stents. These alloys have high x ray attenuation and strength levels when compared with stainless steel which is designed with thinner struts bless up the corrosion resistance, device radiopacity and resulting strength<sup>23</sup>. Currently in clinical trials cobalt alloys are launched. Better radiopacity is provided by cobalt alloy. Since stents market is dominating by balloon expandable stents, the used of self expandable stents are also present which are mainly made up of nickel titanium (nitinol)<sup>24</sup>.

#### 7.1.2. Nitinol (Nickel Titanium) alloy stent

Nitinol (Nickel titanium) alloys have properties that make these alloys suitable for self expanding particularly. Nitinol alloy consist of balance titanium and 55 wt %. Nitinol stent are larger in size than the vessel size that has targeted and driven by delivery system. This type of stent is easily allowed to crimped and position in delivery system at below or below the room temperature and hits the wall until it expands. The design of nitinol stents are Wire-based Stent Designs, Sheet-based Stent Designs and Tube-based Stent Designs shown in Figure 6<sup>25</sup>.

**Figure 6: Laser cut Nitinol stents<sup>25</sup>**

### 7.1.3. Metal alloy stents

Metal alloy bioabsorbable stents execute and perform in same way as permanent metallic stents. There are two proposed types of bioabsorbable metal alloys, which are bioabsorbable magnesium stent and bioabsorbable iron stent. Further these stents are not coated with drugs.

#### 7.1.3.1. Bioabsorbable Magnesium stent

Magnesium stents shown in Figure 7 have higher radial strength which has vital advantage over polymeric stent due to their biocompatibility and metallic nature<sup>26</sup>. The AMS stent composed of bioabsorbable WE43 magnesium-alloy stent that have the property of marinating strength which is similar to that of 316L stainless steel<sup>23</sup>. With 63 patients in the PROGRESS-AMS trial, in the human the first metallic bioabsorbable stent was implanted which is balloon expandable and has a 165  $\mu\text{m}$  thickness<sup>27</sup>. In trials it was found that there was rapid absorption of magnesium stents in humans and also the mechanical support was lasted for about days and/or weeks which caused it too short in order to prevent restenosis. In the early four months of implantation, major cardiac events were found and additional PCI were carries out in 15 patients<sup>27</sup>. And later 45% patients got additional PCI<sup>26</sup>. Within 4 months the magnesium stents can easily degraded but on the other hand these stents have concerns of high restenosis rates. Several investigations are currently underway for AMS stent for prolonged degradation with modification of their mechanical properties<sup>23</sup>.

#### 7.1.3.2. Bioabsorbable Iron stent

Experimental studies were carried out by Peuter et al<sup>28</sup> with bioabsorbable iron stent that is balloon inflatable and has a 100-120  $\mu\text{m}$  thickness. This stent is made of 41mg pure iron which is equivalent to iron taken by human orally and was implanted in New Zealand white rabbits into its descending aorta<sup>26</sup>. After implantation there was no report of inflammation or thrombosis during the follow up of 6 to 18 months but on the contrary products of stent accumulated due to degradation and also arteries internal membrane was destructed experienced by animals<sup>26</sup>.

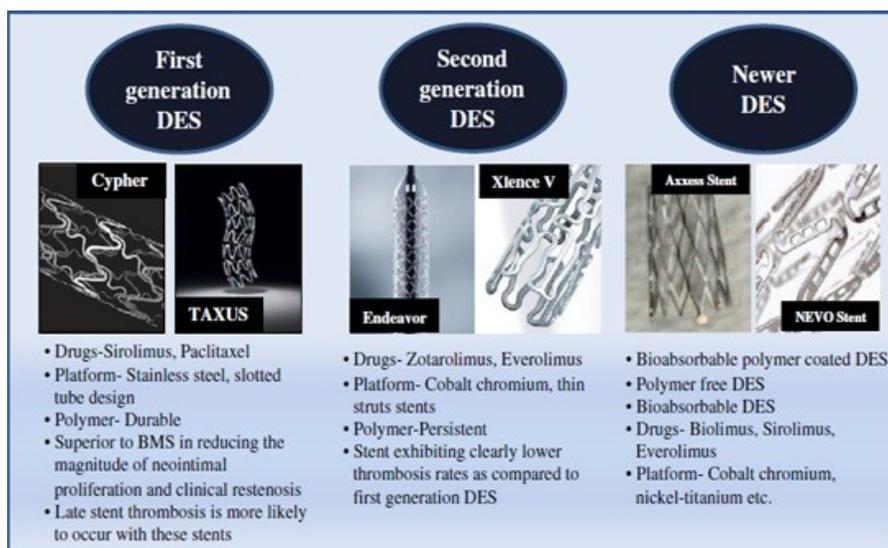
**Figure 7: Magnesium Stent**

## 8. Drug Eluting stents

A drug eluting stent is device that into bloodstream releases single or multiple agents that are bioactive. The agent introduced eliminates in-stent restenosis when deposits in and adjacent to the stent affect tissue. Drug eluting stents minimizes the side effects and provide at the portion of stent deployment a high drug concentration<sup>4</sup>. Due to usefulness for considerable lessening of restenosis in the treatment of carotid artery diseases Drug-eluting stents (DESs) prevail in the world of cardiology internationally. In the cardiology interventional field development and advancement of DES brings key revolutions. An anti migratory and anti proliferative effect must required by the drug that would be ideal on smooth muscles for restenosis prevention on the other side for late thrombosis prevention it must oblige to increases re-endothelialization<sup>29</sup>.

