Relative dependence of diameters of branches in coronary bifurcations after stent implantation in main vessel – importance of carina position

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Abstract

Background and aim: Bifurcation lesions are relatively frequently encountered in everyday interventional practice. Stenting of the vessel chosen to be main (usually the larger one) frequently leads to stenosis at the ostium of the side branch (SB) and compromises its flow (side branch compromise – SBC). The relative dependence of main and side branch diameters, based on the concept of carina displacement of stent struts, was examined in a cohort of patients with bifurcation stenting.

Methods: We accept that the basic mechanism for SBC after stent placement in the parent vessel is carina shifting from expanded stent struts. The ostial SB minimal lumen diameter (MLD), percentage diameter stenosis (%DS) at maximal and calculated actual carina displacement, as well as distal limb diameter (DLD) in the main branch were calculated and compared with actually observed values.

Results: A group of 55 consecutive patients with acceptable quality angiograms formed the study population. General patient characteristics were similar to other bifurcation studies. Left anterior descending artery was predominantly treated in 73% of patients. There was worsening SB ostial stenosis after stent implantation (%DS increase from 48%±23% to 69%±21%, p <0.001) and final improvement because of kissing balloon inflation or SB postdilatation (post vs. final – 69±21% and 53±25%, p <0.001). Stent implantation causes straightening of the main vessel, evident from a significant increase in angle C (pre- 148°±19° vs. 156°±16° after stenting, p=0.007). Relations between observed and predicted values for main branch DLD and %DS demonstrated a good correlation between predicted and observed values (for DLD r=0.66, p <0.001, and for %DS r=0.53, p <0.001). There was an excellent fit of regression lines between theoretical predictions and actual measurements for side branches (MLD r=0.91, p <0.001, %DS r=0.89, p <0.001).

Conclusions: Carina displacement from stent struts is a major mechanism governing changes in coronary bifurcations after main vessel stenting. Improvement in the ostium of the side branch causes shifting back of the carina and a decrease of main vessel diameter. The long-term consequences of this phenomenon are not currently known.

Key words: coronary bifurcation stenosis, provisional stenting, prediction of immediate results

Kardiol Pol 2008; 66: 371–378

Background

Bifurcation lesions are relatively frequently encountered in everyday interventional practice – and can be demonstrated during 15% to 20% of all performed percutaneous coronary interventions [1]. Stenting of the vessel chosen to be main (usually the larger one) frequently leads to stenosis at the ostium of the side branch (SB) and compromises its flow (side branch compromise – SBC). Several mechanisms are postulated to cause this phenomenon – so-called "plaque shifting", ostial spasm or dissection caused by balloon barotrauma, stent strut prolapse in the SB lumen, and the carina shifting in the direction of the lateral vessel [2-4]. We have recently shown that the last mechanism is mainly responsible for SBC [5]. According to our hypothesis there must be some residual stenosis if there is no full carina displacement. The latter is important as the final lumen diameter is one of the most powerful predictors of in-stent restenosis [6, 7]. There are only a few reports addressing this issue [8, 9]. Restenosis in the SB is not of great importance in most cases, however significant restenosis in the main vessel always has detrimental consequences.

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Received: 12 December 2007. **Accepted:** 30 January 2008.

