Distal filter protection during percutaneous coronary intervention in native coronary arteries and saphenous vein grafts in patients with acute coronary syndromes

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Key words:
Angina; Coronary angioplasty; Coronary artery bypass graft; Embolism; Myocardial infarction.

Background. **Percutaneous coronary interventions on saphenous vein grafts (SVG) and in patients with acute coronary syndromes (ACS) have been associated with the distal embolization of the thrombus and plaque and to the no-reflow phenomenon. We report on the safety and feasibility of a new distal emboli protection filter.**

Methods. **Angioplasty using distal filter protection (Angioguard, Cordis, Warren, NJ, USA) was attempted in 38 patients (mean age 65 ± 11 years, 79% males) affected by ACS. A percutaneous coronary intervention was performed in 27 native coronary arteries, in 10 SVG and in one arterial graft (mean diameter stenosis 88 ± 9%). Patients with vessels presenting severe proximal tortuosity, more than mild calcification, a diameter < 3.0 mm and a lesion length > 15 mm were excluded.**

Results. **It was possible to position the device in all patients (100%); in 7 patients (18%) the lesion could be crossed with the filter only after balloon predilation. Procedural success with final TIMI flow 3 was obtained in all patients and the mean residual diameter stenosis after stent implantation was 5 ± 8%. Transient procedural complications without clinical sequelae included the no-reflow phenomenon (2 patients, 5%) and vessel perforation (1 patient, 2.5%). In no case was distal embolization observed. As regards the device-related complications, one occlusive dissection (2.5%) occurred and was successfully treated with stent implantation. In-hospital and 30-day major adverse cardiac events consisted of two non-Q wave myocardial infarctions (5%), both occurring during SVG interventions.**

Conclusions. **The use of the Angioguard filter for preselected lesions in patients with ACS had a high technical success and carried a low rate of device-related complications. The clinical efficacy of the device needs further evaluation.**

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Introduction

Percutaneous coronary interventions (PCI) on saphenous vein grafts (SVG) and in patients with acute coronary syndromes (ACS) have been associated with an increased risk of distal embolization of plaque debris or thrombus fragments[1-7]. The occurrence of distal embolization may cause occlusion of the distal branches or of the microvasculature leading to the no-reflow phenomenon, periprocedural myocardial damage, and a worse prognosis[1,8]. In recent years mechanical devices have been proposed in order to minimize distal embolization and improve the outcome of patients undergoing PCI[2,9,10]. This study was designed to demonstrate the safety and effectiveness of a distal emboli protection filter used in native coronary arteries and SVG during interventions on patients with ACS.

Methods

Study population. In 38 consecutive patients (mean age 65 ± 11 years, 79% males) with ACS angioplasty using a distal filter was attempted. In particular, the intervention was performed in native coronary arteries (27 patients), in SVG (10 patients) and in an arterial graft (1 patient). These represented 27.5% of all patients with ACS treated during the time of the study. The remaining 100 ACS procedures were performed using conventional approaches or thrombectomy devices. Patients with vessels presenting severe proximal tortuosity, more than mild calcification, a reference diameter < 3.0 mm and a lesion length > 15 mm were excluded. Six patients (16%) had an ST-segment elevation acute myocardial infarction, 5 patients (13%) had a non-ST-segment elevation acute myocardial infarction, and 27 patients (71%) had unstable

angina. Of the 11 acute myocardial infarction patients, 5 (45%; all with ST-segment elevation) presented with a totally occluded infarct-related artery. Electrocardiograms were obtained before and after PCI. Serial creatine kinase (CK) and CK-MB (upper normal limits of 172 and 25 IU/l respectively) were collected before and 8, 16 and 24 hours after the procedure. In acute myocardial infarction patients the occurrence of a post-procedural increase in enzymes was not considered as a major adverse coronary event. The characteristics of the patients are shown in table I.

