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THE EVOLUTION OF PERCUTANEOUS CORONARY INTERVENTION: FROM BALLOON ANGIOPLASTY TO BIORESORBABLE SCAFFOLDS

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Abstract
Percutaneous coronary intervention (PCI) has evolved from a high-risk experimental procedure into the standard revascularization strategy for obstructive coronary artery disease. Beginning with balloon angioplasty, the field progressed through bare-metal stenting, first- and second-generation drug-eluting stents, and, more recently, bioresorbable scaffold technologies. Each stage addressed limitations of its predecessor, most notably acute vessel recoil, elastic restenosis, neointimal hyperplasia, and late stent thrombosis. This evolution has been accompanied by advances in intracoronary imaging, physiological lesion assessment, antiplatelet pharmacotherapy, and vascular access technique. This review summarizes the historical development of coronary stenting, the transition from bare-metal to drug-eluting

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platforms, the rise and partial retreat of bioresorbable scaffolds, and enabling technologies that continue to shape contemporary interventional cardiology.

Keywords: Percutaneous coronary intervention, Coronary stent, Drug-eluting stent, Bioresorbable scaffold, Restenosis, Stent thrombosis, Fractional flow reserve.

Introduction

1. Historical Evolution of Percutaneous Coronary Intervention

The origins of percutaneous coronary intervention trace back to the transluminal angioplasty technique described by Dotter and Judkins for peripheral arterial disease (Dotter & Judkins, 1964). In 1977, Andreas Gruntzig performed the first percutaneous transluminal coronary angioplasty (PTCA) in Zurich, demonstrating that a balloon catheter could dilate an obstructive coronary lesion without open surgery (Gruntzig, 1978). Although balloon angioplasty provided immediate relief of stenosis, it was limited by acute elastic recoil, abrupt vessel closure requiring emergency bypass surgery in a subset of patients, and angiographic restenosis in approximately thirty to forty percent of treated lesions within six months. These limitations motivated the search for a scaffolding device capable of maintaining luminal patency after balloon dilation. In 1986, Ulrich Sigwart and colleagues implanted the first self-expanding coronary stent, demonstrating that a permanent metallic scaffold could prevent early recoil and abrupt reocclusion (Sigwart et al., 1987). This achievement established the conceptual foundation for the balloon-expandable and self-expanding stent platforms that would come to define modern coronary intervention.

2. Bare-Metal to Drug-Eluting Stents: Solving the Restenosis Problem

The balloon-expandable Palmaz-Schatz stent became the first widely adopted coronary stent following the STRESS and BENESTENT trials, both of which demonstrated that stenting reduced angiographic restenosis compared with balloon angioplasty alone (Fischman et al., 1994; Serruys et al., 1994). Bare-metal stents (BMS) rapidly became standard practice, yet in-stent restenosis driven by exuberant neointimal hyperplasia continued to affect a substantial proportion of patients, particularly those with long lesions, small-vessel disease, or diabetes mellitus. The introduction of drug-eluting stents (DES) directly addressed this limitation by locally delivering antiproliferative agents from a polymer coating. The RAVEL trial demonstrated that a sirolimus-eluting stent could virtually eliminate angiographic restenosis at six months compared with a bare-metal stent (Morice et al., 2002), and the subsequent SIRIUS trial confirmed this benefit in a broader, more complex patient population (Moses et al., 2003). Paclitaxel-eluting stents demonstrated similar efficacy in the TAXUS-IV trial (Stone et al., 2004). These first-generation DES substantially reduced the need for repeat revascularization and were rapidly adopted worldwide. However, longer-term follow-up raised concern regarding late and very late stent thrombosis, attributed to delayed arterial healing and hypersensitivity reactions to the durable polymer coatings used in early DES designs (Pfisterer et al., 2006). This finding prompted a temporary reassessment of DES use in off-label indications and stimulated the development of second-generation platforms.