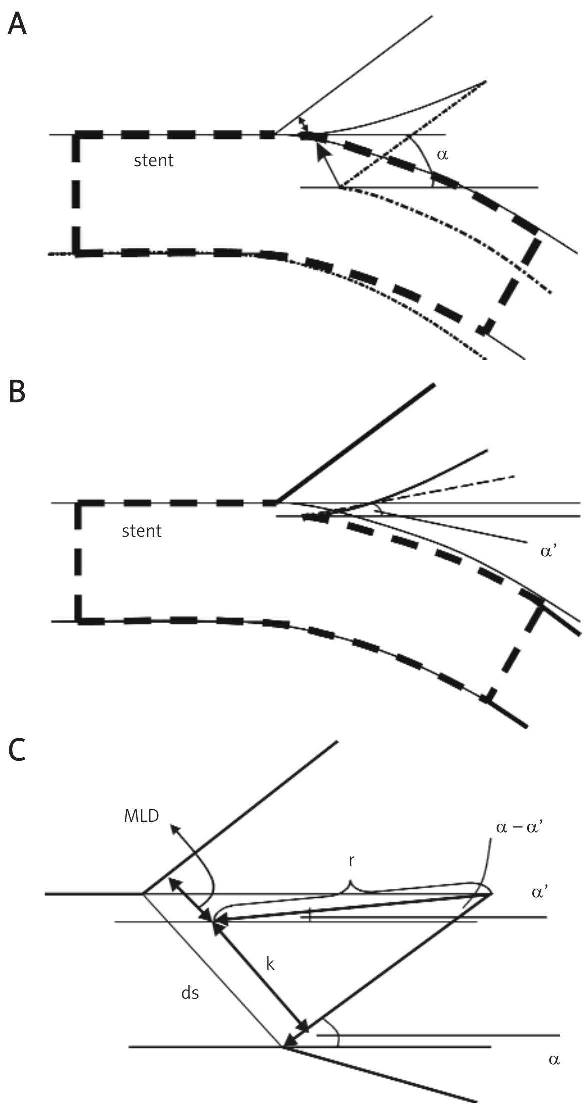

Figure 1. A. Changes in bifurcation after stent implantation. Thick dashed lines represent stent struts, thin dashed lines present vessel wall positions before stent placement. Red arrow presents carina displacement. Angle alpha is formed from intersection of parent vessel and side branch axes. **B.** If there is no full carina shifting, stent underexpansion occurs. As a result angle α' is formed between parent vessel axis and internal wall of SB. In this case MLD in SB is larger, but MLD in main branch is smaller. **C.** Calculation of common case for SB compromise. Black arrows show position of carina before and after stent placement, with length of lever arm $r = ds/tg\,\alpha$. Double blue arrow presents projection k of r on the axis of MLD after carina shifting. The length of $k = r \cdot \sin(\alpha - \alpha') = ds - \sin(\alpha - \alpha')/tg\,\alpha$. Accordingly $MLD = ds - k = ds \cdot (1 - \sin(\alpha - \alpha')/tg\,\alpha)$ and $\%DS = 1 - MLD/ds = \sin(\alpha - \alpha')/tg\,\alpha$

ds – diameter of side branch, MLD – minimal lumen diameter, r – lever arm of carina rotation, a – a´ – angle difference between initial and end position

The aim of our investigation was to verify theoretical predictions for diameters in main and SB with those really present and to compare observed and predicted factors that affect SBC.

Methods

Theoretical considerations

We hypothesised that the basic mechanism for SBC after stent placement in the parent vessel is the carina shifting from expanded stent struts (Figure 1A). Previously [5] we have shown that with full carina shifting, the resulting minimal lumen diameter (MLD) and percentage diameter stenosis (%DS) at the ostium of the SB could be predictably calculated as: $MLD = ds \cdot (1 - \cos\alpha)$, $\%DS = \cos\alpha$, where *ds* is reference SB diameter and $\cos\alpha$ is cosine of angle between parent vessel before bifurcation and SB internal wall axis. In this case MLD in the main vessel will be the stent opened diameter. If there is not full stent expansion and the carina is not displaced fully, then the above parameters can be calculated as follows:

$$MLD = ds\,\frac{1 - \sin(\alpha - \alpha')}{tg\,\alpha}$$

$$\%DS = \frac{\sin(\alpha - \alpha')}{tg\,\alpha}$$

Angle α' is the new angle formed from intersection of the parent vessel wall axis after stenting and SB internal wall axis (Figure 1B and 1C). If this happens, the main vessel diameter at the tip of the carina will be smaller than expected from full stent opening. Using a calculated value for α' (from measured SB MLD, angle α, ds, angle)

$$\alpha' = \alpha - \arcsin\left(tg\,\alpha\,\frac{1 - MLD}{ds}\right)$$

or directly measuring it, the expression for MLD in the main branch at the carina tip is as follows:

$$DLDp = dm \cdot \cos(A - \alpha) + ds\,\frac{\sin\alpha - \sin\alpha}{tg\alpha}$$

Here DLDp (distal limb of bifurcation) is predicted lumen diameter in main branch at carina tip, dm is MB diameter, and A is the angle between branches. Derivation of this equation is presented in Figure 2. Thus, this set of equations fully describes changes in diameters in branches and could be used to predict results from angioplasty in bifurcation lesions.

Angiographic analysis

All patients with treated bifurcation lesions and acceptable quality angiograms for the study period were included in the analysis. The only inclusion criterion was bifurcation lesion treatment. If there was any doubt of vessel overlap, suboptimal visualisation of branching angles or suboptimal vessel filling, the angiogram was discarded.

Quantitative angiographic analyses were performed using commercially available software Medis QCA version 5.0 and Dicom Works version 3.1 for angulations assessment.

