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Review Article

Novel Drug Eluting Stent for Coronary Artery Effected Lesions

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Abstract: A coronary stent is a tube placed in the coronary arteries that supply the heart, to keep the arteries open in the treatment of coronary heart disease. It is used in a procedure called coronary intervention (PCI). Stents reduce chest pain and have been shown to improve survivability in the event of an acute myocardial infarction. Similar stents and procedures are used in non-coronary vessels e.g. in the legs in peripheral artery disease. In development are stents with biocompatible surface coatings which do not elute drugs, and also absorbable stents, generally used for the coronary arteries like as atherosclerosis, angina pectoris.

Keywords: Coronary Arteries, Stent, Biocompatible Surface Coatings Stent.

Introduction

The introduction of first-generation drug-eluting stents (DESs) in the setting of percutaneous coronary intervention (PCI) has led to a significant decrease in the need for repeat revascularization, a common limitation associated with the use of bare-metal stents (BMS)[1]. In stent restenosis, the result of a maladaptive neointimal tissue proliferation is dramatically reduced by the long-lasting inhibitory effect exerted by the local elution of anti-proliferative agents[1–3]. First-generation DES commonly consist of three elements: an anti-proliferative drug, a durable polymer that serves for drug loading and modification of release kinetics, and the stent platform. The first generation of DES employs a cobalt–chromium alloy, a durable polymer, and elutes sirolimus or paclitaxel[2]. Sirolimus- and paclitaxel-eluting stents seem to provide similar rates of revascularization, although several studies report a more profound inhibition of neointimal hyperplasia by sirolimus[4–6]. While other first-generation DES have been produced7 the second-generation DES now include the zotarolimus (Endeavor; Medtronic, Minneapolis, MN) and the everolimus-eluting stents[8,9]. Despite the higher efficacy compared to BMS, concerns remain regarding the long-term safety of DES, including localized hypersensitivity and late stent thrombosis[3].

What is coronary heart disease?

Usually there is nothing wrong with your heart indeed, it is the strongest muscle you have. Your heart trouble has been caused by problems in your coronary arteries. Parts of your coronary arteries have become narrowed over time. This is sometimes known as hardening of the arteries or arteriosclerosis. It is very common. Most people have some narrowing of their arteries as they grow older. When the coronary arteries become narrow the blood supply to your heart is not so good. When your body needs more blood usually when you exert yourself your heart has to pump harder. It needs more blood itself. The heart muscle hurts when it does not have the supply of blood it needs this is angina pain[4]. This pain usually gets better with rest and with nitrate drugs like GTN. Emotional upset or extremes of temperature can also cause angina pain.

What is atherosclerosis?

Atherosclerosis (also known as arteriosclerotic vascular disease or ASVD) is a condition in which an artery wall thickens as a result of the accumulation of fatty materials such as cholesterol and triglyceride. It is a syndrome affecting arterial blood vessels, a chronic inflammatory response in the walls of arteries, caused largely by the accumulation of macrophage white blood cells and promoted by low-density lipoproteins (LDL, plasma proteins that carry cholesterol and triglycerides) without adequate removal of fats and cholesterol from the macrophages by functional high-density lipoproteins (HDL) (see apoA-1 Milano). It is commonly referred to as a hardening or furring of the arteries. It is caused by the formation of multiple plaques within the arteries. To preventing this type of coronary heart disease used stent[5].

What is coronary stent?

A coronary stent is a tube placed in the coronary arteries that supply the heart, to keep the arteries open in the treatment of coronary heart disease6. It is used in a procedure called percutaneous coronary intervention (PCI). Stents reduce chest pain and have been shown to improve survivability in the event of an acute myocardial infarction shown in fig: 1.

