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Progress in Cardiovascular Diseases

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STENTS

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Progress in CARDIOVASCULAR DISEASES

Stents

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New Stent Technologies

Yukio Ozaki, Andonis G. Violaris, and Patrick W. Serruys

Coronary stents were developed to overcome the two main limitations of balloon angioplasty, acute occlusion and long-term restenosis. Coronary stents can tack back intimal flaps and seal the dissected vessel wall, thereby treating acute or threatened vessel closure after unsuccessful balloon angioplasty. After successful balloon angioplasty, stents can prevent late vessel remodeling (chronic vessel recoil) by mechanically enforcing the vessel wall and resetting the vessel size, resulting in a low incidence of restenosis. All currently available stents are composed of metal, and the long-term effects of their implantation in the coronary arteries are still not clear. Because of the metallic surface, they are also thrombogenic; therefore, rigorous antiplatelet or anticoagulant therapy is theoretically required. Furthermore, they have an imperfect compromise between scaffolding properties and flexibility, resulting in an unfavorable interaction between stents and unstable or thrombus-laden plaque. Finally, they still induce substantial intimal hyperplasia that may result in restenosis. Future stents can be made less thrombogenic by modifying the metallic surface or coating it with an antithrombotic agent or a membrane eluting an antithrombotic drug. The unfavorable interaction with the unstable plaque and the thrombus burden can be overcome by covering the stent with a biological conduit, such as a vein, or a biodegradable material that can be endogenous, such as fibrin, or exogenous, such as a polymer. Finally, the problem of persisting induction of intimal hyperplasia may be overcome with the use of either a radioactive stent or a stent eluting an antiproliferative drug.

CORONARY stents were developed to overcome the two main limitations of balloon angioplasty, acute occlusion and long-term restenosis. Coronary stents can tack back intimal flaps and seal the dissected vessel wall, thereby treating acute or threatened vessel closure after unsuccessful balloon angioplasty. After successful balloon angioplasty, stenting can prevent late vessel remodeling (chronic vessel recoil) by mechanically enforcing the vessel wall and resetting the vessel size, resulting in a low incidence of restenosis. These theoretical advantages of coronary stenting have been tested in two major randomized trials.[1,2] Both the Belgium Netherlands Stent Study (Benestent) and Stent Restenosis Study (STRESS) confirmed the theoretical advantages of coronary stenting by showing a reduction in angiographic restenosis and clinical events during follow-up examination.[1,2] This reduction in restenosis was achieved by a greater luminal gain despite the accommodation of a greater absolute loss in lumen diameter in the stent group, suggesting greater neointimal hyperplasia in this group. The reduction in long-term restenosis was counterbalanced by bleeding complications related to the anticoagulant therapy. Therefore, a number of limitations have to be overcome before coronary stenting achieves its full potential.

CURRENTLY AVAILABLE STENTS

The currently available stents, a description of their design, and the year of their clinical introduction are listed in Table 1 and are shown in Fig 1. In the absence of prospective randomized interstent comparative trials, it is difficult to draw conclusions on the relative merits and demerits of each stent design. However, individual experience and registry data from each stent allow preliminary impressions to be made on the advantages and limitations of each stent.

Wallstent

The Wallstent (Schneider, Bulach, Switzerland) was the pioneer of stents[3-5] through which we learned the risk profile and indications for coronary stenting and the necessity and adverse effects of antithrombotic measures. The new less-shortening Wallstent has been developed recently with a change in the braiding angle, and results of the first clinical implantation of this second generation stent in coronary vein grafts have been promising.[6] The unique advantages of the Wallstent include the extensive range of diameters and lengths available, thereby allowing the Wallstent to be used for the management of long spiral dissections[7] and for vessel reconstruction.[8] The sheathed "balloon-

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Table 1. Currently Available Stents Undergoing Clinical Evaluation