Bifurcation lesions were classified according to the Medina classification, using a value of 1 or 0 for presence or absence of stenosis >50%. Analysis was performed for SBs with more than 2mm diameter. The main vessel before SB (MV), main branch (MB) and SB were analysed separately. Reference vessel diameter (RVD), minimal lumen diameter (MLD) before and after stenting, acute lumen gain (RVD post stenting minus MLD before stenting), acute lumen gain at proximal and distal limb of bifurcation (vessel diameter at proximal or distal limb after stent implantation minus MLD in MV or MB), percentage diameter stenosis (%DS) in MV, MB and SB before, after stent implantation and at the end of the procedure were calculated.

Three angles were recorded: angle A, which is the angle between the main axes of MB and SB; angle B, between MV and SB; angle C, between MV and MB. All measurements were performed before and after stent implantation. Measurement of angle α was made from the projection with the widest opening between branches. A line was traced parallel to the MV axis through the apex of the carina. Then a line parallel to the internal contour of the SB was traced and crossed with the first line. The resulting angle is α. It was also measured before and after stent implantation.

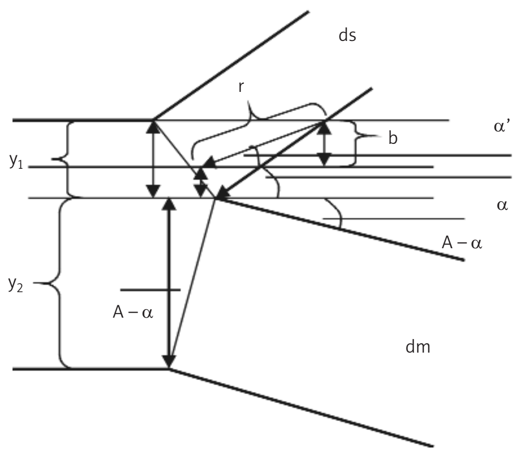

Figure 2. Calculation of distal limb diameter (DLDp). DLDp is sum of lengths of bolded double arrows. $DLDp = y_2 + (y_1 - b)$, $b = r \cdot \sin\alpha' = ds \cdot (\sin\alpha'/tg\,\alpha)$, $y_1 = ds \cdot tg\,\alpha$, $y_2 = dm \cdot \cos(A - \alpha)$. Combining and rearranging equations we receive $DLDp = dm \cdot \cos(A - \alpha) + ds \cdot (\sin\alpha - \sin\alpha')/tg\,\alpha)$

r – fulcrum lever, part of internal SB wall, rotating after stent placement, y_1 – part of parent vessel diameter occupied from SB, y_2 – part of parent vessel diameter occupied from MB, b – new distance occupied from SB after carina displacement, A – distal angle between branches

Procedure

Simple provisional T-stenting as a default strategy is accepted in our catheterisation laboratory. First main vessel stenting is performed, with or without predilatation of the main or SB. The SB is treated (first balloon angioplasty, then stenting if necessary) only if significant impairment of flow occurs (e.g. dissection) or ostial stenosis is more than 85% in diameter. Heparin in a standard dose of 100 U/kg was given at the start of the procedure. If a patient was not pretreated with clopidogrel, 8 tablets were given before starting. Application of GP IIb/IIIa inhibitor was left to the discretion of the operator. Generally, two wires were inserted in both distal branches. Predilatation of one or both branches depends on operator preference, as does final kissing balloon inflation or sequential balloon inflation. However, in most cases direct stenting was the preferred strategy. Application of DES in bifurcation lesions was recommended in our lab for all diabetic patients and for vessel size below 3.0 mm.

Statistics

All data are presented as means ± one standard deviation or number and percentage. Kolmogorov-Smirnov test was used to test for normality. Differences between groups were examined with t-tests or with non-parametric test as appropriate. Analysis of Variance (ANOVA) was used for multiple comparisons. Multiple regression analysis was used to identify predictors of MB distal limb and SB ostial stenoses. Comparisons were made between pre- and post-stenting parameters. The χ^2 test was applied for qualitative data. The significance of differences was determined by p values less than 0.05. All calculations were performed with the Win STAT package for Windows.

Results

Between 1 December 2006 and 30 April 2007, 126 patients were treated for bifurcation lesions, of whom 17 (13%) were treated with two stent techniques. In 16 (13%) patients records were of unacceptable quality for analysis. In 38 (30%) patients there was no optimal projection for opening of bifurcation angles. Finally, 55 (44%) patients formed the study population. Demographic and procedural characteristics of the patient population are presented in Tables I and II. Our group of patients was relatively severely diseased, reflected by high prevalence of diabetes (33%), previous myocardial infarction (31%) and post-CABG individuals (13%). Typically left anterior descending – diagonal (LAD – D) lesions were dominant. Presentation of circumflex marginal branch (LCX – OM) stenosis was rare (only 3%), but the percentages of left main (LM) – LAD and LM – LCX were relatively high (8% and 11% respectively). Kissing balloon inflation (KBI) was used in 19 lesions (31%).

