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Impact of stent diameter and length on in-stent restenosis after bare metal stent implantation

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Abstract

The stents utilisation in the interventional treatment of coronary lesions is associated with a reduced risk of peri and post-procedural complications rate compared with balloon angioplasty. The knowledge of the technical risk factors for in-stent restenosis can guide the patient selection or the choice of stent type. The aim of this study was to identify the "bare metal" stents characteristics associated with high risk of angiographic recurrence. Patients with in-stent restenosis have smaller stent diameter and greater stent length comparing to control group. The clinical and paraclinical follow-up of patients with these risk factors should be more frequent.

Keywords: *bare metal stent, diameter, length, restenosis*

1. Introduction

Despite the fact that stents utilisation in the interventional treatment of coronary artery diseases is associated with a reduced risk of post-procedural complications compared with balloon angioplasty, several trials have proved a high "bare metal" stents (BMS) restenosis rate, around 30-40% [1, 2, 3, 4]. Further, "drug-eluting" stents (DES) have dramatically reduced the restenosis rate but their large utilisation is limited by higher costs and increased risk of stent thrombosis [3]. Restenosis, or reduction in lumen diameter after stent implantation, is a consequence of vessel wall damage with subsequent inflammation, vascular smooth muscle cell proliferation and migration, extracellular matrix formation and neointimal hyperplasia [4, 5]. It can be also considered an exaggerated biological response to coronary metal prosthesis as a permanent "foreign body" [5]. Over the last years, many predictive clinical, biological, lesion-related, stent-related and procedural risk factors for restenosis have been identified [4]. Furthermore, knowledge of these parameters may help to optimize indications and stent choice and to guide stent implantation strategies. The objective of the present study is to identify characteristicsof stainless steel or cobalt chrome alloy "bare-metal" stents that are able to predict the risk of restenosis in the first year after stent placement. Therefore, our research underlines the importance of optimization and adjustment of stents biotechnological parameters in clinical practice.

2. Materials and Methods

The study was conducted in the Department of Interventional Cardiology of Army's Centre for Cardiovascular Disease "Academician Vasile Cândea", Bucharest and included a group of patients who underwent "bare metal" stents (BMS) angioplasty for coronary heart disease. The study group was formed by patients treated percutaneously with BMS implantation

addressed to our department from January 2005 to December 2013, who had clinically based indication for repeat angiographic examination.

Inclusion criteria: patients with complete interventional revascularization with "bare metal" stent who underwent invasive angiographic evaluation within one year following the initial procedure.

Exclusion criteria:

- patients who had at least one drug eluting stent (DES) simultaneously implanted,
- patients with stents in arterial or venous coronary grafts,
- patients with initial suboptimal postprocedural results,
- patients with major cardiac events in the first month after implantation,
- patients with incomplete data acquisition.

Coronary angiography was performed according to standard operating protocols, each lesion being examined in at least two orthogonal projections. Data regarding the length and diameter of the implanted stents have been collected from medical records. In-stent restenosis was defined in terms of angiographic criteria as recurrent restenosis with percentage diameter ≥ 50% within the stent level or within its 5-mm proximal and distal edges. Stent length (the stented segment length) was determined from the manufacturer reference chart for balloon inflation at nominal pressure. When multiple stents were implanted for long coronary lesions ("overlapping stents"), the stent length was defined as the sum of individual lengths. Stent diameter was defined as its minimal diameter specified by manufacturer at nominal pressure. When post-dilation was performed, it was defined as the diameter of the balloon used (according to compliance chart at nominal inflation pressure provided by manufacturer).

Statistical analysis was performed with the following software: IBM Statistical Package for Social Sciences 22 (SPSS) and S-PLUS 8. We calculated OR and 95% CI to estimate relative risk assuming the fact that odds ratio over-estimate this risk.

3. Results and discussions

During the study period 512 eligible patients with implanted stents for coronary ischemic heart disease were identified. A total number of 808 coronary stented segments were angiographically analysed. Most of them had a diameter of 2.5 to 3.25 mm (351; 43.4%). The most frequently used stents had the length of 15-28 mm (407; 50.4%) (figure 1).

