

이상적인 스텐트 선택과 디자인

장 양 수

Ideal Stent Selection and Design

Yang-Soo Jang, M.D., F.A.C.C.

Division of Cardiology, Yonsei Cardiovascular Center, Yonsei University, Seoul, Korea

Benestent ¹⁾	Stress ²⁾	stent	ition	final MLD가	가	12)
, stent				가	stent occlusion	
nt		ticlopidine		13)	Colombo	16
		6-7) stent				
가		가	stent	16		
stent		stent가				
		stent				
stent	8-10)	vessel size, lesion		final MLD가	가	
length, final MLD(minimal lumen diameter)				. Pal - maz - Schaz stent		
			11),		가	14), AVE
		stent		Microll ¹⁵⁾ , Wiktor stent ¹⁶⁾		
A)		stent가				Ozaki
stent			17) Less shortening Wall stent			
, B)		stent design	oversizing balloon			18)
이상적인 stent 가 갖추어야 할 조건에				, stent	good	
따른 기존의 stent 의 특장점				apposition		,
				stent		
				가		
1. Good apposition				, complication		
Stent		stent appos -				

2. Good radial forces

, chronic total occlusion, aorto
ostial lesion, calcified lesion stent
radial force가 stent가

1) Medium to small vessels

recoil vessel size
radial force가 ¹⁹⁾ miniCrown, Nir, sm -
all vessel BeStent, small vessel Devon stent

2) Chronic total occlusion

Plaque radial force가 stent
(Palmaz - Schatz)가 ²⁰⁾
Palmaz - Schatz stent가 PTCA
(32% vs 74%).

3) Aorto ostial lesions

radial force radio - opacity 가 slot -
ted tubular design stent가 ²¹⁾,
4mm Palmaz biliary stent, 4mm
spiral articulated Palmaz - Schatz stent
(good radial support and fair radiopacity), Nir
stent with radiopaque version(Nir Royal)

4) Calcified lesion

stent
final lumen 가 , final lumen
recoil radial force 가
Palmaz - Schatz stent with spiral articulation, Nir,
Devon stent, AVE micro II, AVE Gfx, Cross - Flex,
ACS - Multilink stent ²²⁾.

3. Good flexibility

3mm ,
, proximal tortuosity, 45 acute ang -
ulation flexibility가 stent가

1) Vessels smaller than 3.0mm

distal lesion fle -

xibility가

radial force . Palmaz - Schatz
stent 23%, 9 cells Nir stent 23%

2) Acute closure and threatened closure

Flexible
premount가 가 G - RII²³⁾, AVE mic -
roll²⁴⁾, AVE Gfx, Cross Flex II stent가

3) Proximal tortuosity or acute angulation(45°)

Palmaz - Schatz stent edge dissection
G - R, Wiktor, Cordis stent coil
stent vascular geometry AVE
Gfx, ACS multilink

4. Less shortening

Shortening stent deployment
가 , osteal lesion, tortuous
lesion shortening stent
. Wallstent 가 (30%) Cor -
dis 10%, Cross Flex 5%, Crown 5%, ACS multilink
3% , AVE Microll, Gfx, Nir, Pa -
lma - Schatz, G - R II stent shorten -
ing

5. Good metal coverage

Protruding plaque, dissection flap ,
strut cell ,
plaque dissection flap
cell
stent welding
spine coil stent angled lesion
unit 가 bare area
Colombo 163 lesions(45angle)
overall restenosis rate 33%, Palmaz - Schatz 21%

, Micro II stent
45 bend

lesion		Gfx, Wallstent	moderate radiopaque	G -
Curved lesion	G - R II, Wiktor - I,	RII, Palmaz - Schatz, Nir, Davon	stent	low
Crossflex, AVE micor II lesion	flexible bend	radiopaque	bifurcation lesion	aorto
		ostial lesions	radiopaque	stent

6. Possible side branch approach

Bifurcation lesion sidebranch occlusion
G - R stent ²⁵⁾ , pal -
maz - Schatz 10% ²⁶⁾
G - R stent side branch 가
wire balloon G - R stent , coil
 side branch jail strut
 가 side branch PTCA
 slotted type stent side branch
 jail strut 가 balloon entrapment
 side branch PTCA low
profile balloon . side br -
anch jail cell 가
 stent T - stent, Y - stent

