In treating thrombus-loaded lesions through percutaneous coronary intervention (PCI) in the settings of acute myocardial infarction (MI), saphenous vein grafts (SVGs) and acute coronary syndromes (ACS), distal embolisation is a recognised prevalent occurrence, adversely affecting reperfusion and mortality rates. Thus, efficient management of embolisation, in terms of both reduced occurrence and minimised impact, could significantly improve the long-term success of PCI procedures in acute settings of thrombus-containing lesions. This article reviews the prevalence of distal embolisation in these settings, its clinical implications and current strategies to prevent embolisation and present a new, innovative and promising approach to treat these lesions.

**Distal Embolisation – Clinical Consequences and Prevalence**

There are two distinct sources within the affected artery for distal embolisation: the thrombus occluding the artery and the plaque residing on the lesion’s lumen. Both thrombus and plaque embolisation often cause a shower of emboli to be released into circulation, potentially leading to life-threatening intra- or post-procedural complications. The trigger to the embolisation process is the result of mechanical interference with the thrombus or the plaque by various devices during PCI, rendering the plaque layers unstable and causing crushing and fragmentation. However, embolisation may also be a consequence of a spontaneous rupture of plaque without any mechanical interference. In either case, it is clear that the atherothrombotic burden of the patient is a major determinant of embolisation.

The clinical effects of distal embolisation range in severity from small MIs to cardiogenic shock and death. The outcome depends on the extent of embolisation, the size of the vascular bed involved and the haemodynamic status and associated co-morbidities of the patient. Emboli released distally can block a capillary – part of the microvasculature – leading to a potential ischaemia in part of the epicardium, which, in turn, can lead to necrosis. In addition, it can cause a local inflammatory reaction at the blocked capillary due to platelet aggregation, further aggravating the thrombogenic microenvironment. This chain of events is associated with suboptimal perfusion, larger infarct size, lower ejection fraction and higher mortality rate. The suboptimal perfusion ranges from lower epicardial flow to an impaired flow (no re-flow) and occurs despite a full restoration of flow (TIMI 3) in the infarcted lesion through PCI. The clinical implications of suboptimal perfusion have been shown to significantly affect one-year mortality rates: 3.9% for a reduced perfusion and 4.5% for an absent perfusion, compared with 1.4% for a normal perfusion.

A good indication for the high prevalence of embolisation in an acute MI setting can be deduced from the exceptionally high rate of suboptimal perfusion – as high as 82%. Direct evidence of the presence of embolised debris through its retrieval from various embolic protection devices points to more than 70% of cases.

**Management of Distal Embolisation – Current Strategies**

**Distal Protective Devices**

The devices that belong to this category are distal filter devices and distal occlusion devices. Although distal filter devices have proved to be beneficial in SVGs, they have failed to show clinical benefits in acute MI. Distal occlusion devices are based on a combination of an inflation of a balloon distally to the lesion and concomitant aspiration of debris released during the procedure. Although some clear benefits have been proved in SVGs, these devices have failed to demonstrate clear benefits in acute MI settings.

**Proximal Protective Devices**

Proximal protective devices are based on balloon occlusion proximal to the lesion and aspiration of released debris during the procedure. Although this concept theoretically addresses the issues of distal side branches and crossing the lesion, the clinical benefits remain to be demonstrated.

**Thrombectomy Devices**

These devices are designed to remove thrombus through excision and aspiration. However, their clinical benefits have not been proved.
study of 215 patients randomised to thrombectomy pre-treatment or standard PCI, the infarct size in the thrombectomy group was larger (15%) compared with the standard treatment group (8%).

**Plaque Trapping Devices – Covered Stents**

This class of device is based on the concept of utilising specially designed stents for trapping embolic debris against the arterial wall during and post-PCI. Specially designed stents covered with microporous polytetrafluoroethylene (PTFE), used for life-threatening coronary perforation, were thought to provide a useful tool for addressing embolisation, particularly in SVGs. Unfortunately, none of the devices was able to demonstrate reduction in acute major adverse cardiovascular events (MACEs), and their rate of re-stenosis was higher than bare metal stent (BMS).10–14

**A New Stenting Approach**

A new stenting approach has recently been introduced. The MGuard™ from InspireMD attempts to block debris at its source, preventing it from entering the bloodstream in the first place. The first product based on this approach is a novel breakthrough technology combining the clinical benefits of stent efficacy with ‘add-on’ embolic protection at the target lesion site, both pre- and post-procedure. There is no need for an additional embolic protection device (EPD) procedure, with the simplicity of the MGuard procedure being identical to that of a stent.