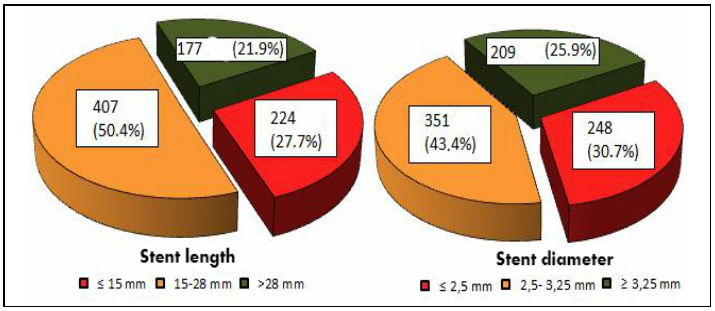

Figure 1. Distribution of implanted stents based on length and diameter

Based on the angiographic examination data, patients were divided into two groups: patients with angiographic restenosis in at least one stent (398 patients, 77.7%) and patients without invasive criteria for in-stent restenosis (114 patients, 22.3%). The average time interval from the initial procedure to the invasive re-evaluation was 210 (± 35) days for the first group and 280 (± 40) days for the second group. From a total number of 808 analysed segments, 472 (58.42%) presented angiographic criteria for in-stent restenosis and 336 (41.58%) showed stents without

restenosis. Considering the anatomical localisation of the lesion, 384 (47.52%) were implanted at the level of anterior descending artery, 251 (30.1%) at the level of right coronary artery and 173 (21.4%) at the level of circumflex artery. The proportion of stents that had angiographically criteria for restenosis comparing to the proportion of patent stents is higher at the level of right coronary artery and circumflex artery. There was no significant association between the vessel where the stent was implanted and the presence of in-stent restenosis (table 1).

Table 1. Localisation of stents with or without restenosis

Coronary artery	Restenosis (472)	No restenosis (336)	P value
LAD	217 (46%)	167 (49.7%)	0.329
CxA	104 (22%)	69 (20.5%)	0.671
RCA	151 (32%)	100 (29.8%)	0.549

LAD-left anterior descending artery, CxA-circumflex artery, RCA-right coronary artery

We also compared the coronary segments taking into view the stent diameter, stent length and the presence or absence of in-stent restenosis. The proportion of stents with diameter less than 2.5mm and length more than 28mm was statistically significant higher in the patients group with in-stents restenosis comparing with the patients group with patent stents (38,6% versus 19,6% and 28,6% versus 12,5%; $p<0,001$). There is also a significant association between stent diameter more than 3.25mm, stent length less than 15mm and no angiographic criteria for restenosis (39,3% versus 16,3% and 37,2% versus 21%; $p<0,001$) (table 2, figure 2).

Table 2. Relation between stent parameters and presence of in-stent restenosis

Parameter (mm)	Restenosis (n=472)	No restenosis (n=336)	P value
Stent diameter:			
≤ 2.5 mm	182 (38.6%)	66 (19.6%)	**<0.001**
2.5- 3.25 mm	213 (45.1%)	138 (41.1%)	0.282
≥ 3.25 mm	77 (16.3%)	132 (39.3%)	**<0.001**
Stent length:			
≤ 15 mm	99 (21%)	125 (37.2%)	**<0.001**
15-28 mm	238 (50.4%)	169 (50.3%)	0.971
>28 mm	135 (28.6%)	42 (12.5%)	**<0.001**

The in-stent restenosis risk was evaluated as 2.5-fold higher for the stents with diameter less than 2.5 mm and as 2.8-fold higher for the stents with length more than 28 mm (table 3).