Palmaz - Schatz version Crown
Palmaz - Schatz stent cells Pa -
Imaz - Schatz stent straight sinuso -
idal jailed side branch catheter 가
 Palmaz - Schatz stent
bifurcation lesion

AVE Microll stent MiniCrown stent
low profile stent side branch
occlusion stent strut
jailed side branch stent
 Kissing balloon technique
 side branch stent strut balloon ru -
pture 가 AVE Gfx stent sharp
edge 가 radial support 가 moderate
visible

7. Radiopacity

Angio, Cordis, Cross FlexII, Wiktor stent
high radiopaque , ACT one, AVE microll, AVE

8. Optimal coverage in the long lesion

Saphenous vein grafts long lesion
cover wallstent, Palmaz - Schatz, Cr -
own, 9cells Nir stent wall
stent 가 long diffuse lesions
 Yokoi ²⁷⁾ 20mm
long lesion multiple Palmaz - Schatz stent,
G - R stent, less shortening wall stent
 42%, 35%, 56% 3
 가 ²⁸⁾
 20mm Micro II, Wall, GR - II
stent
 가
 suboptimal result
 stenting focal stenting in the long
lesion

이상적인 Stent Design

1) design,
2) material, 3) surface 3가
 stent design

1993 Fontaine ²⁹⁾ stent ind -
uced neoin - timal hyperplasia flexible rigid
stent , Rogers Edelman ³⁰⁾
 slotted tu -
be type corrugated ring type injury
score 가 , ,
 , Carter ³¹⁾
multicellular box type slotted tube type
 multicellualr box type injury score 가
 60% ,

slotted tube type vascular geometry
 design

Stent material	가
stainless steel	가 mat -
erial	Scott ³²⁾
shunt	stainl -
ess steel tantalum	가
, Barth ³³⁾	lower hoop stre -
ngth higher profile	tantalum stent
stainless steel	recoil
. Sheth ¹³⁾	slotted nitinol
slotted stainless steel	
thrombogenicity vascular injury	
nitinol	, Sch -
urman ³⁴⁾	nitinol, palmaz
	wallstent
	가 stent
Stent surface	가
chemical polishing	Wang ³⁵⁾ electro - roughness
, Hehrlein ³⁶⁾	, ,
stent	, high charge
local delivery	가
polymer coating	37-40)
	stent
stent design	가
	stent

References

- 1) Serruys PW, de Jaegere P, Kiemeneij, et al : *A comparison of balloon-expandable-stent implantation with balloon angioplasty in patients with coronary artery disease.* *N Engl J Med* 331 : 489, 1994
- 2) Fishman DL, Leon MB, Baim DS, et al : *A randomized comparison of coronary-stent placement and balloon angioplasty in the treatment of coronary artery disease.* *N Eng J Med* 331 : 496, 1994
- 3) Colombo A, Hall P, Nakamura S, et al : *Intracoronary stenting without anticoagulation accomplished with intravascular ultrasound.* *Circulation* 91 : 1676, 1995
- 4) Schomig A, Neumann FJ, Kastrati A, et al : *A randomized comparison of anticoagulation of anticoagulation therapy after the placement of coronary-artery stents.* *N Eng J Med* 334 : 1084-1089, 1996
- 5) Karrillon GJ, Morice MC, Bertheniste E, et al : *Intracoronary stent implantation without ultrasound guidance and with placement of conventional anticoagulation by antiplatelet therapy. 30 days clinical outcome of the French Multicenter Registry.* *Circulation* 94 : 1519, 1996
- 6) Serruys PW, Emanuelsson H, van der Giessen W, et al : *Heparine-coated Palmaz-Schatz stents in human coronary arteries. Early outcome of the Benestent-II pilot study.* *Circulation* 93 : 412, 1996
- 7) Colombo A, Ferraro M, Itoh A, et al : *Results of coronary stenting for restenosis.* *J Am Coll Cardiol* 28 : 830-836, 1996
- 8) Rau T, Tscharuer BI, Mathey DG, Schofer J : *Comparison of restenosis rates after placement of Palmaz-Schatz stents and AVE micro stents (abstr).* *Eur Heart J (Suppl)* 17 : 179, 1996
- 9) Itoh A, Hall P, Maiello L, et al : *Coronary stenting of long lesions (greater than 20mm) : A matched comparison of different stents (abstr).* *Circulation (Suppl I)* 92 : I-688, 1995
- 10) Yokoi H, Nobuyoshi M, Nosaka H, Kimura T, Hamasaki N, Nakagawa Y, Tamura T, Nakano Y, Hayashi F : *Coronary stent for long lesions (lesion length 20mm) in native coronary arteries : Comparison of three different types of stent (abstr).* *Circulation (Suppl I)* 94 : I-685, 1996
- 11) Antonio Colombo. Coronary stenting : *Stent indications. The vascular stent summit. Milano, May 29-31, 1997*
- 12) George G, Haude M, Junbo GE, Voegele E, Gerber T, Rupprecht H-J, Meyer J, Erbel R : *Intravascular ultrasound after low and high inflation pressure coronary artery stent implantation.* *J Am Coll Cardiol* 26 : 725-730, 1995
- 13) Sheath S, Litvach F, Dev V, et al : *Subacute thrombosis and vascular injury resulting from slotted-tube nitinol and stainless steel stents in a rabbit carotid artery model.* *Circulation* 94 : 1733-1740, 1996
- 14) Hall P, Nakamura L, Blengino S, Martini G, Finci L, Colombo A : *factors associated with late angiographic outcome after intravascular ultrasound guided Palmaz-Schatz coronary stent implantation.* *J Am coll Cardiol*

