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ORIGINAL ARTICLE

The effect of stent coating on stent deliverability: direct randomised comparison of drug eluting and bare metal stents using the same stent platform

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Abstract

Background: There is certain experimental and clinical evidence indicating that the covering of bare metal stents (BMS) with drug eluting polymers to produce drug eluting stents (DES) results in increased stent stiffness and modifies the mechanical properties of the stent platform. In addition, it has been speculated that the mechanical performance of DES, compared to BMS, may be related to the type of polymer used to cover stents.

Aim: We aimed at evaluating the deliverability of DES with a lactate based biodegradable polymer and BMS in patients with stable coronary artery disease in a prospective randomised study.

Methods: One hundred eleven consecutive patients (age: 36–77, mean 58.8 years) scheduled for routine angioplasty due to stable coronary disease were randomised to receive BMS (Chopin II™, Balton, Poland) or paclitaxel eluting stent (Chopin Luc™, Balton, Poland) using the same metal platform. Only patients scheduled for angioplasty using the direct implantation technique of a single stent were randomised. The exclusion criteria included patients > 80 years, multivessel disease and reference diameter of the target vessel > 3.5 mm.

Results: In the BMS group (n = 55; 35 males and 20 females), the mean diameter of implanted stents was 3.09 ± 0.40 and the mean length was 11.37 ± 2.80, whereas in the DES group (n = 56; 34 males and 22 females) the mean stent sizes were 3.02 ± 0.34 and 17.90 ± 7.38 mm, respectively ($p > 0.05$ for length). The groups did not significantly differ regarding the frequency of stent implantation to particular coronary vessels. The direct stenting technique was attempted and failed, leading to the stents' implantation after predilatation in five patients in the BMS group and six patients in the DES group. Failure of stent implantation and subsequent implantation of another stent type was observed in no BMS patients and in one DES patient (NS).

Conclusions: Although stent covering with lactate based drug eluting polymer may increase its stiffness, it does not affect its deliverability in patients with stable coronary disease.

Key words: coronary stents, drug eluting stents, coronary angioplasty, stable coronary disease

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INTRODUCTION

The rapid development of coronary angioplasty (PTCA) techniques has been observed in recent years as a result of the wide use of coronary stents. Both high quality metal stent platforms, as well as advanced stent design, have been introduced, resulting in excellent performance of newer generations of stents.

Initially, stent implantation was always preceded by balloon predilatation. Recently, the direct stenting technique, i.e. coronary stenting without balloon predilatation, has been introduced and is used widely by many operators. This approach, by reducing the aggression to the vessel wall and immediately sealing the dissections created by the balloon inflation by stent struts, is believed [1, 2] to enhance the early

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Table 1. Basic characteristics and procedural data in patients enrolled to bare metal stents (BMS) and drug eluting stents (DES) groups

	BMS patients (n = 55)	DES patients (n = 56)	P
Sex (male/female)	35/20	34/22	NS
Stent diameter [mm]	3.09 ± 0.40	3.02 ± 0.34	NS
Stent length [mm]	11.37 ± 2.80	17.90 ± 7.38	< 0.05
Failure of direct stenting and use of predilatation (n)	5	6	NS
Use of another stent type after predilatation (n)	0	1	NS

results of coronary interventions while warranting similar late clinical outcomes. Improved design, profile and flexibility of the currently available stents have allowed the safe delivery of stents without predilatation to the majority of coronary vessels. Although not all studies have confirmed the clinical benefit of direct stenting [3], decreased procedural time, fluoroscopic time, contrast medium usage as well as overall procedural cost reduction [1, 4] makes direct stenting a very attractive approach in the majority of patients undergoing stent implantation.

Drug eluting stents (DES), after extensive evaluation in multicentre clinical trials, have been introduced to everyday practice to decrease the rate of restenosis. Lesion predilatation before stent placement has been the predominant implantation strategy in these trials. DES implantation without balloon predilatation has been undertaken in certain studies [4, 5] at the investigators' discretion as well as in patients enrolled to post-marketing surveillance registries. Since direct DES implantation results in a similar clinical outcome [4, 5], it is currently widely used by operators.

