Hemodynamic performance of different stent strategies for coronary bifurcations. Evaluation with a mathematical model.

J A. Fernandez Diaz1, J. Goicolea Ruigomez1, J. Garcia Garcia2, F. Manuel Martin2, Y. Doce Carrasco2, A. Garcia Touchard1, JF. Oteo Dominguez1, F. Castro Ruiz2, A. Crespo Martinez2, LA. Pulpon Rivera1 - (1) Hospital Universitario Puerta de Hierro, Majadahonda, Spain (2) Escuela Superior de Ingenieros Industriales. Universidad Politécnica de Madrid, Madrid, Spain

Purpose

Best percutaneous treatment strategy for lesions in coronary bifurcations is an ongoing subject of debate. There is limited data that analyses the effect of the different bifurcation strategies on coronary flow.

Our aim is to evaluate the influence of different bifurcation stenting strategies on hemodynamic parameters, both in the main vessel (MV) and side branch (SB).

Methods

A computerized mathematical model based on finite volume analysis, was used to evaluate hemodynamic patterns in the following cases: bifurcation with no stenting, simple stenting in main vessel (SS), simple stent in main vessel and "kissing balloon" through the side branch (KB) and "Coulotte Technique" (CT). For each case a 45º and 90 º bifurcation configuration was evaluated (Fig.1).

Three parameters were measured in MV and SB: volumetric flow and pressure decrease, low shear stress area (<20%(<0.1 Pa) of the value proximal to bifurcation) and vorticity (index of turbulence). Low shear stress has been related to plaque formation and restenosis.

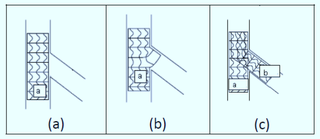

Figure 1. Stenting techniques considered in this study: (a) simple, (b) kissing and (c) culotte stenting.

Results

Overall 90º bifurcations, regardless of the technique, had a worse haemodynamic behaviour (greater decrease in pressure and SB flow and more turbulence) compared to 45º (Fig 2). CT technique preserves the best the flow in the SB but only in the 45º configuration, with no advantage over KB in 90º (Table 1).

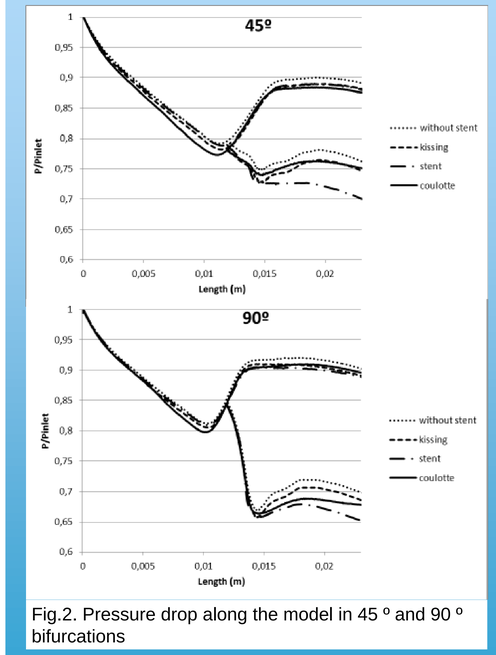

Fig.2. Pressure drop along the model in 45 º and 90 º bifurcations

	Technique	NS	SS	KB	CT
Flow MB/Flow SB	45º	1,203	1,285	1,215	1,172
	90º	1,217	1,395	1,305	1,309
Low shear stress area (mm2)	45º	7,94	35,92	30,63	92,43
	90º	4,16	45,30	33,64	39,40
Average Vorticity (1/s)	45º	238,680	252,986	246,175	231,239
	90º	246,843	258,851	250,639	245,878

Table 1. Values of different flow parameters with several bifurcation techniques.

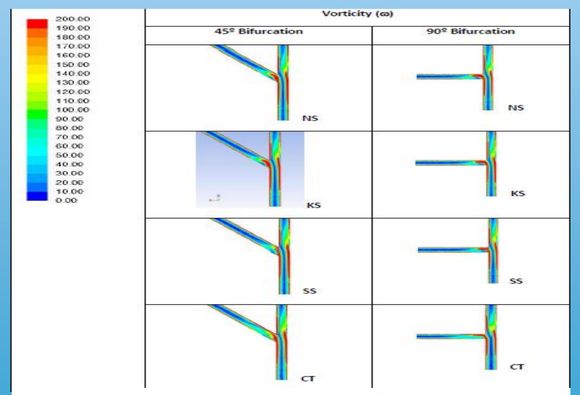

Figure 3. Average vorticity (turbulence index) in different models

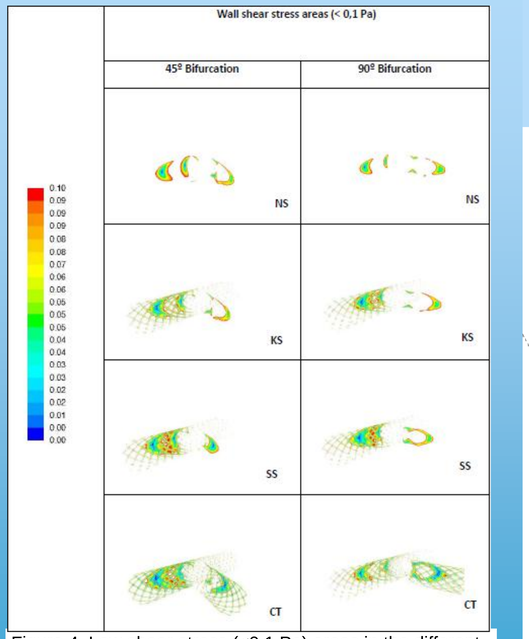

Figure 4. Low shear stress (<0,1 Pa) areas in the different models

SS is the technique that provides worst haemodynamic performance (Table 1) . This behaviour may be explained by differences in turbulence (Vorticity- Fig. 3), however the area exposed to low shear stress was the greatest with the CT technique at 45º (Fig. 4).

Conclusions

In our mathematical model, bifurcation angle has a great influence in the haemodynamic behaviour of different stenting techniques. SS technique has the worst results in terms of haemodynamics due to a higher degreee of turbulence. However CT creates the largest low shear stress area mainly, in 90º bifurcations.

ESC Congress 2011