Hemodynamic Analysis of Coronary Circulation in the Angulated Coronary Stenosis Following Stenting

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1. Introduction

The acute cellular response manly comes from strut imposed vascular damage, which dictates the extent of intimal thickening. Stent deployment transfixes the artery in a permanently altered shape, the transitions in diameter, contour, and changes of flow pattern also influence on repair and restenosis. Immediate post-deployment luminal geometry determines neointimal thickness independently. Not only biological but also biomechanical factors influence on in-stent restenosis. Restenosis of mechanically revascularized coronary arteries may be related in part to abnormalities of disturbed local flood flow and shear stress.

To test hypothesis that changed geometry of coronary artery after stenting affects on the restenosis by bio-mechanical factors such as shear stress and flow-velocity. We examine clinical results of the patients treated with stenting in angulated coronary stenosis and analyze the influence of flow velocity and shear stress before and after stenting using human in vivo hemodynamic parameters and computed simulation of coronary artery model qualitatively and qualitatively.

2. Methods

2.1 Coronary angiography and coronary stenting

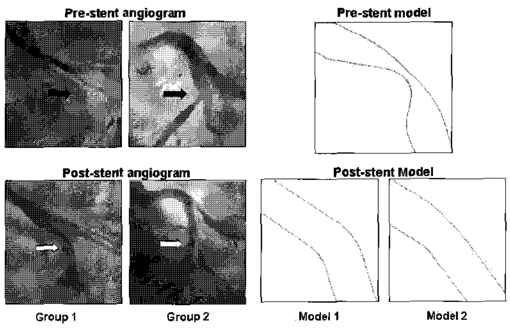
Coronary angiography and coronary stenting for critical stenosis (>70% diameter stenosis) by the femoral approach according to standard techniques. We performed6-month follow up coronary angiography and select the highest angulation with angular measurements using the serial images of angiography taken in different angle before and after stenting. Each arterial diameter measured by quantitative coronary assessment (QCA) for computer simulation. Doppler ultrasound for measurement of coronary flow-velocity at proximal and distal regions of interest of coronary artery

2.2 Coronary artery models

Two models: < 50 % changed (model 1, n=43), > 50% changed group (model 2, n=39) according to the percent change of vascular angle between pre- and post-stenting.

3. Results

Percent diameter restenosis in 6-month follow up coronary angiography revealed model 2 had significantly lower % restenosis than model 1. The flow-velocity vector of pre-stenting revealed very high flow velocity



Coronary groups and computerized schematic models before and after stenting, based on the images of human left anterior descending (LAD) artery (Closed arrow : pre-stent stenosis, Open arrow : post-stent status). Subjects & Models were grouped by % angle changed(Group & Model 1; <50%, Group & Model 2; >50%)

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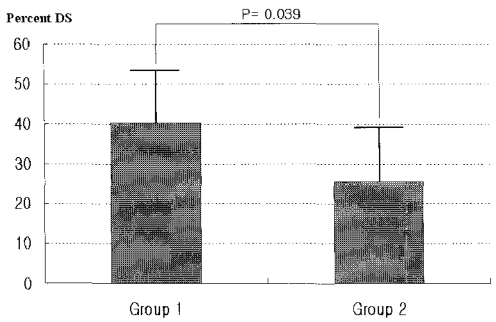
toward outer wall of the artery due to critical coronary stenosis and flow separation, flow recirculation, as well as flow attachment phenomenon in inner wall. Post-stenting-flow-vector model revealed reduced peak flow velocity in the same coronary artery and disappeared flow recirculation.