Device description. The distal filter device (Angioguard, Cordis, Warren, NJ, USA) consists of a 0.014" stainless steel guidewire with a filter at the distal end. The filter is made of a nitinol skeleton which supports a porous polyurethane membrane with a pore diameter of 100 μm. Filters with a diameter ranging from 4.0 to 5.0 mm were used. A 7F guiding catheter is needed to accommodate the delivery sheath (diameter 3.2-3.4F) which holds the device in the closed position. After the filter has crossed the lesion, the delivery sheath is pulled back to open the filter basket. Intracoronary nitrates are given only if required before filter placement. The filter is placed at least 1.5 cm distal to the lesion to allow balloon and stent treatment. If possible, the filter is positioned proximal to the origin of major side branches. In 8 cases (21%) the presence of an "unprotected side branch" 1.5 mm in diameter was observed. The origin of this branch was distal to the lesion but proximal to the filter (Fig. 1). In case of occluded arteries, the size of the filter to be used was determined on the basis of the dimensions of the proximal, non-occluded segment of the vessel. Additional, high support 0.014" "buddy-wires" were used in 3 cases (7.9%, all SVG).

Once the PCI is completed, a retrieval catheter (diameter 5.2F) is advanced on the wire to close the filter basket and remove the device.

Table I. Characteristics of the patients.

No. patients	38
Age (years)	65 ± 11
Sex (M/F)	30/8
ST-segment elevation acute MI	6 (16%)
Non-ST-segment elevation MI	5 (13%)
Unstable angina	27 (71%)
Risk factors	
Hypertension	29 (76%)
Hyperlipidemia	25 (66%)
Diabetes	9 (24%)
Smoking	13 (34%)
Previous MI	21 (55%)
Previous CABG	14 (37%)
Previous PCI	12 (32%)

CABG = coronary artery bypass graft; MI = myocardial infarction; PCI = percutaneous coronary intervention.

Procedural details. Having obtained the patient's informed consent, cardiac catheterization was performed through the percutaneous femoral approach and using a 7F sheath. Before the procedure an intravenous bolus of unfractionated heparin (70-100 IU/kg) was administered. The patients were taking aspirin (100 mg/day) and clopidogrel (75 mg once daily and, if necessary, a loading dose of 300 mg) or ticlopidine (250 mg twice daily). The operator judged that it was best to administer glycoprotein IIb/IIIa inhibitors to 17 (45%) patients before the intervention. After filter deployment, the PCI was performed according to standard techniques. The procedure was considered successful when TIMI flow 3 and a post-interventional diameter stenosis < 30% (by visual estimation) were achieved. Technical filter protection was deemed successful when the device could be placed and opened distal to the lesion and when it could be retrieved after stent implantation. Angiographic filter protection success was defined as successful filter protection without the occurrence of filter-related complications, a non-Q wave myocardial infarction and slow flow.

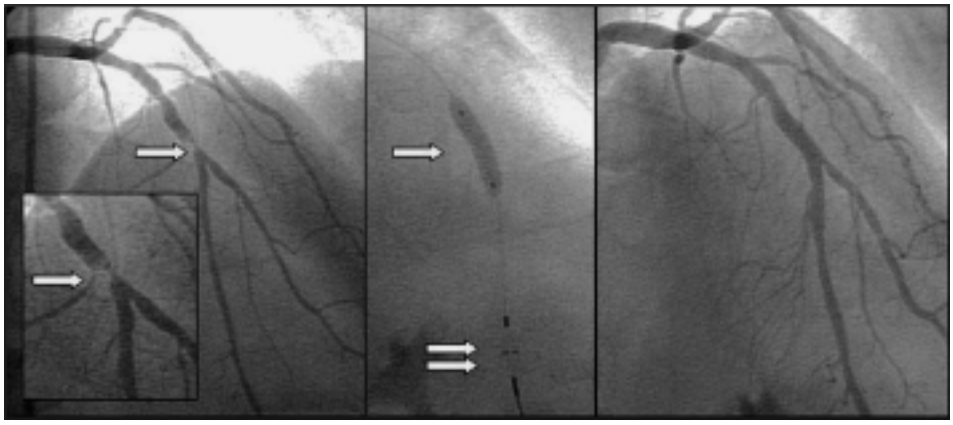

Figure 1. *A tight stenosis* (arrow) *of the mid-left anterior descending coronary artery is shown* (left panel). *The* middle panel *shows the filter protection device* (double arrow) *positioned distally to the stenosis during stent deployment* (single arrow). *The final angiographic result is shown in the* right panel.