Angiographic characteristics of lesions and changes in angulation pattern after stent implantation in the main vessel are presented in Table III. There is worsening SB ostial stenosis after stent implantation (%DS increase from 48±23% to 69±21%, p<0.001) and final improvement because of KBI or SB postdilatation (post vs. final – 69±21% and 53±25%, p <0.001). Stent implantation causes straightening of the

Table I. Demographic characteristics of patient cohort

Patient characteristics	Number
Age [years]	66±11
Gender – males	36 (65%)
Stable angina	38 (69%)
NSTEMI/unstable angina	9 (16%)
STEMI	6 (11%)
Hypertension	39 (71%)
Elevated cholesterol/statin treatment	42 (76%)
Diabetes	18 (33%)
Smoking	32 (58%)
Family history	22 (40%)
Previous myocardial infarction	17 (31%)
Previous PCI	28 (51%)
Previous CABG	7 (13%)
Obesity	31 (56%)

Abbreviations: STEMI – ST segement elevation myocardial infarction, NSTEMI – non-ST segement elevation myocardial infarction, PCI – percutaneous coronary intervention, CABG – coronary artery bypass graft surgery

Table II. Procedural characteristics

Affected vessel – lesions	Number
LAD – diagonal	43 (73%)
LCX/OM	2 (3%)
RCA	6 (10%)
LM – LAD	5 (8%)
LM – LCX	7 (11%)
Main vessel predilatation	25 (40%)
Balloon size diameter	2.57±0.43
Balloon length	17±5
Inflation pressure (max., atmospheres)	12±4
Side branch predilatation	19 (31%)
Balloon size diameter	2.32±0.30
Balloon length	15±4
Inflation pressure	10±2
Stent used	60
DES	29 (48%)
Co-Cr	11 (18%)
SS	20 (33%)
Stent diameter	3,39±0,35
Stent length	22±9
Implantation pressure (max., atmospheres)	15±2
Kissing balloon inflation	19 (31%)
Sequential balloon inflation – both branches	1 (2%)
main vessel	5 (8%)
side branch	8 (13%)
GP IIb/IIIa inhibitor	9 (16%)

Abbreviations: LAD – left anterior descending, LCX/OM – left circumflex coronary artery marginal branch , LM – left main, RCA – right coronary artery, DES – drug-eluting stent, Co-Cr – cobalt chromium alloy stent, SS – stainless steel stent

Table III. Angiographic characteristics. All lengths and diameters are in millimetres

Angiographic characteristics	Before stent	After stent	p
MV – RVD	3.52±0.61	3.49±0.54	NS
MV – MLD	1.78±0.93	3.28±0.40	0.001
MV – acute lumen gain		1.53±0.95	
MV – %DS	51%±26%	5%±11%	0.001
MV lesion length	6.68±5.43		
MB – RVD	3.02±0.51	3.1±0.40	NS
MB – MLD	1.27±0.76	2.96±0.41	0.001
MB – acute lumen gain		1.69±0.73	
MB – %DS	64%±19%	3%±12%	0.001
MB lesion length	9.95±8.78		
SB – RVD	2.51±0.46	2.52±0.47	NS
SB – MLD	1.29±0.59	1.23±0.74	NS
SB – acute gain		-0,02±0,67	
SB – %DS	48% ± 23%	69% ± 21%	0.001
SB – %DS – final		53% ± 25%	
SB lesion length	4.37 ± 4.15		

Abbreviations: MV – main vessel, RVD – reference vessel diameter, MLD – minimal lumen diameter, %D – percentage diameter stenosis, MB – main branch, SB – side branch

main vessel, evident from a significant increase in angle C (pre- 148±19° vs. 156±16° after stenting, p=0.007). There were no significant changes in angles A, B and alpha (Figure 3).

Main branch parameter comparisons: the MB lumen diameter at the carina tip after stent implantation was significantly correlated with main branch MLD (DLD = = 3.04±0.41 mm vs. MB MLD = 2.96±0.41 mm, r=0.79, p <0.001), but in 26% of patients it did not correlate, meaning non-uniform stent expansion. To make further comparisons the value of angle α' first was calculated by using formulae derived in the Methods section and measured values for angle alpha and SB MLD (α'=17±12° for total group, or α'=20±12° if only positive values were considered). Relations between observed and predicted values for main branch DLD and %DS are presented in Figures 4A and 4B. There was a good correlation between predicted and observed values (for DLD r=0.66, p <0.001, and for %DS r=0.53, p <0.001).