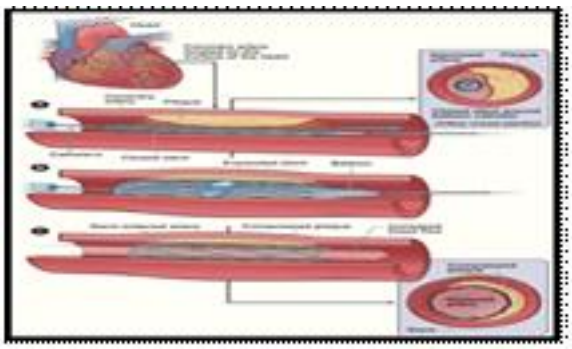

Fig.1: Coronary stent is a tube placed in artery

Placement

In A, the catheter is inserted across the lesion. In B, the balloon is inflated, expanding the stent and compressing the plaque. In C, the

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catheter and deflated balloon have been removed. Before-and-after cross sections of the artery show the results of the stent placement. Treating a blocked ("stenosed") coronary artery with a stent follows the same steps as other angioplasty procedures with a few important differences. The interventional cardiologist uses angiography to assess the location and estimate the size of the blockage ("lesion") by injecting a contrast medium through the guide catheter and viewing the flow of blood through the downstream coronary arteries. Intravascular ultrasound (IVUS) may be used to assess the lesion's thickness and hardness ("calcification"). The cardiologist uses this information to decide whether to treat the lesion with a stent, and if so, what kind and size. Drug eluting stents are most often sold as a unit, with the stent in its collapsed form attached onto the outside of a balloon catheter. Outside the US, physicians may perform "direct stenting" where the stent is threaded through the lesion and expanded[7]. Common practice in the US is to predicate the blockage before delivering the stent. Predictions are accomplished by threading the lesion with an ordinary balloon catheter and expanding it to the vessel's original diameter. The physician withdraws this catheter and threads the stent on its balloon catheter through the lesion. The physician expands the balloon which deforms the metal stent to its expanded size. The cardiologist may "customize" the fit of the stent to match the blood vessel's shape, using IVUS to guide the work. It is critically important that the framework of the stent be in direct contact with the walls of the vessel to minimize potential complications such as blood clot formation. Very long lesions may require more than one stent; this result of this treatment is sometimes referred to as a "full metal jacket" The procedure itself is performed in a catheterization clinic. Barring complications, patients undergoing catheterizations are kept at least overnight for observation[8]. Dealing with lesions near branches in the coronary arteries presents additional challenges and requires additional techniques shown in fig: 2

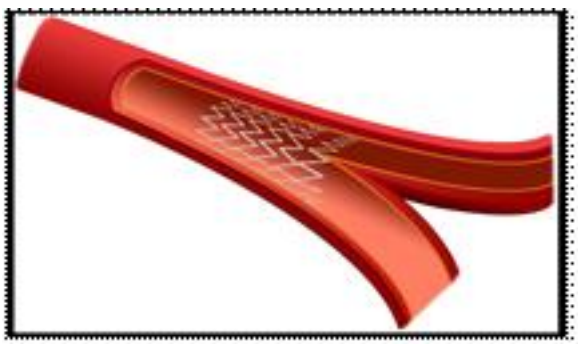

Fig.2: Coronary stent placements

Magnetic Guidance as a Physical Targeting Approach-Promises and Limitations:

Magnetically guided delivery is evolving as an experimental targeting strategy with the potential to improve the efficacy and biocompatibility of therapeutic agents by enabling control over their bio-distribution. Despite considerable progress made in developing drug candidates with optimized therapeutic profiles, it is still challenging to achieve the pharmacological specificity

Necessary for providing effective therapy without causing local or systemic toxicity. A concern for adverse reactions often caused by the same primary mechanisms and occurring within the same dose range as required for the therapeutic effect can preclude attaining adequate local drug levels in target cells or tissues. This is particularly true for the potent cytotoxic or cytostatic drugs used to treat proliferative conditions, including rest enosis and cancer. This concern has provided a rationale for the design of safer formulations and delivery strategies aimed at extending the therapeutic window, improving efficacy, and minimizing systemic drug exposure. The use of magnetic guidance as a novel strategy for achieving localized delivery of therapeutic agents to injured blood vessels has been recently explored in several studies[9]. This accounts for the discrepancy between the apparent ease of targeted delivery to internal tissues and organs using externally applied magnets in small animals and the difficulty in applying this approach to non-superficially located targets in humans shown in fig.3.