Coronary Stent	Design	Deployment	Premounted	Delivery	Diameter (mm)	Length (mm)	First Clinical Implantation
Wallstent	Wire mesh	Self-expanding	Balloon not required	Over-the-wire	3.5-6.0	12-42	1986 1991 (less-shortening)
Palmaz-Schatz	Slotted tube	Balloon-expandable	Premounted and unmounted	Over-the-wire and both	3.0-4.0	8-18	1988 1994 (heparin-coated)
Gianturco-Roubin	Incomplete coil clam-shell loop	Balloon-expandable	Premounted	Over-the-wire	2.5-4.0	20-40	1989 (GR-I) 1995 (GR-II)
Wiktor	Sinusoidal helical coil	Balloon-expandable	Premounted	Over-the-wire or monorail	3.0-4.5	16	1991 1995 (short-wave)
Multi-Link	Multiple rings with multiple links	Balloon-expandable	Premounted	Over-the-wire	3.0-3.5	15	1993
Cordis	Sinusoidal helical coil	Balloon-expandable	Premounted	Over-the-wire	3.0-4.0	15	1994
AVE Micro	Zigzag axial struts	Balloon-expandable	Premounted	Monorail	2.5-4.0	6-36	1994 (Micro-I) 1995 (Micro-II)
NIR	Expandable uniform cellular mesh	Balloon-expandable	Unmounted	Both	2.0-5.0	9-32	1995

less" delivery system in combination with the free, unconnected wire-mesh design, render the Wallstent one of the most trackable, pushable, and flexible stents for negotiating tortuous vessel and passing through proximally deployed stents (Fig 2). Furthermore, recent modification of the delivery system allows recapture of the stent before final deployment and also allows

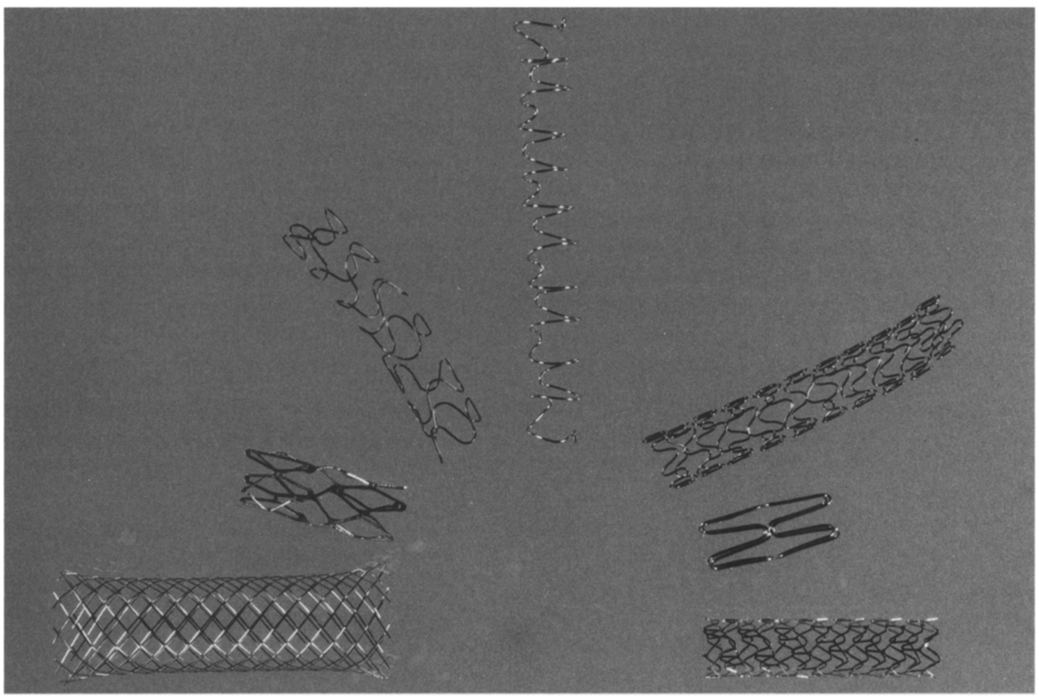

Fig 1. Coronary stents that have undergone clinical evaluation are shown clockwise from the left: Wallstent, Palmaz-Schatz, Wiktor, Gianturco-Roubin, Cordis, AVE Micro, and ACS Multi-Link. (Reprinted with permission.[3])

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