- 1995 : (in press)
- 15) 최동훈 · 장양수 · 홍범기 · 이남호 · 하종원 · 임세중 · 정남식 · 심원흠 : AVE Micro II stent : 6month follow up. 순환기 1997 : (in press)
 - 16) Yang P, Hassen A, Heyer G, Klein W, Luha O, Muehlberger V, et al : Highpressure postdilatation of the Medtronic Wiktor stent : intravascular ultrasound and quantitative angiographic data from the Astrian Multicenter Trial (abstr). Circulation 94 (Suppl I) : I-207, 1996
 - 17) Ozaki Y, Violaris AG, Hamburger JAAP, Melkert R, Foley D, Keane D, et al : Short and long clinical and quantitative angioaggraphic results with the new, less shortening wallstent for vessel reconstruction in chronic total occlusion : A qualitative angiographic study. J Am Coll Cardiol 28 : 354-360, 1996
 - 18) 이남호 · 장양수 · 홍범기 · 최동훈 · 하종원 · 임세중 · 심원흠 · 조승연 : Long lesion의 관동맥 협착에서 coronary less shortening wallstent의 6개월 follow-up results. 순환기 1997 : (in press)
 - 19) Antonio Colombo : Coronary stenting : Techniques of coronary stenting. The vascular stent summit. Milano, May 29-31, 1997
 - 20) Sirnes PA, Golf S, Myreng Y, et al : Stenting in chronic coronary occlusion (SICCO) : a randomized, controlled trial of adding stent implantation after successful angioplasty. J Am Coll Cardiol 28 : 1444, 1996
 - 21) Zampieri P, Colombo A, Almagor Y, Maiello L, Finci L : Results of coronary stenting of ostial lesions. Am J Cardiol 73 : 901, 1994
 - 22) Antonio Colombo : Coronary stenting : Stent designs. The vascular stent summit. Milano, May 29-31, 1997
 - 23) Leon MB, Fry ETA, O'Shaughnessy CD, et al : Preliminary multicenter experiences with the new GR-II stent for abrupt and threatened closure syndrome. Circulation 94 Suppl I : 2071, 1996
 - 24) Ozaki Y, Keane D, Ruygrok P, de Feyter P, Stentzers, Serrius P : Acute clinical and angiographic results with the new AVE micro coronary stent in bailout management. Am J Cardiol 76 : 112, 1995
 - 25) Mazur W, Grinstead C, Hakim A, et al : Fate of side branches after intracoronary implantation of the Gianturco-Roubin flex-stent for acute or threatened closure after percutaneous transluminal coronary angioplasty. Am J Cardiol 74 : 1207-1210, 1994
 - 26) Fischman DL, Savage MP, Leon MB, et al : Fate of lesion-related side branches after coronary artery stenting. J Am Coll Cardiol 22 : 1641-1646, 1993
 - 27) Yokoi H, Nobuyoshi M, Nosaka H, Kimura T, Yokoi H, et al : Coronary stenting for long lesions (lesion length <20mm) in native coronary arteries : comparison of three different types of stent. Circulation 94 (Suppl I) : I-685, 1996
 - 28) 최동훈 · 심원흠 · 김태용 · 고충원 · 홍범기 · 조승연 · 김동수 · 장양수 · 김현승 : Long lesion의 관동맥 협착에서 long stent : 3가지 다른 stent의 비교. 순환기 26(5호부록) : 298, 1997