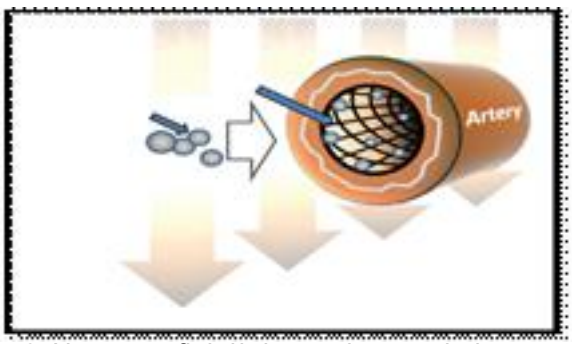

Fig.3: Non-superficially located targets in humans

Stents with bio-degradable polymers:

The Supralimus stent (Matrix; Sahajanand Medical Technologies, Surat, Gujarat, India) is a stainless steel stent with a two layer biodegradable polymer coating. The base layer is a mix of Poly-l-lactic acid (PLLA), poly-lactide-co-glycoside, and polyvinyl-pyrrolidone, which releases 50% of sirolimus within the first week and the remaining 50% in the next 41 days. The surface polyvinyl-pyrrolidone layer has a protective function and degrades completely within 2 h after implantation. In the prospective, nonrandomized, first-in-man Series.I study, 100 patients were treated with the Supralimus stent. Data showed a 6% rate of MACE at 9 months follow-up and an event-free survival rate of 93% at 30 months10. The rates of 6-month in-stent and in-segment rest enosis in a pre-specified

subgroup of 60 patients were 0% and 1.7%, respectively; the in-stent and in-segment late loss were 0.09 ± 0.28 and 0.02 ±0.37 mm, respectively, at the same angiographic follow-up.45 The safety and efficacy of the supralimus stent in the treatment of unselected patients with acute coronary syndrome undergoing PCI have been evaluated in the prospective, multicenter E-SERIES registry which showed acceptable rates of MACE, TLR, and stent definite and probable thrombosis of 10.0%, 2.7%, and 0.6%, respectively, at 12 months follow-up.46 Further data will be produced by the prospective, multicenter, randomized, no inferiority series iii trial ,which is currently ongoing. This study includes a head-to-head comparison with the Xience V stent for the primary endpoint of in-stent luminal late loss at 9 months after stent implantation shown in fig: 4.

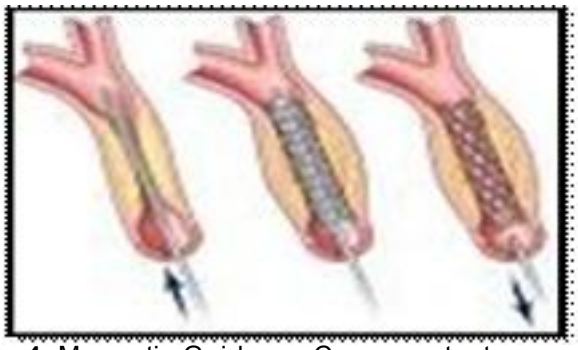

Fig.4: Magnetic Guidance Coronary stent

Fig.5: Bilious-based stent

Bilious-based:

The Biometric Flex stent and the Nobori stent, both coated with a biodegradable polymer, are described in the Innovations in drug – New drugs section shown in fig: 5

Paclitaxel-based:

The biodegradable polymers, which coat the stainless steel balloon-expandable platform of the Infinnium stent (Matrix; Sahajanand Medical Technologies), are poly-l-lactase, poly lactase-co-glycoside, poly lactase-co-caprolactone, and polyvinyl-pyrrolidone. These polymers are stratified in composition with the anti-proliferative agent paclitaxel, each layer with different drug release kinetics. Infinnium stent's safety and efficacy have been assessed in 103 patients Enrolled in the multicenter, prospective, nonrandomized SIMPLE II study, which aimed at investigating the incidence of MACE (primary endpoint) at 30 days and in-stent binary rest enosis by QCA at 6 months follow-up[11]. Results showed rates of MACE at 30 days, 6 months, and 9 months to be 2.9%, 4.9%, and 9.7%, respectively. Data from QCA indicated in-stent and in-segment binary restenosis rates of 7.3% and 8.3% associated with in-stent and in-segment late loss of 0.38 ± 0.49 and 0.18 ± 0.46 mm, respectively. The Infinnium stent has been compared with the abovementioned Supralimus stent and a BMS control in the randomized, multicenter PAINT trial (NCT00752362), which reported a significant reduction in late loss and TVR at 9 months follow-up for DES (both Infinnium 0.54–0.44 mm and supralimus 0.32–0.43 mm) compared with BMS (0.90–0.45 mm) This stent has received the CE Mark[12].