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3. Second-Generation Drug-Eluting Stents and Bioresorbable Scaffolds

Second-generation DES incorporated thinner cobalt-chromium or platinum-chromium struts, more biocompatible durable polymers, and newer antiproliferative agents including everolimus and zotarolimus. The SPIRIT and RESOLUTE trial programs demonstrated that these platforms achieved low rates of target lesion failure and stent thrombosis comparable to, or better than, earlier-generation devices, while maintaining low restenosis rates (Stone et al., 2010). These improvements re-established confidence in DES technology and contributed to their adoption as the default stent choice in most clinical scenarios. Building on this progress, bioresorbable vascular scaffolds (BVS) were developed with the goal of providing temporary mechanical support followed by complete scaffold resorption, theoretically restoring normal vasomotor function and eliminating the risk of very late complications associated with a permanent metallic implant. The ABSORB II trial reported encouraging early angiographic outcomes with a polylactide-based everolimus-eluting bioresorbable scaffold (Serruys et al., 2015). However, the larger ABSORB III trial and subsequent longer-term follow-up revealed higher rates of target lesion failure and, notably, scaffold thrombosis compared with a second-generation metallic DES, particularly in small vessels and when implantation technique did not account for the scaffold's greater strut thickness (Ellis et al., 2015; Kereiakes et al., 2017). These findings led to the withdrawal of the first commercially available BVS from most markets in 2017, while research has continued into thinner-strut and magnesium-based bioresorbable platforms designed to overcome the mechanical and healing limitations of earlier designs.

4. Enabling Technologies: Physiology, Imaging, and Pharmacotherapy

The refinement of PCI has depended heavily on technologies that improve lesion selection, stent optimization, and post-procedural management. Fractional flow reserve (FFR), a pressure-wire-derived index of the physiological significance of a coronary stenosis, has been shown to improve outcomes by guiding revascularization toward lesions that are truly ischemia-producing. The FAME trial demonstrated that FFR-guided PCI reduced death, myocardial infarction, and repeat revascularization compared with angiography-guided PCI in multivessel disease (Tonino et al., 2009), while FAME 2 demonstrated that FFR-guided PCI plus medical therapy reduced urgent revascularization compared with medical therapy alone in patients with stable disease and hemodynamically significant lesions (De Bruyne et al., 2012). Intravascular imaging modalities, including intravascular ultrasound (IVUS) and optical coherence tomography (OCT), allow direct visualization of vessel wall architecture, stent apposition, and expansion, improving procedural precision beyond angiography alone. Radial arterial access has also become the preferred approach in most centers after the RIVAL trial demonstrated a reduction in vascular access-site complications compared with femoral access, without compromising procedural success (Jolly et al., 2011). Finally, the appropriate duration of dual antiplatelet therapy following DES implantation has been informed by randomized evidence such as the DAPT Study, which demonstrated that prolonged dual antiplatelet therapy reduced stent thrombosis and myocardial infarction at the cost of increased bleeding risk, underscoring the need for individualized, risk-adapted antiplatelet strategies (Mauri et al., 2014).

Conclusion

The evolution of percutaneous coronary intervention illustrates a recurring pattern in interventional cardiology: each technological advance resolves a specific limitation of its predecessor while introducing new challenges that drive further innovation. Balloon angioplasty solved the problem of fixed stenosis but was limited by recoil and abrupt closure; bare-metal stents solved recoil but were limited by neointimal restenosis; first-generation drug-eluting stents solved restenosis but raised concern for late thrombosis; second-generation platforms substantially mitigated this risk; and bioresorbable scaffolds, while conceptually attractive, have thus far been limited by mechanical and healing considerations that remain under active investigation. Continued progress in stent metallurgy, polymer biocompatibility, physiological lesion assessment, intracoronary imaging, and individualized antiplatelet therapy is likely to define the next phase of coronary intervention, with the long-standing goal of a fully resorbable, thrombosis-resistant scaffold remaining an important area of ongoing research.