Table 3. Estimated risk of restenosis based on stent diameter and length

Parameter (mm)	OR	CI 95%
Stent diameter:		
≤ 2.5 mm	2.567	(1.851-3.559)
2.5-3.25 mm	1.179	(0.889-1.565)
≥3.25 mm	0.301	(0.217-0.418)
Stent length:		
≤15 mm	0.448	(0.327-0.612)
15-28 mm	1.005	(0.759-1,329)
>28 mm	2.804	(1.917-4.100)

The observations regarding the localisation of interventionally treated lesions and subsequent risk of restenosis are inconsistent and inconclusive. Stent angioplasty on anterior descending artery has a negative long-term prognosis comparing with the right coronary artery

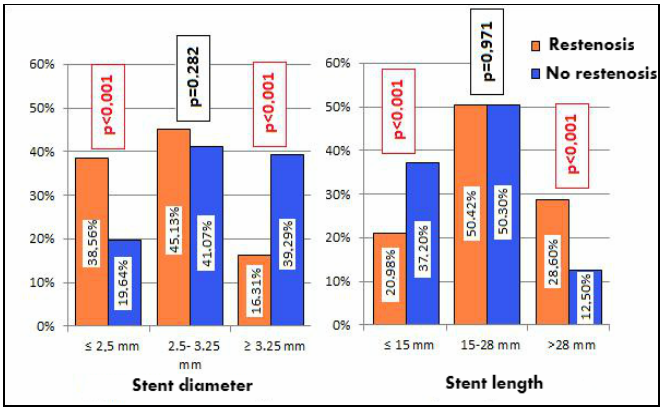

Figure 2. Distribution of stents with or without restenosis based on stent diameter and length

or circumflex artery angioplasty [2]. SCAAR registry data (Swedish Coronary Angiography and Angioplasty Registry) showed that both restenosis and stent thrombosis are reported more frequently in case of proximal left anterior descending artery lesions comparing to circumflex artery lesions and similar to right coronary artery lesions [6]. In our group, we noticed a higher proportion of stents with angiographically defined restenosis at anterior descending artery level (45.97%) comparing to right coronary artery (32%) or circumflex artery (22.03%). But we did not found a significant association between coronary artery localisation and in-stent restenosis risk, this having a minimal influence on the phenomenon of restenosis in our study. The results demonstrate that the stent length more than 28 mm is significantly associated with the presence of in-stent restenosis. Contrary, the stent length less than 15 mm is correlated with stent patency, with no angiographic restenosis criteria. Our observations are consistent with several studies that showed that the lesion or stent length is an important predictor for in-stent restenosis. This is correlated with the degree of vascular injury and neo-intimal response [7, 8, 9, 10, 11, 12]. For example, one study has analysed 3770 interventional BMS treated coronary lesions. Angiographic examination at 6 months showed that lesion's length more than 30 mm was significantly associated with in-stent restenosis, representing an important predictor for restenosis (OR 1.64; 95% CI 1.33 to 2.02; p <0.001) [9]. From the beginning of their use, a linear relationship between stents' length and angiographic in-stent recurrences at 6-9 months was confirmed [11]. For all types of stent (DES or BMS), their total length is significantly associated with the phenomenon of restenosis independently of the length of treated lesion (OR 1.27; 95% CI 1.21 to 1.33 for each 10-mm increment) [10]. Our study findings are similar, the stents with length more than 28 mm having a 2.8 times higher risk of restenosis. The vessel size and the implanted stent diameter are parameters strongly associated with the phenomenon of restenosis [13, 14]. These observations are also confirmed by ultrasound studies that have showed that the minimalpostproceduralluminal area and the stent length are independent predictors of restenosis in both DES and BMS stents [15]. BMS implantation in blood vessels of small diameter is associated with an increased incidence of restenosis and subsequent revascularization needs [10, 16, 17, 18, 19]. The reduction of the reference vessel diameter is associated with an increased risk of restenosis at 6-8 months for both DES and BMS (OR 1.59; 95% CI 1.52-1.68 for each decrease of diameter by 0.5 mm) [10]. Our study results are similar. Therefore, the implanted stent diameter is an important predictor for in-stent restenosis. Thus, the diameterless than 2.5 mm is significantly associated with the presence of in-stent restenosis and the diametermore than 3,25 mm with stent patency. In our study group, the estimated risk of restenosis is 2.5 times higher for a stentwithdiameter less than 2.5 mm.

4. Conclusions

Bare metal stents diameter and length represents important factors that can be correlated with the risk of late in-stent restenosis. Therefore, we conclude that a first step for in-stent restenosis prevention may be the adaptation of stent dimension to the underling coronary lesions.

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