**The MGuard Design**

The MGuard design is based on a stent covered with an ultra-thin, micron-level, flexible mesh net fabricated by circular knitting (see Figure 1). During stent deployment, the net stretches and slides over the expanding stent struts, creating custom-designed pores parallel to the arterial wall. Once in place, MGuard captures embolic debris between the fibre net and the arterial wall and isolates the pro-thrombotic intima components from the bloodstream.

**Advantages of the New Concept**

**A Cushion-like Effect**

In addition to embolic protection properties, the MGuard net diffuses stent strut impact, providing a ‘cushion-like’ effect. By diffusing strut pressure, the MGuard net may, in turn, minimise injury to the vessel wall and lower the level of re-stenosis.

In an animal study, 30-day post-MGuard histological results showed that the MGuard net facilitated endothelial growth essential for prompt healing (see Figure 2). Histology and histomorphometric data from the MGuard stented segments suggested that MGuard exhibited low Schwartz injury scores (0.15±0.23), 76% lower than the BMS segment. MGuard also yielded exceptionally good endothelisation (4±0), low adventitial fibrosis (0.27±0.28), acceptable inflammatory response (0.87±0.45 on a scale of 0–3), an absence of fibrin score (0 on a scale of 0–3) and an absence of medical necrosis, mineralisation, neovascularisation or granuloma response.15

**Deliverability and Position**

The net has minimal effect on the stent’s crossing profile and is delivered on a conventional delivery system with no impact on dilatation pressure. The protection net is deployed simultaneously with the stent as it reaches its position and expanded size upon stent deployment. There are no limitations on vessel size, and the range of sizes fits all standard diameters and lengths of target lesions.

**Flow Preservation**

As the net follows the vessel topography, it has no adverse impact on blood flow. The immediate, full control of both thrombus- and plaque-generated emboli may contribute positively to epicardium perfusion in acute MI.

**Duration of Embolic Protection**

The net serves as a built-in, permanent EPD, extending the protection time beyond the end of the procedure. It falls short of extending protection pre-stent deployment and does not protect against
Clinical Study Outcomes to Date
A ‘first-in-man’ trial is currently being conducted in two centres in Germany in order to evaluate the safety and efficacy of the MGuard™ stent in SVGs and native coronaries. Between October 2006 and February 2008, 41 high-risk patients were enrolled. Currently, 32 of them have completed their six-month follow-up period. So far, results are encouraging. After six months, the first 32 patients experienced 100% device success during the procedure, with a target lesion revascularisation (TLR) rate of 6.6%, a MACE rate of 6.6% and late loss of 0.38mm. To date, the safety and efficacy of MGuard in humans has been established.

Ongoing Clinical Trials
Two additional trials with MGuard are now under way. The MAGICAL Trial (MGuard in SVG and Native Coronaries Trial) is being conducted in Brazil. The main objective of the trial is to investigate the safety and efficacy of the MGuard stent in human subjects who are candidates for a PCI due to a narrowing of a native coronary artery or a bypass graft. Since November 2007, 21 patients have been enrolled.

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The device has so far demonstrated an excellent performance in a highly complex lesion subset, with no angiographic and/or procedural complications and 0% clinical events at 30 days. Six-month angiographic follow-up has started and enrolment is ongoing. In Poland, the GUARD Trial (MGuard in Acute Myocardial Infarction Study) started enrolment in July 2008 and will investigate 60 patients with acute ST elevation MI who will receive the MGuard stent with no additional distal embolisation or aspiration device. The primary outcome of this trial will be to determine the clinical benefit of MGuard™ in patients with acute MI, an outcome as yet not proved to be beneficial in this cohort of patients.

Indicated Use of the MGuard Coronary
The MGuard coronary stent is commercially available and received CE mark approval in October 2007 to treat patients with coronary artery diseases.

Conclusion
Our currently available strategies for the management of embolisation, whether mechanic or therapeutic, fail short of adequately addressing the adverse clinical effects of embolisation. The prevalence of embolisation in SVGs and primary PCI, coupled with its known adverse impact on event-free survival, underlines the importance of improving our current approach.

MGuard represents an innovative approach to the management of embolisation, offering blockage at the source, simple delivery and lifelong protection.