Re-occlusion:

Coronary artery stents, typically a metal framework, can be placed inside the artery to help keep it open. However, as the stent is a foreign object (not native to the body), it incites an immune response. This may cause scar tissue (cell proliferation) to rapidly grow over the stent. In addition, there is a strong tendency for clots to form at the site where the stent damages the arterial wall. Since platelets are involved in the clotting process, patients must take dual antiplatelet therapy afterwards, usually clopidogrel and aspirin for one year and aspirin indefinitely. In order to reduce the treatment, a new generation of stent has been developed with biodegradable polymer. However, the dual anti-platelet therapy may be insufficient to fully prevent clots that may result in stent thrombosis; these and the cell proliferation may cause the standard ("bare-metal") stents to become blocked (restenosis)[13]. Drug-eluting stents were designed to lessen this problem; by releasing an anti-proliferative drug (drugs typically used against cancer or as immune suppressants, they can help avoid this in-stent restenosis (re-narrowing).

Controversy:

The value of stenting in rescuing someone having a heart attack (by immediately alleviating an obstruction) is clearly defined in multiple studies, but studies have failed to find reduction in hard endpoints for stents vs. medical therapy instable angina patients (see below). The artery opening stent can temporarily alleviate chest pain, but does not contribute to longevity. The "vast majority of heart attacks do not originate with obstructions that narrow arteries. A more permanent and successful way to prevent heart attacks in patients at high risk is to give up smoking, to exercise regularly, and take "drugs to get blood pressure under control, drive cholesterol levels down and prevent blood clotting. Some cardiologists believe that stents are overused;

however, in certain patient groups, such as the elderly, GRACE and other studies have found evidence of under-use. Guidelines recommend a stress test before implanting stents, but most patients do not receive a stress test[14].

Clinical trials:

While revascularization (by stenting or bypass surgery) is of clear benefit in reducing mortality and morbidity in patients with acute symptoms (acute coronary syndromes) including myocardial infarction, their benefit is less marked in stable patients. Clinical trials have failed to demonstrate that coronary stents improve survival over best medical treatment.

The courage trial compared PCI with optimum medical therapy. Of note, the trial excluded a large number of patients at the outset and undertook angiography in all patients at baseline, thus the results only apply to a subset of patients and should not be over-generalized. The MASS-II trial compared PCI, CABG and optimum medical therapy for the treatment of multi-vessel coronary artery disease. Several other clinical trials have been performed to examine the efficacy of coronary stenting and compare with other treatment options. A consensus of the medical community does not exist.

Restenosis:

One of the drawbacks of vascular stents is the potential for restenosis via the development of a thick smooth muscle tissue inside the lumen, the so-called neointima. Development of a neointima is variable but can at times be so severe as to re-occlude the vessel lumen (restenosis), especially in the case of smaller diameter vessels, which often results in re-intervention. Consequently, current research focuses on the reduction of neointima after stent placement. Substantial improvements have been made, including the use of more biocompatible materials, anti-inflammatory drug-eluting stents, resorbable stents, and others. Restenosis can be treated with a re-intervention using the same method. The new research was presented by Dr. Gabriel Steg of the Hospital Bichat-Claude Bernard in Paris at a meeting of the European Society of Cardiology in Vienna. Dr. Eckhart Fleck, director of cardiology at the German Heart Institute in Berlin and a spokesman for the European Society of Cardiology, said, "Drug-eluting stents are not for everyone15.

Conclusions

The combination of new drugs, as the biolimus, with other innovative DES components, as biodegradable polymers, has already provided good results, and it is an established fact in the landscape of interventional cardiology.

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