References

1. De Bruyne, B., Pijls, N. H., Kalesan, B., Barbato, E., Tonino, P. A., Piroth, Z., et al. (2012). Fractional flow reserve-guided PCI versus medical therapy in stable coronary disease. New England Journal of Medicine, 367(11), 991–1001.
2. Dotter, C. T., & Judkins, M. P. (1964). Transluminal treatment of arteriosclerotic obstruction: description of a new technic and a preliminary report of its application. Circulation, 30(5), 654–670.
3. Ellis, S. G., Kereiakes, D. J., Metzger, D. C., Caputo, R. P., Rizik, D. G., Teirstein, P. S., et al. (2015). Everolimus-eluting bioresorbable scaffolds for coronary artery disease. New England Journal of Medicine, 373(20), 1905–1915.
4. Fischman, D. L., Leon, M. B., Baim, D. S., Schatz, R. A., Savage, M. P., Penn, I., et al. (1994). A randomized comparison of coronary-stent placement and balloon angioplasty in the treatment of coronary artery disease. New England Journal of Medicine, 331(8), 496–501.
5. Gruntzig, A. (1978). Transluminal dilation of coronary-artery stenosis. New England Journal of Medicine, 298(2), 101–102.
6. Jolly, S. S., Yusuf, S., Cairns, J., Niemela, K., Xavier, D., Widimsky, P., et al. (2011). Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. The Lancet, 377(9775), 1409–1420.
7. Kereiakes, D. J., Ellis, S. G., Metzger, C., Caputo, R. P., Rizik, D. G., Teirstein, P. S., et al. (2017). 3-Year clinical outcomes with everolimus-eluting bioresorbable coronary scaffolds: the ABSORB III trial. Journal of the American College of Cardiology, 70(23), 2852–2862.
8. Mauri, L., Kereiakes, D. J., Yeh, R. W., Driscoll-Shempp, P., Cutlip, D. E., Steg, P. G., et al. (2014). Twelve or 30 months of dual antiplatelet therapy after drug-eluting stents. New England Journal of Medicine, 371(23), 2155–2166.
9. Morice, M. C., Serruys, P. W., Sousa, J. E., Fajadet, J., Ban Hayashi, E., Perin, M., et al. (2002). A randomized comparison of a sirolimus-eluting stent with a standard stent for coronary revascularization. New England Journal of Medicine, 346(23), 1773–1780.

10. Moses, J. W., Leon, M. B., Popma, J. J., Fitzgerald, P. J., Holmes, D. R., O'Shaughnessy, C., et al. (2003). Sirolimus-eluting stents versus standard stents in patients with stenosis in a native coronary artery. New England Journal of Medicine, 349(14), 1315–1323.
11. Pfisterer, M., Brunner-La Rocca, H. P., Buser, P. T., Rickenbacher, P., Hunziker, P., Mueller, C., et al. (2006). Late clinical events after clopidogrel discontinuation may limit the benefit of drug-eluting stents: an observational study of drug-eluting versus bare-metal stents. Journal of the American College of Cardiology, 48(12), 2584–2591.
12. Serruys, P. W., de Jaegere, P., Kiemeneij, F., Macaya, C., Rutsch, W., Heyndrickx, G., et al. (1994). A comparison of balloon-expandable-stent implantation with balloon angioplasty in patients with coronary artery disease. New England Journal of Medicine, 331(8), 489–495.
13. Serruys, P. W., Chevalier, B., Dudek, D., Cequier, A., Carrié, D., Iniguez, A., et al. (2015). A bioresorbable everolimus-eluting scaffold versus a metallic everolimus-eluting stent for ischaemic heart disease caused by de-novo native coronary artery lesions (ABSORB II): an interim 1-year analysis. The Lancet, 385(9962), 43–54.
14. Sigwart, U., Puel, J., Mirkovitch, V., Joffre, F., & Kappenberger, L. (1987). Intravascular stents to prevent occlusion and re-stenosis after transluminal angioplasty. New England Journal of Medicine, 316(12), 701–706.
15. Stone, G. W., Ellis, S. G., Cox, D. A., Hermiller, J., O'Shaughnessy, C., Mann, J. T., et al. (2004). A polymer-based, paclitaxel-eluting stent in patients with coronary artery disease. New England Journal of Medicine, 350(3), 221–231.
16. Stone, G. W., Rizvi, A., Newman, W., Mastali, K., Wang, J. C., Caputo, R., et al. (2010). Everolimus-eluting versus paclitaxel-eluting stents in coronary artery disease. New England Journal of Medicine, 362(18), 1663–1674.
17. Tonino, P. A., De Bruyne, B., Pijls, N. H., Siebert, U., Ikeno, F., van 't Veer, M., et al. (2009). Fractional flow reserve versus angiography for guiding percutaneous coronary intervention. New England Journal of Medicine, 360(3), 213–224.

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