

## Vascular Technologies

### Introduction:

The introduction of new endovascular devices has provided alternatives to surgeries for vascular disease. These advances present new choices to patients for carotid stenting, abdominal aortic aneurysms, acute renal failure and disease in vessels of the lower extremities. Most recent advances have occurred in researching solutions for vulnerable plaque, stent development with an emphasis on preventing in-stent restenosis, and new technologies in treatment of radio-contrast nephropathy. In this monograph we focus on these current medical developments, the existing technology and the future therapeutic treatments. The information below was derived from the resources listed at the end of this paper.

### Vulnerable Plaque:

One of the largest underlying problems in vascular disease is vulnerable plaque. Damaged vessels or vessels with high plaque progression and instability have a high risk of plaque rupture known as vulnerable plaque or atherosclerotic cardiovascular disease. Rupture of vulnerable plaque leads to heart attacks and sudden cardiac death. Each year more than 750,000 people in the United States experience a sudden cardiac event <sup>4</sup>.

The rupture of vulnerable plaque is related to two different factors; the intrinsic characteristic within the vessel that influences vulnerability and an extrinsic force triggering plaque disruption. One intrinsic factor in determining the vulnerability of plaque is the core's thrombogenicity. The core of vulnerable plaque contains macrophages which produce thrombogenic lipid forms called lipoprotein. When blood comes into contact with plaque thick with lipids, the core is at a higher risk of thrombus formation which can potentially lead to an occluded vessel. The vessel wall is exposed to many stresses which are contributing extrinsic factors leading to plaque rupture. In diseased arteries with luminal differences and plaque buildup, the distribution of circumferential stress along the vessel wall contribute to higher stress levels often near the shoulders of the plaque especially at lesions containing a lipid pool.

### Future Technologies:

Identification of vulnerable plaque is a key element to the success of treatment. There are several new emerging diagnostic procedures to assist in the detection of vulnerable plaque. These new imaging modalities include intravascular ultrasound (IVUS) which provides structural tomographic images of the arterial wall, and optical coherence tomography, using a technique with optical echoes of an infrared light source directed at the vessel wall to create high resolution tomographic images of a vessel. There is also spectroscopy which analyzes the emission and absorption of different wavelengths of light for various chemical components and intravascular magnetic resonance imaging capable of determining plaque structure on the basis of biophysical and biochemical parameters of superficial vessels. Finally, there is the modality of thermography. This technique was developed under the findings that plaques with superficial inflammation are warmer than other plaques, whereas temperatures are uniform in normal arteries. It is now commonly recognized that macrophages have a valuable impact in the pathogenesis of acute coronary syndromes. This causes an inflammation that might enhance plaque vulnerability and the reaction causes local heat production ultimately leading to changes in temperature.

There is another treatment under investigation for vulnerable plaque using light infusion technology. This concept is very new and very little discussion regarding the latest developments has taken place thus far. The technology uses a drug-light combination system to close the neovascular supply at sites of proliferative disease. This technology is developed using a new understanding that small blood vessels around the plaque are the primary cause of plaque rupture leading to clot formation and heart attack.

### Stent Technologies:

The most common procedure for disrupted, thrombotic and stenotic plaque is coronary intervention with a stent. This procedure is usually done in combination with glycoprotein IIb/IIIa receptor inhibitors. In-stent restenosis still presents a limitation for this procedure, however new technology with drug-eluting stents (DES) could potentially solve this problem. The development of the drug eluting stent combines a stainless steel scaffold of a bare metal design with controlled release of an antiproliferative agent to prevent restenosis.

Currently only two drug-eluting stents have received approval from both the Food & Drug Administration as well as the Conformité Européenne; they are the Cypher™ sirolimus-eluting stent (SES) developed by Cordis, Johnson & Johnson, and the TAXUS™ paclitaxel-eluting stent (PES) developed by Boston Scientific. Both stents had similar results in clinical trials showing a reduction in restenosis and a need for repeat revascularization <sup>2</sup>.

### **Future Technologies:**

The sirolimus-eluting stent and paclitaxel eluting stent are the most clinically researched drug-eluting stents, however new technologies are being developed to improve on the current devices. The future of this technology is in biodegradable, polymer-coated, drug-eluting stents and stents designed specifically for drug delivery. There are several advantages to biodegradable stents, the primary advantages being their ability to not interfere with cardiac MRI images, long vessels could be treated without fear of geographic miss, and these stents may be used only when needed during the vessel healing process. There are disadvantages as well to be examined such as loss of stent strength leading to restenosis due to vessel remodeling, or the risk of biodegradable breakdown leading to inflammation and restenosis.

### **Radio Contrast Nephropathy:**

Radio Contrast Nephropathy is defined as impairment of renal function occurring within 48 hours after administration of contrast media <sup>1</sup>. This form of nephropathy has become the third leading cause of hospital-acquired acute renal failure accounting for 12% of all cases <sup>1</sup>. Often creatinine levels will peak 3-5 days after contrast media has been administered, leaving a large group of patients potentially overlooked who may develop nephropathy up to a week after the procedure.

### **Current Technologies:**

Currently the most effective measure in reducing the risk of radio-contrast nephropathy is saline hydration. In a study of the effectiveness of saline among patients who suffered contrast medium nephropathy after cardiac angiography, the incidence of nephropathy was significantly lower. Saline hydration alone, however, is not sufficient enough to reduce the risk of nephropathy altogether.

There are new drug studies under investigation concentrating on particular agents to help prevent radio-contrast nephropathy. Fenoldopam is one of the drugs currently under investigation to demonstrate a decrease in renal vascular resistance and increase in renal blood flow. It also has a strong glomerular filtration rate and sodium and water excretion, both of which are positive effects in the prevention of contrast-medium nephropathy. In a small randomized pilot trial, use of fenoldopam in addition to normal saline treatment proved a lower incidence in radio-contrast nephropathy than the use of saline alone, although the difference was not especially significant.

N-acetylcysteine is also under investigational use to reduce renal damage by scavenging oxygen free radicals, generated as a result of toxic damage to renal tubules <sup>1</sup>. In a clinical study, patients received standard saline hydration and n-acetylcysteine orally. This group was compared to patients who received standard saline hydration alone. The results showed a significant decrease of contrast-medium nephropathy in the group who also received n-acetylcysteine vs. saline hydration alone. However, multiple trials with both fenoldopam and n-acetylcysteine have shown conflicting results neither for or against the use of these agents with saline hydration.

### **Future Technologies:**

New investigations are taking place to address the issue of how these drugs are administered. These studies focus on drugs being administered directly to the kidneys as opposed to being systemically administered. Delivery of the agents directly to the kidneys takes place during a percutaneous intervention or diagnostic coronary procedure. These investigations will show if delivery of agents directly to the kidneys is a useful and preventative measure in radio contrast nephropathy with minimal side effects to the patient which have been demonstrated through some systemically administered drugs.

World Wide Web

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