Surprisingly, there was a negative linear relation between stent-artery ratio and distal limb diameter (r=0.38, p=0.002). Multivariate linear regression analysis revealed that it was not an independent parameter. The only predictors of distal limb diameter were reference MB diameter (p=0.03), main branch lesion length (p=0.044), MLD before stenting (p=0.047) and proximal limb diameter (diameter of parent vessel immediately before division of daughter branches) after stenting (p <0.001). Angle (A – α) had a borderline predictor significance value (p=0.06).

When we compared final DLD in the group with KBI with the group with main branch stenting only there was a strong trend to smaller DLD in the KBI group (non-KBI vs. KBI 3.16±0.43 mm vs. 2.96±0.37 mm, p=0.057). Kissing balloon inflation did not give any additional increase in main branch diameter (pre-KBI vs. post-KBI 2.92±0.38 mm vs. 2.96±0.37 mm, p=0.257).

The relations between theoretical predictions and real values of SB parameters are presented in figures 5a and 5b. There was an excellent fit of regression lines between theoretical predictions and measured values (MLD r=0.91, p <0.001, %DS r=0.89, p <0.001).

The multiple regression analysis showed that the only independent predictors of SB MLD were angle alpha and SB reference vessel diameter. For percentage diameter stenosis, the only independent predictor was angle alpha value. All predictors are presented on a continuous scale and the relation between predictors and the dependent variable is uninterrupted. We identified angle α=32° as a predictor for functionally significant stenosis according to Koo (2006) criteria (%DS at SB ostium more than 85%), with a sensitivity of 82% and a specificity of 80%.

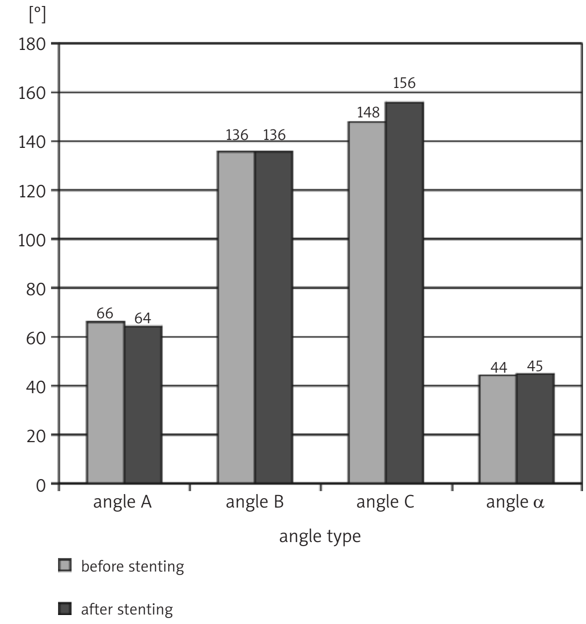

Figure 3. Changes in bifurcation angles after stent implantation

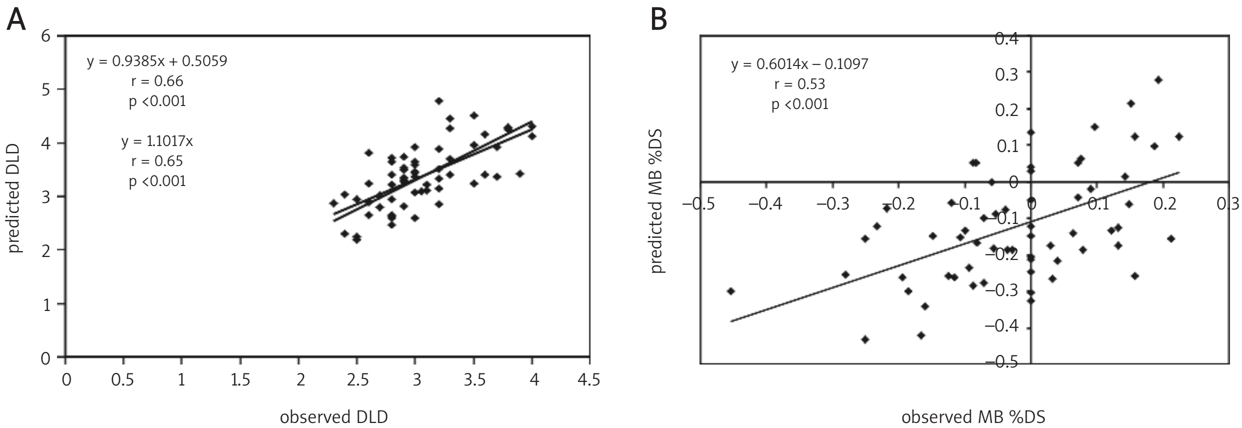

Figure 4. A. Relation between observed and predicted main branch minimal lumen diameter (MLD). The best regression line and regression line crossing zero are shown. **B.** Relation between observed and predicted main branch percentage diameter stenosis (%DS)