Mechanical stent properties are crucial to obtain procedural success in the direct stenting technique [1, 6–8]. DES production requires covering of the metal stent platform with a drug-containing polymer. Since adding the polymer coating on the metal stent platform obviously modifies flexibility and profile of the stent, it may also affect stent deliverability. This hypothesis has been suggested also by both computer simulations and bench testing [6, 7]. The aim of our study was to compare in a randomised study the deliverability of bare metal stents (BMS) and stents covered with a drug eluting polymer (DES), based on identical metal stent platform, in patients with stable coronary artery disease.

METHODS

One hundred eleven consecutive patients with stable coronary disease scheduled for routine coronary angioplasty (aged 36–77 years, mean age 58.8 years) were enrolled to this prospective, randomised study. The inclusion criterion was the presence of a significant lesion suitable, in the operators' opinion, for direct coronary stenting. The exclusion criteria were: age > 80 years, vessel reference diameter > 3.5 mm, multiple lesions within the target vessel, and vessel anatomy not suitable for direct stenting.

Patients were randomly assigned to one of two groups: to undergo the implantation of bare metal stent (the BMS group) or of a paclitaxel-eluting stent (the DES group). Both stents studied shared the same basic metal platform (stainless steel 316L): bare metal stents Chopin II™, produced by Balton (Warsaw, Poland) and drug eluting stents Chopin Luc™, from the same producer. Chopin Luc™ stents are coated with lactate based polymer, a fully biodegradable polymer releasing paclitaxel.

The diameter of stent to be implanted, equal to the reference diameter, was chosen on the basis of visual estimation as well as QCA analysis according to the routine operator's practice. The length of stent to be used was left to the operator's discretion, and was based on visual evaluation and QCA measurement of the lesion length.

Every procedure in both groups was approached using a direct stenting technique. If this failed, the same stent was used again to cross the lesion after balloon predilatation, with a balloon catheter left to the operator's discretion, but without changing the guiding catheter or the guide wire. Only experienced operators, who had each performed at least 500 coronary interventions, participated in the study.

Statistical analysis

Demographic comparison of the groups studied was performed using a t-student test. Since other data was not normally distributed, a non-parametric Mann-Whitney test was used to compare the groups.

RESULTS

The BMS group consisted of 55 patients, 35 males and 20 females (Table 1). Of the 56 patients enrolled in the DES group, there were 34 males and 22 females. Both groups did not differ regarding the basic demographic data, including age, history of myocardial infarction (MI), or previous coronary interventions.

In the BMS group, the mean diameter of implanted stents was 3.09 ± 0.40 mm, whereas in the DES group the mean stent diameter was 3.02 ± 0.34 mm (NS). The mean length of im-

planted stents was 11.37 ± 2.80 in the BMS group, whereas in the DES group the mean stent length was 17.90 ± 7.38 mm ($p > 0.05$ for length). The groups did not significantly differ regarding the frequency of stent implantation to particular vessels: the ratio LAD/Cx/RCA was 28/8/19 in the BMS group and 26/6/24 in the DES group (NS). Similarly, the groups did not differ regarding the frequency of A, B or C lesion types (19/28/8 in the BMS group and 16/31/9 in the DES group).

The direct stenting technique was attempted and failed, leading to stent implantation after predilatation in five patients in the BMS group and six patients in the DES group (NS). The mean length of stents attempted but not implanted using the direct stenting technique was no different from the length of implanted stents. Failure of stent implantation and subsequent implantation of another stent type was not observed in BMS patients, but was observed in one DES group patient (NS). All final stent implantations were completed without changing the guiding catheter or the guide wire.

No major adverse events (death, infarction or blood transfusion) were observed in patients in either group at hospital discharge.