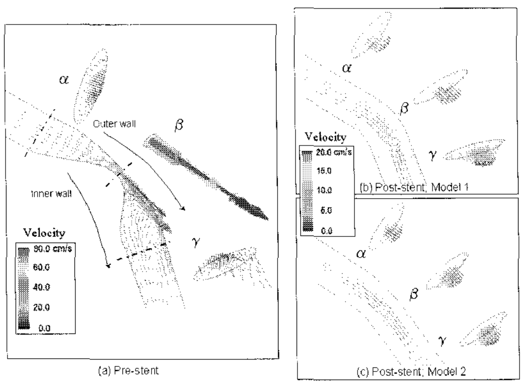
Table 2. Initial angiographic characteristics

	Group 1 (n=33)	Group 2 (n=27)	p
Stent data			
Stent diameter(mm)	3.2 ± 0.4	3.1 ± 0.4	NS
Stent length(mm)	23.0 ± 6.6	20.9 ± 6.7	NS
Quantitative coronary angiographic data			
* MLD prestent	0.7 ± 0.3	0.7 ± 0.2	NS
poststent(mm)	3.0 ± 0.3	3.0 ± 0.5	NS
Reference diameter(mm)	3.1 ± 0.3	3.0 ± 0.5	NS
%**DS prestent	78.1 ± 9.3	78.7 ± 8.7	NS
poststent	3.8 ± 4.8	3.2 ± 5.0	NS
Lesion length(mm)	14.5 ± 7.3	13.2 ± 4.1	NS
Vessel angulation (°)			
Vessel angle prestent	43.3 ± 22.5	34.3 ± 22.0	NS
poststent	32.9 ± 19.3	14.7 ± 13.8	<0.001
Changes in angle	10.4 ± 7.0	22.3 ± 13.7	<0.001

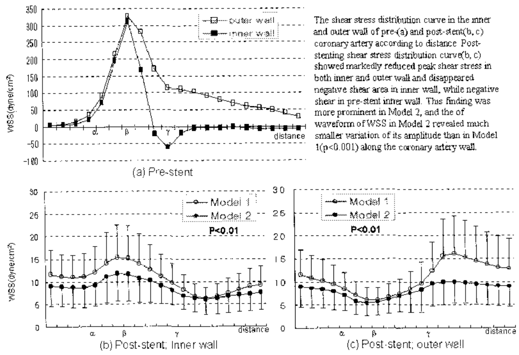
* MLD: minimal lesion diameter, **DS: diameter stenosis
Data are presented as mean ± SD or patient numbers and percentages in parentheses



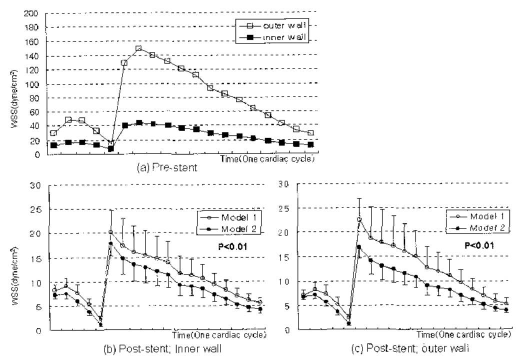
Percent DS in 6-month follow up coronary angiography revealed group 2 had significantly lower % RS than group 1



The negative WSS was disappeared after stenting. High spatial and temporal WSS before stenting fell into within physiologic WSS after stenting. This finding was prominent in Model 2 (p<0.01)



The shear stress distribution curve in the inner and outer wall of pre-(a) and post-stent(b, c) coronary artery according to distance. Post-stenting shear stress distribution curve(b, c) showed markedly reduced peak shear stress in both inner and outer wall and disappeared negative shear area in inner wall, while negative shear in pre-stent inner wall. This finding was more prominent in Model 2, and the of waveform of WSS in Model 2 revealed much smaller variation of its amplitude than in Model 1(p<0.001) along the coronary artery wall.



4. Conclusion

The present study suggest that hemodynamic forces exerted by pulsatile coronary circulation termed WSS might affect on the evolution of atherosclerosis within the angulated vascular curvature. Moreover, geometric characteristics, such as angular difference between pre -, and post-intracoronary stenting might define optimal rheologic properties for vascular repair after stenting.

References

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