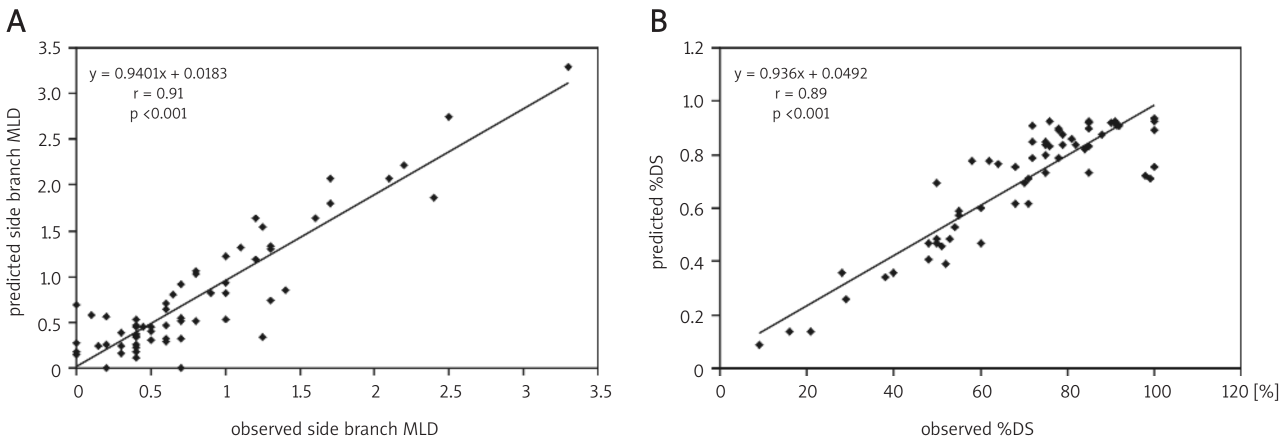

Figure 5. A. Relation between observed and predicted side branch minimal lumen diameter (MLD). **B.** Relation between side branch observed and predicted percentage diameter stenosis (%DS)

Discussion

The main finding of our study is that there is a relationship between sizes of main and SBs after stent implantation in the main vessel. This relation could be described quantitatively according to our theoretical analysis. Here we widen our previous concept of carina displacement as a leading mechanism for SBC [5]. Although we did not find a direct correlation between minimal lumen diameters at the SB ostium and DLD, the significant correlation between predicted and observed values strongly supports our hypothesis. In reality, because of differences between individual anatomical structures, there is some variation in the exact places of minimal diameters. Surprisingly, univariate regression analysis showed a negative relation between stent-artery ratio and distal limb diameter. It is possible that larger acute stent recoil is responsible for this deviation. Also our study was designed to detect primary changes in SBs and it is possible that projections most suitable for side vessels are not best for main vessels. This may explain the considerably higher regression coefficients between theoretical predictions and observed values in SBs than for main branches.

We demonstrated that the mechanism of carina displacement governs B ostial %DS as well as DLD of the main branch. In SBs there was full concordance between theoretical predictions and independent predictors from multiple regression analysis – the only predictor for %DS was angle alpha, and for MLD independent predictors were angle alpha and SB reference diameter, in accordance with our formulae. In the main branch the relation is more complex and there are additional factors that could come into play. From theoretical predictions we can hypothesise that possible predictors will be reference vessel diameters and distal branching angle minus angle alpha difference and angle alpha per se. From this only MB reference diameter was identified by multivariate analysis, showing the importance of other factors – mainly plaque burden. Its presence (as could be assessed from lesion length and minimal lumen diameter) is much larger in the main branch and it is logical that its effect will be significant. Our analysis was intended to describe only geometric changes in the branching point after stent placement, without taking into account plaque redistribution. Thus, it is more applicable in SBs, where plaque volume is much lower. This is another explanation for the better correlations with theory in SB than in main branches.