In the patients with acute myocardial infarction myocardial blush grade analysis was performed as previously described[11]. ST-segment analysis was performed comparing the baseline and the 60-min post-treatment ECG of each patient. The sum of ST-segment elevations was assessed at 20 ms from the J point in leads V_1-V_6, DI, and aVL for anterior infarction and in leads DII, DIII, aVF, V_5-V_6 for non-anterior infarction; in the latter, an ST-segment depression in leads V_1-V_4 was also considered as a sign of transmural ischemia of the myocardial posterior wall. The ST-segment elevation was classified as having returned to normal if there was no residual ST-segment elevation after the procedure, as having improved if a regression ≥ 50% was seen, and as unchanged if the ST-segment elevation sum appeared to be the same, worsened or regressed < 50%[12]. The criterion for the evaluation of distal embolization was the occlusion of a distal branch in the target vessel during the procedure. The no-reflow phenomenon was defined as TIMI flow ≤ 2 in the target vessel without evidence of significant epicardial stenosis or dissection[13].

Follow-up. All patients were monitored in hospital and at 30 days of follow-up for major adverse cardiac events defined as death, acute myocardial infarction, emergent coronary artery bypass graft or re-PCI. Periprocedural myocardial infarction was defined as an increase in CK-MB > 3 times the upper limit after PCI[14]; this definition does not include the patients undergoing primary PCI for acute myocardial infarction.

Results

A PCI was performed in 27 native coronary arteries, in 10 SVG and in one arterial graft (left internal mammary artery to the left anterior descending coronary artery). An angiographically visible thrombus was present in 18 lesions (47%), mild-to-moderate proximal tortuosity in 12 patients (32%), and mild calcification in 2 cases (5%). The mean diameter stenosis was 88 ± 9%, the vessel reference diameter was 3.7 ± 0.5 mm, and the mean lesion length was 11 ± 4 mm. Angiographic data are shown in table II.

Filter positioning, opening and retrieval was technically successful in all patients (100%). In 31 cases (82%) it was possible to cross the lesion. In the remaining 7 patients (18%; 5 native coronary arteries and 2 SVG) predilation with balloons 1.5 or 2.0 mm in diameter was necessary to advance the device through the lesion. All lesions were treated with stent implantation. Angiographic filter success (defined as successful filter protection without the occurrence of filter-related complications, non-Q wave myocardial infarction and slow flow) was achieved in 87% of patients. Procedural success with TIMI flow 3 was obtained in all patients (100%) and the mean post-PCI diameter stenosis was 5 ± 8%. In the patients with acute myocardial infarction, a myocardial blush grade 3 was achieved in 4 (66%) patients, and a myocardial blush grade 2 in 2 patients. In 4 of these patients (66%), the ST-segment elevation decreased ≥ 50%. The angiographic adverse events consisted of: a no-reflow phenomenon that occurred after stent implantation in 2 (5%) patients treated on native coronary arteries [both resolved following the hyperselective intracoronary administration of nitrates (repeat bolus of 100 μg nitroglycerin) and verapamil (0.125 mg) through a probing catheter (multifunctional probing, Boston Scientific, Natick, MA, USA)]; dissections in 4 (10%) native coronary arteries (2 type A, 1 type B and 1 type F), all successfully managed with stent implantation [1 of these dissections (type F) occurred after filter crossing and 3 after balloon dilation]; a perforation in 1 patient during angioplasty on the body of a SVG, effectively treated with the deployment of a covered stent. In no case was distal embolization observed. None of the above-mentioned adverse events resulted in major adverse cardiac events. In all the 18 patients with angiographic evidence of thrombus it was possible to cross the lesions without the occurrence of angiographically visible distal embolization of material. In these patients 1 dissection after balloon dilation and 1 transient no-reflow phenomenon (5.5%) were observed. Debris was present in 32 filters (84%) (Fig. 2). Histopathologic analysis revealed the presence of foam cells, fibrin, cholesterol clefts, and acellular material which are characteristic of atheromatous plaques. Procedural data are shown in table III.