In order to load drugs the ideal drug eluting stent has large surface area, better radial strength and is flexible. There is a small gap between struts that provides over the target lesion of equal and finest supply of drug. Neointimal proliferation is influence by stent biocompatibility, properties of electrophysiological and material of stent. Theoretically in recent years it is deduced that in-stent restenosis prevented by drug-eluting biodegradable stent is an ideal way out because the drug repressed damage vessel and stent inhibited negative remodeling along with elastic recoil, ultimately there is prevention of injury of chronic wall of vessel in combination with degradation of stent overtime. Other than the poly-l-lactate biodegradable stent<sup>12, 30</sup>, in the past because of inflammatory reaction there was increased proliferation of neointimal. Three main parts of drug eluting stents are drug, polymer coating and the stent<sup>31</sup>. Bare metal stents have been replaced by drug-eluting stents (DES) to reduce the possibility of risk of in stent stenosis (ISR)<sup>32</sup>. To address the problem of in stent restenosis DESs have been developed in recent years. For DES, the platform is mainly provided by BMS which in turn coated with carriers of materials and drug formulation. This drug used disturbed molecular and cellular processes with are in combination with ISR<sup>23</sup>. Different generations of drug eluting stents are given in Figure 8.

Figure 8: Different generation of drug eluting stents<sup>33</sup>



### 8.1. First Generation DESs

**8.1.1 Cypher:** The Cypher sirolimus-eluting stent (SES) comprises of two permanent polymers that is PBMA and PEVA as well as Bx velocity BMS made from 316L stainless steel is a closed cell and consists of series of strut segments which is sinusoidal that is linked by N shaped link segments<sup>34</sup>. To the entire stent surface the drug polymer is applied and consists of diameters from 2.25 to 3.5mm and length ranges from 8 to 33mm. About five clinical trials were carried out for efficacy of Cypher SES includes: the First In Man (FIM) trial, the RAVEL trial, and the SIRIUS trials (SIRIUS, E-SIRIUS and C-SIRIUS). In these trials over the Bx Velocity BMS the supremacy of Cypher SES was observed that have lower rates of lesion target<sup>23, 35</sup>.

**8.1.2. Taxus:** The Taxus Express PES comprises of co polymer SIBS and EXPRESS BMS coated by paclitaxel made from 316L stainless steel is a closed cell and consists of series of strut segments which is sinusoidal that is linked by narrow strut

segments. To the entire stent surface the drug polymer is applied and consists of diameters from 2.5 to 3.5mm and length ranges from 8 to 33mm<sup>23, 36</sup>. About three clinical trials were carried out for efficacy of Taxus EXPRESS PES includes the TAXUS I, II and IV trials. The Liberté stent, a newly developed platform employed by Taxus EXPRESS PES for the assessed of paclitaxel-SIBS. The Liberté stent have dense thinner struts 0.097mm vs 0.132mm when compared to EXPRESS stent. Taxus Liberté PES has a diameter about 2.25 to 4mm and length ranges from 8 to 38mm. TAXUS ATLAS trial clinical trial was carried out for efficacy of Taxus Liberté PES<sup>23, 37</sup>.

## 8.2. Second Generation stents

**8.2.1. The Endeavor ZES:** The Endeavor ZES comprises of PC co polymer and Driver BMS coated with zotarolimus. The Driver BMS made from MP35N cobalt–chromium joined by thin axial struts of 0.091mm. To the entire stent surface the drug polymer is applied and consists of diameters from 2.5 to 3.5mm and length ranges from 8 to 30mm<sup>23, 38</sup>. The ENDEAVOR I–IV trials clinical trial was carried out for efficacy of Endeavor ZES<sup>39, 40</sup>. The initial results of these trials were unsatisfactory but in stent late loss which was of higher rates were observed with a short term follow up in these trials.

**8.2.2. Xience-V:** The Xience V EES comprises of copolymer, PVDF-HFP, PBMA and Multi-Link Vision BMS coated with everolimus. Multi-Link Vision BMS made from L605 cobalt chromium alloy having zigzag segments of struts connected by link segments in a single turn<sup>23</sup>. To the entire stent surface the drug polymer is applied and consists of diameters from 2.5 to 3.5mm and length ranges from 8 to 28mm. About four clinical trials were carried out for efficacy of Xience V EES includes the SPIRIT FIRST trial and the SPIRIT II–IV trials<sup>41</sup>.