 - 29) Fontaine AB, Spigos DG, Eaton G, Das Passos S, Christoforidis G, Khabiri H, Jung S : Stentinduced intimal hyperplasia : are there fundamental differences between flexible and rigid stent design? J Vas Interv Radiol 5 : 739-744, 1994
 - 30) Rogers C and Edelman ER : Endovascular stent design dictates experimental restenosis and thrombosis. Circulation 91 : 2995-3001, 1995
 - 31) Carter AJ, Scott D, Baily LR, Jones R, Virmani R, Fischell TA : Stent geometry influences arterial injury and neointimal formation in normal porcine coronary arteries. The proceedings of restenosis summit IX 3, 1997 :
 - 32) Scott NA, Robinson KA, Nunes GL, Thomas CN, Viel K, King SB, Harker LA, Rowland SM, Juman I, Cipolla GD : Comparison of the thrombogenicity of stainless steel and tantalum coronary stents. Am Heart J 129 : 866-872, 1995
 - 33) Barth KH, Virmani R, Floelich JM, Takeda T, Lossef SV, Newsome J, Jones R, Lindisch D : Paired comparison of vascular wall reactions to Palmaz stents, Strecker tantalum stents, and Wallstents in canine iliac and femoral arteries. Circulation 93 : 2161-2169, 1996
 - 34) Schurman K, Vorwerk D, Kulisch A, Stroehmer-Kulisch E, Biesterfeld S, Stopinski T, Gunther K : Neointimal hyperplasia in low-profile nitinol stents, Palmaz stents, and Wallstents : a comparative experimental study. Cardiovasc Interv Radiol 19 : 248-254, 1996
 - 35) Wang K, Verbeken SE, Zhou XR, Frooyen L, Humbeek J, Oiessen J, Scheerder I : Metallic surface treatment using electrochemical polishing decreases thrombogenicity and neointimal hyperplasia after coronary stent implantation in a porcine model. The proceedings of restenosis summit IX 6, 1997 :
 - 36) Hehrlein C, Zimmermann M, Ensinger W, Kubler W : Influence of surface texture and charge on the biocompatibility of endovascular stents. Coron Artery Dis 6 : 581-586, 1995
 - 37) Aggarwal RK, Ireland DC, Azrin MA, Ezekowitz MD, Bono DP, Gershlick AH : Antithrombotic potential of polymer-coated stents eluting platelet glycoprotein IIb/IIIa receptor antibody. Circulation 94 : 3311-3317, 1996
 - 38) Van der Gissen WJ, Lincoff AM, Schwartz RS, van Beusekom HM, Serruys PW, Holmes DR, Ellis SG, Topol EJ : Marked inflammatory sequelae to implantation of biodegradable and nonbiodegradable polymers in porcine coronary arteries. Circulation 94 : 1494-1495, 1996

- 39) De Scheerder IK, Wilczer KL, Verbeken EV, Vandorp J, Lan PN, Schacht E, Piessens J, De Geest H : *Biocompatibility of biodegradable polymer-coated stents implanted in porcine peripheral arteries*. *Cardiovasc Intervent Radiol* 18 : 227-232, 1995
- 40) Seeger JM, Ingegno MD, Bigatan E, Klingman N, Amery D, Widenhouse C, Goldberg EP : *Hydrophilic surface modification of metallic endoluminal stents*. *J Vasc Surg* 22 : 327-335, 1995