Table II. Angiographic data.

	Native coronary arteries	Saphenous vein grafts
No. lesions	27	10
Lesion location	RCA 14, LAD 8, LCx 5	Proximal 6, mid 2, distal 2
Mean diameter stenosis (%)	88 ± 9	82 ± 17
Vessel reference diameter (mm)	3.6 ± 0.3	3.8 ± 0.9
Stenosis length (mm)	10 ± 5	13 ± 3
Thrombus	13	5
Proximal tortuosity	7	5
Calcification	2	0

LAD = left anterior descending coronary artery; LCx = left circumflex coronary artery; RCA = right coronary artery.

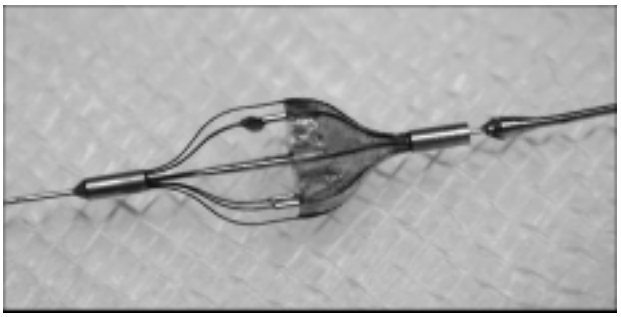

Figure 2. *The Angioguard filter retrieved after the procedure shown in figure 1.*

Table III. Procedural data.

Final TIMI flow 3	38 (100%)
Post-PCI diameter stenosis (%)	5 ± 8
Technical success	38 (100%)
Need for predilation	7 (18%)
Adverse events	
No-reflow phenomenon	2 (5%)
Dissection	4 (10%)
Perforation	1 (3%)
Distal embolization	0
Presence of debris in the filter	32 (84%)

PCI = percutaneous coronary intervention.

Post-percutaneous coronary intervention myocardial damage. With the exception of the 6 patients with an evolving acute myocardial infarction, following PCI we found an increase in CK-MB levels > 3 times the upper normal limit in 2 patients (5%). Both patients suffered a non-Q wave myocardial infarction after treatment of a SVG lesion without angiographic evidence of distal embolization or no-reflow. Q wave acute myocardial infarctions were not observed. The incidence of major adverse cardiac events (all non-Q wave acute myocardial infarction) was 5% for the whole study population, 0% for patients treated on native coronary arteries, and 20% for SVG interventions. No further adverse events occurred during the 30-day follow-up period.

Discussion

Embolization of plaque debris and fragments of thrombus leading to distal branch occlusion or diffuse microvascular obstruction occurs during PCI in a wide spectrum of clinical situations[1,2,7,8,15]. In SVG interventions embolization has to be considered as being particularly relevant. Several studies report a 5-15% incidence of distal embolization during SVG interventions[16-22] which has been associated with a 10-fold increase in the risk of an adverse outcome (death, myocardial infarction, repeat coronary artery bypass graft)[8]. With regard to patients with an acute myocardial infarction undergoing primary PCI, embolization resulting in microvascular obstruction has been associated with a worse clinical outcome both in angiographic[11] and in magnetic resonance imaging studies[7]. Recent reports suggest that embolization occurs when treating thrombotic lesions and friable plaques typically present in patients with ACS[1,2].