DISCUSSION

The introduction of coronary stents to clinical practice has resulted in increased safety and a higher success rate of coronary interventions [9–12]. New stents allow safe and efficacious implantation without balloon predilatation, i.e. using the direct stenting technique. Initial observations with direct stenting suggested that lack of balloon predilatation and immediate sealing of dissected lesion with the stent struts may result in a superior outcome [2]. Additional benefits of direct stenting may be expected in patients with acute MI [13–15]. Ozdemir et al. [15] randomised consecutive patients undergoing primary angioplasty for acute MI to direct stenting and conventional stenting with balloon predilatation. Postprocedural corrected TIMI frame count was significantly lower in the direct stenting group. Both during and after the procedure, the complication rate and procedural time were lower in patients undergoing direct stenting.

On the other hand, randomised trials evaluating elective stent implantations have not confirmed convincingly that the direct stenting technique may result in a superior clinical outcome over conventional stenting. In a meta-analysis of ten clinical trials comparing the direct stenting technique to conventional stenting with balloon predilatation, Burzotta et al. [1] found similar procedural success rates, but direct stenting procedures had a shorter fluoroscopic time and overall procedure time, less contrast volume, and an approximately 22% cost reduction [1]. In the early postintervention period, direct stenting was associated with a trend toward reduction of each of the major adverse events and with a significant reduction of MI and death. However, at six months, no important difference in the clinical outcome was observed [1].

Recently published observations from randomised studies confirm that direct stenting is feasible in approximately 94% of lesions and is associated with lower resource utilisation: i.e. decrease in balloon and contrast media use, shorter procedure time, but larger number of guiding catheters [3].

Direct stenting has become a routine technique in many cardiac catheterisation laboratories. As a result, the introduction of drug eluting stents to clinical practice has caused direct DES implantation at the operators' discretion. A post hoc analysis of direct implantation of sirolimus-eluting stents was described by Schluter et al. [4]. Fifty seven patients received direct implantation of a sirolimus-eluting stent in the pooled cohorts of the European and Canadian Sirolimus-Eluting Stent in Coronary Lesions (E-SIRIUS and C-SIRIUS) trials. At eight months, in-lesion late loss and in-lesion binary restenosis tended to be lower after direct stenting, but no statistical significance was observed at one year clinical follow-up [6]. In a similar post hoc analysis of patients enrolled to the TAXUS II trial evaluating polymer-based paclitaxel-eluting stents, no differences in clinical, angiographic or Intravascular ultrasound parameters at six months were observed [5].

Drug eluting stents have been studied extensively in randomised controlled trials in patients with native de novo coronary lesions. Lesion predilatation before stent placement has been the predominant implantation strategy in these trials. At present, despite the lack of randomised trial data, DES implantation using the direct stenting technique is commonly used, based on observational studies indicating similar clinical efficacies of direct stenting and conventional DES implantation with predilatation. On the other hand, it is clear that longitudinal flexibility, stiffness and mechanical properties of the stent may affect stent deliverability to the area of stenosis. Bench testing confirms that mechanical properties of different DES types significantly differ. Schmidt et al. [11] compared commercially available DES systems under standardised in-vitro conditions and found important differences in stent 'pushability', expressed as the ratio of distal force at a specific proximal push force, and stent 'trackability', measured as the mean track-forces, as well as in the bending stiffness and in crossing forces. However, it has to be stressed that these differences may result not only from the mechanical properties of the stents themselves, but more importantly may be related to the type of delivery system, including the balloon catheter used.

Covering BMS with drug eluting polymers to produce DES may result in increased stent stiffness and modify the mechanical properties of the stent platform, by both increasing the stent diameter and by the adherence of the polymer layer to the stent struts [6, 7]. Despite that, there is no clinical data comparing direct stenting using BMS and DES, which share an identical metal stent platform as well as the same delivery system.

Our current report aimed at evaluating the possible difference in deliverability in direct stenting technique between BMS and DES using the same stent platform in patients with

stable coronary artery disease in a prospective randomised study. The results indicate that covering a metal stent platform with a lactate-based drug eluting polymer does not change the stent deliverability across the coronary lesions in a clinical situation of stable angina. Patients were randomly assigned to one of the groups, but the selections of the stent length and diameter were left to the operator's discretion. This resulted in somewhat longer stents used in the DES group, as the majority of operators tend to use longer DES to avoid edge restenosis. Despite that, no important difference in stent deliverability was observed.