The distal limb diameter coincided with main branch MLD in 74% of cases. It could be speculated that this is a place predisposed to restenosis as it is well known that smaller postintervention diameter is associated with larger restenosis [6, 7]. There are two recent reports addressing this issue. In the study of Pan et al. [9] in six-month control IVUS analysis it was demonstrated that at the distal carina limb minimal lumen area was significantly smaller than maximal stent expansion (maximal vs. distal limb areas – 6.7±1.8 mm^2 vs. 5.6±1.6 mm^2). This result was not influenced by kissing balloon inflation. However, in 6-month follow-up this smaller lumen area did not influence target lesion revascularisation rates. Opposite results were reported by Di Mario et al. – in 150 patients smaller main branch diameter was the only predictor of target lesion (TLR) and target vessel revascularisation (TVR) in bifurcation lesions. In this study the rate of TLR was higher in the main vessel – 14%. This is important information as in our study the majority of MLD cases were localised in the distal limb region. What the relation between predicted and naturally observed parameters and future restenosis will be is under investigation.

What are the practical implications of our study? First – we have proposed the first quantitative explanation for SBC after main vessel stenting in coronary bifurcations. Thus, we added a considerable amount of data to current knowledge on the pathophysiology of coronary bifurcation disease. Second – as our analysis showed, carina shifting is a predictable phenomenon. By changing the carina position, the stent changes the shape of the ostium of the SB to ellipsoid [10] and as a consequence the area at the ostium is larger than expected if it was a circle. At this point, as our study demonstrated, any attempt to improve angiographic appearance at the SB ostium will return the carina back and will **decrease** the main branch lumen diameter. We can speculate that this is possibly the reason for higher restenosis rate in the main vessel in the study of Di Mario et al. [8], where the rate of kissing balloon inflation was 75% in one stent group. It is important to note that in this study the only predictor of target lesion revascularisation was MLD in the main branch. Thus, in the light of these data and our current results looking back into the main vessel seems worthwhile. It is possible that a future dedicated stent, created to accommodate the specific anatomy of branching vessels, could resolve the problem.

Limitations

Our study has several limitations. First, this was a retrospective study and some patient selection bias is highly possible. As in any angiographic study, the results of analysis are highly dependent on the optimal projection. We analysed a three dimensional object using a two dimensional plane and so there is some uncertainty in the measurements. It is possible that new 3D reconstruction software systems will permit much better determination of angulation parameters. However, the correlation between theoretical predictions and observed parameters was quite high.

We did not systematically evaluate the effects of kissing balloon inflation as the last group was small. The observation that the KBI group has lower DLD with borderline statistical significance is to be a subject of our future investigation.

Conclusions

Carina displacement from stent struts is a major mechanism governing changes in coronary bifurcations after main vessel stenting. We developed theoretical apparatus to predict changes in diameters and extent of diameter stenosis in side and main branches. Improvement in the ostium of the SB causes shifting back of the carina and a decrease of main vessel diameter. The long-term consequences of this phenomenon are not currently known.

References

1. Iakovou I, Ge L, Colombo A. Contemporary stent treatment of coronary bifurcations. *J Am Coll Cardiol* 2005; 46: 1146-55.
2. Louvard Y, Lefevre T, Morice MC. Percutaneous coronary intervention for bifurcation coronary disease. *Heart* 2004; 90: 713-22.
3. Poerner TC, Kralev S, Voelker W, et al. Natural history of small and medium-sized side branches after coronary stent implantation. *Am Heart J* 2002; 143: 627-35.
4. Kralev S, Poerner TC, Basorth D, et al. Side branch occlusion after coronary stent implantation in patients presenting with ST-elevation myocardial infarction: clinical impact and angiographic predictors. *Am Heart J* 2006; 151: 153-7.
5. Vassilev D, Gil RJ, Rzezak J, et al. Quantitative analysis allows predicting side branch compromise after main branch stenting of bifurcation lesions. *Am J Cardiol* 2007; 100 (Suppl 1): S73 (abstract).
6. Kasaoka S, Tobis JM, Akiyama T, et al. Angiographic and intravascular ultrasound predictors of in-stent restenosis. *J Am Coll Cardiol* 1998; 32: 1630-5.
7. Hoffmann R, Mintz GS, Mehran R, et al. Intravascular ultrasound predictors of angiographic restenosis in lesions treated with Palmaz-Schatz stents. *J Am Coll Cardiol* 1998; 31: 43-9.
8. Di Mario, Morici N, Godino C, et al. Predictors of restenosis after treatment of bifurcational lesions with paclitaxel eluting stents: a multicenter prospective registry of 150 consecutive patients. *Catheter Cardiovasc Interv* 2007; 69: 416-24
9. Pan M, Suárez de Lezo J, Medina A, et al. Six-month intravascular ultrasound follow-up of coronary bifurcation lesions treated with rapamycin-eluting stents: technical considerations. *Rev Esp Cardiol* 2005; 58: 1278-86 (Spanish).
10. Vassilev D, Gil R. Changes in coronary bifurcations after stent placement in the main vessel and balloon opening of stent cell – theory and practical verification on bench test model. *Jour/Geriat Cardiology* (accepted for publication).