## 8.3. NEWER DES

**8.3.1. NEVO STENT:** The NEVO SES comprises of cobalt chromium having holes that acts as micro reservoirs which are coated with bioabsorbable polymer such as poly-, L-lactide-co-glycolide (PLGA). PLGA was created by copolymerisation of D,L-lactic acid as well as by glycolic acid and by ester links hydrolysis is degraded in the body that metabolized easily with byproducts<sup>23</sup>. Its designed is same as Cypher SES drug release profile from micro reservoirs provided together with both formulation of bulk erosion and diffusion of drug polymer. Nevo SES in the NEVO-RES-I study provided significant results in the clinical assessment, later on NEVO –I, NEVO-11 and NEVO-III trials were also carried out for Nevo SES<sup>42</sup>.

**8.3.2. Axxess stent:** The Axxess stent designed over a nickel titanium platform to be self expanding and for bifurcation anatomy it is in cone shaped. This design of axcess stent has the capability of access the distal branches. The results of nine month of DIVERGE study made a conclusion that there is about 7.7% low rate of cardiac event and 4.3% revascularization rate of target vessel<sup>43</sup>.

## 9. Polymeric stents

The polymeric bioabsorbable stents include Igaki-Tamai coronary stent and bioabsorbable everolimus-eluting coronary stent (BVS), both of these coronary stents used poly-L-lactic acid (PLLA). Above this other bioabsorbable polymeric stents are bioabsorbable therapeutics .

**9.1. Igaki-Tamai stent:** The first bioabsorbable stent that was implanted in human was Igaki-Tamai. This stent has thickness of 0.17mm having helical coil pattern of zigzag and is balloon expandable and made of PLLA [30]. In the initial study of this stent it was revealed that there was no thrombosis of stent, lumen size increased and PLLA was considered safe in coronary arteries of humans and the results of initial six months of this stent deployment was declared promising. This stent have a drawback in lacking of drug coating<sup>26</sup>.

**9.2. BVS stent:** As compared to metallic DES implantation BVS everolimus-eluting bioabsorbable PLLA stent have similar imaging and clinical outcomes. The release of drug everolimus is controlled by coating of polymer over BVS stent which in turn halt the reproduction of cells<sup>26</sup>. The thickness of this stent is 150 µm. It was revealed in the initial study that there was quickly absorption of stent, increase in lumen size, no thrombosis was found and out of 30 patients only one patient got heart attack<sup>44</sup>.

**9.3. Bioabsorbable therapeutics:** The Bioabsorbable Therapeutics (BTI) developed polymeric stent coated with sirolimus. Between the salicylic acid molecules the bonds formed the coating polymer and base polymer of the stent. Here the salicylic acid releases prevent restenosis. The BTI stent is balloon expandable and has a 200 µm thickness<sup>23</sup>. The WHISPER trial the first BTI SES was evaluated that involves 11 patients and without incur any chronic recoil BTI SES

exhibited structural reliability and adequate prevention. Attribution to rapid drug release and inadequate dosing of drug because of insufficient suppression of neointimal the design of this stent has been revised. The revised consists of higher dose of sirolimus, profile of lower drug release, minimum crossing profile and having (0.175 vs. 0.20mm) thinner struts<sup>45</sup>.

**9.4. REVA stent:** The REVA stent is mainly composed of stent platform that is bioabsorbable made from L-tyrosine permeate with iodine molecules for radiopacity. The capability of absorption of this stent is about three years with a rate of absorption that is tunable act as a matrix of drug delivery<sup>23</sup>. This stent has slide and lock design which allows expansion exclusive of deformation of material. In the RESORB trial the REVA stent was for the first time evaluated involving 27 patients and at implant lesions was successfully dilated, minimizes stenosis diameter having no sign of shrinkage<sup>46</sup>.

## 10. Conclusion

Coronary heart disease treatment now utilizes the coronary stent implantation technique which is spectacular alternate to medical therapy and surgical revascularization. The introduction of stenting appreciably minimizes the rates of complications related to procedure of balloon angioplasty. A variety of stents are designed and manufactured and new stents have been introduced and in progress by different researchers to increase the performance of coronary stents. It is found that stenting improves the success rate of short term and percutaneous coronary intervention. In the literature it is established that bare metal stent (BMS) caused restenosis due to neointimal formation and proliferation, however in recent years cobalt-chromium alloys are mostly implanted by clinicians due to in-stent restenosis, corrosion resistance and radiopacity. To cover up the problems of BMS, drug eluting stent (DES) developed, introduced and in functional condition where drug on metal surface reduces restenosis. Now there is more research work towards the biodegradable stent in order to overcome the problem of thrombosis and restenosis. However, in the cardiology interventional field development and advancement of DES brings key revolutions.

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