In addition, it has to be noted that these findings certainly may be related to the type of polymer used to cover the stent platform [16, 17], as it might be speculated that the mechanical properties of DES could be related to the stiffness of polymer used. Furthermore, no objective quantitative data on lesion calcification is available. This could, despite randomisation, affect the study results.

CONCLUSIONS

There are no clinically important procedural problems with direct DES implantation compared to BMS implantation. Future trials assessing the long term clinical effect of DES implanted using the direct stenting technique are warranted.

Conflict of interest: *DES stents were provided for the study by their producer (Balton sp. z o.o., Warsaw, Poland) at a reduced cost. The authors declare no other conflict of interest regarding this study. In particular, the authors did not receive any financial support from the stent producer.*

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Ocena możliwości bezpośredniej implantacji stentów powlekanych: randomizowane badanie porównujące stenty metalowe i uwalniające leki, oparte na identycznej platformie

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Streszczenie

Wstęp: Technika bezpośredniej implantacji stentów, a więc bez uprzedniej predylatacji cewnikiem balonowym, stała się ostatnio dominującą metodą poszerzania wszystkich kwalifikujących się do niej zmian w tętnicach wieńcowych. Istnieją dane eksperymentalne i obserwacje kliniczne sugerujące, że pokrycie stentu metalowego polimerem uwalniającym leki zwiększa jego sztywność i zmienia właściwości mechaniczne, co może wpływać na możliwość implantacji bezpośredniej stentu.

Cel: Celem pracy było porównanie możliwości bezpośredniej implantacji stentów metalowych (BMS) i uwalniających leki (DES) opartych na identycznej platformie metalowej.

Metody: Badanie przeprowadzono w grupie kolejnych 111 pacjentów skierowanych do planowej angioplastyki wieńcowej, w przypadku których operator zadecydował o zakwalifikowaniu do techniki stentowania bezpośredniego. Pacjentów w wieku 36–77 lat (śr. 58,8 roku) zrandomizowano do jednej z dwóch grup, w celu implantacji bezpośredniej stentu BMS (Chopin II™, Balton, Polska) lub stentu DES, uwalniającego paklitaksel (Chopin Luc™, Balton, Polska) z biodegradowalnego polimeru mleczanowego i opartego na identycznej platformie metalowej. Z badania wyłączono pacjentów w wieku > 80 lat, z chorobą wielonaczyniową lub zwężeniem pnia lewej tętnicy wieńcowej oraz ze średnicą referencyjną zwężonej tętnicy powyżej 3,5 mm.

Wyniki: W grupie BMS (n = 55; 35 mężczyzn — M i 20 kobiet — K) średnia średnica implantowanego stentu wynosiła 3,09 ± 0,40 mm, a średnia długość 11,37 ± 2,80 mm. W grupie DES (n = 56; 34 M i 22 K) średnica implantowanych stentów nie różniła się istotnie (3,02 ± 0,34 mm), natomiast średnia długość była znamiennie ($p > 0.05$) wyższa i wynosiła 17,90 ± 7,38 mm. Grupy nie różniły się istotnie w zakresie częstości implantacji stentów do poszczególnych tętnic wieńcowych. U 5 (9,09%) pacjentów z grupy BMS oraz u 6 (10,71%) osób z grupy DES próba implantacji stentu techniką bezpośrednią zakończyła się niepowodzeniem i zmusiła operatora do wykonania predylatacji cewnikiem balonowym i następowej ponownej implantacji stentu (NS). Brak możliwości implantacji stentu i następowe zastosowanie stentu innego rodzaju stwierdzono u 1 pacjenta w grupie DES i u żadnego z pacjentów zakwalifikowanych go grupy BMS (NS).

Wnioski: Uzyskane wyniki sugerują, że mimo ewentualnego zwiększenia sztywności stentu w wyniku powlekania biodegradowalnym polimerem mleczanowym stenty DES tego rodzaju mają podobną skuteczność w technice bezpośredniej implantacji u pacjentów ze stabilną chorobą wieńcową.

Słowa kluczowe: stenty wieńcowe, stenty uwalniające leki, angioplastyka wieńcowa, stabilna choroba wieńcowa

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