Zmiany średnic tętnic wieńcowych tworzących rozgałęzienie po implantacji stentu w głównym naczyniu – znaczenie pozycji ostrogi

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Streszczenie

Wprowadzenie i cel: Zwężenia zlokalizowane w rozgałęzieniach wieńcowych (tzw. zwężenia bifurkacyjne) występują stosunkowo często w klinicznej praktyce kardiologa interwencyjnego. Najczęściej stosowana technika leczenia takich zwężeń, polegająca na stentowaniu naczynia uznanego za główne (zwykle o większej średnicy), często prowadzi do zawężenia ujścia naczynia bocznego (SB), a tym samym do upośledzenia w nim przepływu (SBC). W pracy analizowano zmiany w średnicach składowych rozgałęzienia wieńcowego dokonujące się pod wpływem implantacji stentu do naczynia głównego. Do analiz wykorzystywano koronarogramy wykonane przed zabiegiem i po nim oraz stosowne wzory stworzone na podstawie własnej koncepcji zachowania się ostrogi (łac. *carina*).

Metodyka: W pracy przyjęto założenie, iż głównym mechanizmem SBC po implantacji stentu do naczynia głównego jest przesunięcie ostrogi przez elementy strukturalne stentu (ang. *struts*), odpowiadające za utrzymanie jego światła. Analizie poddano: minimalną średnicę (MLD) w ujściu SB, stopień redukcji jej światła (%DSSB) oraz średnicę dalszego ramienia naczynia głównego (DLD) i zmiany pozycji ostrogi. Wartości ww. parametrów uzyskane z pomiarów angiogramów były porównywane z wartościami obliczanymi ze stosownych wzorów.

Wyniki: Na populację badaną składało się 55 kolejnych chorych ze zwężeniami bifurkacyjnymi, zakwalifikowanymi do leczenia przezskórnego z użyciem stentu w naczyniu głównym. Charakterystyka kliniczna chorych była podobna do populacji przedstawianych w innych pracach dotyczących leczenia zmian bifurkacyjnych. Implantacja stentu najczęściej (73%) miała miejsce w tętnicy przedniej zstępującej. Analiza udowodniła, iż taki zabieg powodował istotne pogorszenie zwężenia w ujściu SB (z 48±23% DS do 69±21% DS, odpowiednio przed i po; p <0,001). Natomiast zastosowanie techniki dwóch baloników (ang. *kissing balloons inflation*) albo dodatkowego poszerzenia SB cewnikiem balonowym skutkowało poprawą światła i zmniejszeniem stopnia zwężenia w ujściu SB (z 69±21 %DS do 53±25 %DS, odpowiednio przed i po; p <0,001). Implantacja stentu w naczyniu głównym prowadzi do jego „wyprostowania" z widocznym wzrostem kąta pomiędzy częścią proksymalną i dalszą naczynia głównego (tzw. kąt C: 148±19% *vs* 156±16%, odpowiednio przed i po; p <0,007). Analiza zależności pomiędzy wyliczonymi z koronarogramów a oczekiwanymi wartościami DLD i %DS w naczyniu głównym wykazała dobre korelacje (dla DLD r=0,91; p <0,001; dla %DS r=0,53; p <0,001). Bardzo dobre korelacje stwierdzono także dla MLD oraz %DS gałęzi bocznej (dla MLD r=0,91; p <0,001).

Wnioski: Nasze badania potwierdzają, że głównym mechanizmem odpowiadającym za zmiany w rozgałęzieniach wieńcowych poddawanych stentowaniu jest przesunięcie ostrogi spowodowane uciskiem elementów strukturalnych stentu. Poprawa światła ujścia SB za pomocą dodatkowych poszerzań balonikiem angioplastycznym powoduje przesunięcie ostrogi w kierunku prawidłowej pozycji, co daje redukcję średnicy naczynia głównego. Ocena znaczenia tego zjawiska w aspekcie wyniku odległego jest obecnie przedmiotem prac badawczych. Zaproponowane przez nas wzory, opisujące ww. zmiany, pozwalają uzyskać wartości najistotniejszych parametrów bardzo dobrze korelujące z wartościami uzyskiwanymi z analiz koronarogramów.

Słowa kluczowe: zwężenie rozgałęzienia wieńcowego, stentowanie bifurkacji, przewidywanie wyniku końcowego

Kardiol Pol 2008; 66: 371–378

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Praca wpłynęła: 12.12.2007. **Zaakceptowana do druku:** 30.01.2008.