Several new devices have been evaluated for the prevention of distal embolization during SVG and other vascular interventions. In the SAFER (Saphenous Vein Graft Angioplasty Free of Emboli Randomized) trial[6], the use of a distal balloon protection device during a SVG intervention was associated with a significant reduction in the incidence of myocardial infarction and no-reflow phenomenon compared to the conventional SVG interventions without protection. However, it is to be pointed out that the balloon protection devices occlude the vessel and hence do not allow normal blood flow and angiographic visualization during the intervention. On the contrary, distal filters allow perfusion and contrast injection, thus ensuring better angiographic control during angioplasty and stent deployment, but are hampered by a larger crossing profile. This may potentially lead to plaque or thrombus dislodgment while crossing the lesion and possibly require an unprotected predilation. The recent, large, randomized FIRE trial compared distal balloon protection with a distal filter during SVG interventions. In this study the device success and the incidence of myocardial infarction were reported to be similar[23]. In our study a device success of 100% was achieved, but in 7 (18%) cases the filter crossed the lesions only after gentle predilation with a small diameter balloon catheter. This highlights the limitations of the filter device. In this setting it is also important to state that in our study only preselected, relatively large vessels (> 3.0 mm in diameter) without excessive proximal tortuosity and without or with only mild calcifications were included. Most of the filter protections were applied to right coronary arteries which appear particularly suitable for distal protection devices because of the often favorable anatomy and the absence of major side branches. This underlines some of the limitations of protection filters when used on the left coronary arteries. In fact, in our experience we observed an incidence of 21% of side branches with a diameter of 1.5 mm that could not be protected.

However, during the study, a first-generation filter device was used. A more recent filter (Angioguard XP) with a reduced profile and an increased torque and flexibility is now available. These device improvements may increase the primary crossing rate. Present results are concordant with previous experiences reporting a device success rate of 96%[2].

In our study the only device-related complication was one occlusive type F dissection successfully treated with a stent implantation. The no-reflow phenomenon was observed in 2 patients with unstable angina who were submitted to an angioplasty procedure on na-

tive coronary arteries. In both cases normal flow was restored after the selective intracoronary administration of nitrates and verapamil. In both patients no increase in the serum levels of cardiac enzymes was observed. In the 2 patients who suffered from a non-Q wave acute myocardial infarction no procedural complications or angiographic evidence of flow alterations or distal vessel occlusion were observed. It cannot be excluded that plaque or thrombus debris has been dislocated during the lesion crossing or that it had not been captured by the filter. Both non-Q wave acute myocardial infarctions occurred after SVG interventions. The 20% incidence of non-Q wave acute myocardial infarction while treating SVG compares unfavorably with results from the SAFER trial[6] and may be explained by the combination of ACS and extensively degenerated SVG lesions. This underlines the still present limitations of distal protection devices. In such complex lesion subsets as degenerated SVG, the role of mechanical distal protection in comparison or synergism with pharmacological approaches needs further investigation.

Atheromatous material was present in a high percentage of filters. The presence of this material, dislocated during the coronary intervention, underscores the importance of embolization during procedures for ACS.

Study limitations. This small prospective registry does not allow any conclusions on the clinical efficacy of the Angioguard filter used during PCI in patients with ACS and further studies involving a larger number of patients are needed. During the study a first-generation filter device has been used. Newly available devices featuring a lower profile and an improved flexibility and torque may well increase the indications of the devices to more difficult anatomic settings and facilitate their use.

In conclusion, the present study demonstrates that the use of the Angioguard filter in preselected native coronary arteries and in SVG in the setting of ACS is feasible with a high technical success rate. The risk of device-related complications is low. Further randomized studies are required to demonstrate that the use of the filter reduces the incidence of major adverse cardiac events with respect to the control group, in particular for the treatment of SVG, and to define the optimal adjunctive pharmacological therapy.

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