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Case report

Longitudinal deformation – Price we pay for better deliverability of coronary stent platforms

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ABSTRACT

Coronary stents, especially drug eluting stents (DES), have revolutionized the practice of interventional cardiology. Newer stents are manufactured by altering basic design characteristics to tackle complex coronary morphologies more effectively. Alteration in one particular attribute might affect other attributes adversely. Even though, reduction in the number and alteration of the orientation of the connectors improves the stent flexibility and deliverability, it adversely decreases the axial strength of the stent with resulting longitudinal stent deformation. A 67 year old female underwent percutaneous coronary intervention for a mid left anterior descending artery stenosis with a 2.75×16 mm Promus Element stent (Boston Scientific, Natick, Massachusetts). The stent got longitudinally distorted during post-stent balloon dilatation which was effectively managed with further dilatation with non-compliant balloon.

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1. Introduction

Coronary stents, especially drug eluting stents (DES), have revolutionized the practice of interventional cardiology. With the availability of newer stent designs with better deliverability and conformability, more complex coronary subsets are now effectively managed with percutaneous intervention rather than coronary artery bypass surgery.¹ However, these newer stents have issues previously unknown with older platforms. Longitudinal compression, one such issue with newer DES platforms, has caused concern among the interventionist.^{2–5} We report a case of such deformation in

a patient who underwent percutaneous intervention for a mid left anterior coronary artery (LAD) lesion.

2. Case report

A 67 year old female, diabetic, hypertensive and hypothyroid was evaluated for exertional chest pain of CCS class III. Her exercise stress test was strongly positive for inducible ischemia and the coronary angiogram showed a 12 mm long concentric 80% type B stenosis in LAD starting just beyond the second septal branch (Fig. 1A).

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Fig. 1 – A. Preprocedure coronary angiogram showing the mid left anterior descending coronary stenosis, starting just beyond the origin of the septal branch, B. coronary angiogram showing stent position across the stenosis, C. fluoroscopy showing the stent post deployment and the wire bias toward the outer border, D. fluoroscopy showing shortened stent with deformed proximal end, E. fluoroscopy showing stent following final dilatation, F. final angiogram showing shortened stent with the proximal end well beyond the septal branch. Proximal and distal ends of the stent are marked with arrows.

Patient was taken up for percutaneous coronary angioplasty and stenting to LAD. The LAD was engaged with a 6F, JL 3.5 guiding catheter (Medtronic, Inc, Minneapolis, MN, USA). The lesion was crossed with 0.014" Hi-torque All Star guide-wire (Abbott Vascular, Santa Clara, CA, USA) and pre-dilated with 2.5 × 10 mm Sprinter balloon (Medtronic, Inc, Minneapolis, MN, USA). A 2.75 × 16 mm Promus Element stent (Boston Scientific, Natick, Massachusetts) was deployed at 12 atm across the lesion starting well proximal to the septal branch (post deployment stent length 15.7 mm) (Fig. 1B & C). As per our routine practice, the stent was post dilated with 2.75 mm Voyager NC balloon (Abbott Vascular, Santa Clara, CA, USA) up to 24 atm. As there was persistent 20% stenosis in the mid segment, it was decided to post dilate the stent with a 3 mm balloon. The balloon entered the stent without difficulty and post dilatation was done up to 20 atm. Post ballooning angiogram showed shortened stent, starting well beyond the septal branch, with deformation at the proximal end (Fig. 1D). As the shortened stent fully covered the lesion, the proximal end of the stent was dilated further with another 3 mm balloon to crush the longitudinally deformed segment (Fig. 1E and F). Patient had uneventful hospital stay and is doing well at 3 months follow-up.

3. Discussion

Current coronary stents are laser cut from metal tubes made of stainless steel, cobalt–chromium, or platinum–chromium.

The structure consists of series of rings (struts) and connectors. The rings are in the form of sinusoidal hoops which effectively scaffold the vessel wall to provide radial strength to the stent. The orientation of the stents may be in-phase or out-of-phase. The connectors attach the adjacent rings. The orientation of the connections may be peak-to-valley (in-phase), peak-to-peak (out-of-phase), and mid-shaft or offset peak-to-peak and the number varies between two and six. The thickness of the struts ranges between 81 and 140 μ. Number of connectors determines the stent flexibility and deliverability, side branch access and longitudinal integrity (Table 1).^{5,6}

Stents with less number of connectors may be prone to deformation when subjected to longitudinal compressive or elongating forces. This happens in following clinical scenarios during PCI: (1) crossing the deployed stent with non-compliant balloon for post dilatation, the most commonly reported cause for longitudinal compression, (2) guide catheter or its extensions coming in contact with the stent, either in case of stent in the ostial location or guide catheter deep seating, (3) IVUS catheter pull back for post stent deployment assessment, (4) withdrawal of the stent delivery system following stent deployment when the balloon gets stuck in the struts, (5) crossing the newly deployed stent with another stent for the treatment of a distal lesion, (6) wire entanglement.^{2,3,6} These result in either nesting of stent rings into or over each or elongation longitudinally. This phenomenon occurs commonly at the proximal end of the stent and is accentuated by stent malapposition and wire bias toward the outer border of the stent.³

Table 1 – Profile of commonly used drug eluting stents.

Stent	Manufacturer	Metal	Strut thickness (μ)	Connector design	Number of connectors
Cypher Select	Johnson & Johnson	Stainless steel	140	Mid-strut	6
Liberte	Boston Scientific	Stainless steel	100	Out-of-phase, peak-to-peak	3
Xience V	Abbott Vascular	Cobalt–chromium	81	In-phase, peak-to-valley	3
Xience Prime	Abbott Vascular	Cobalt–chromium	81	In-phase, peak-to-valley	3
Endeavor Sprint	Medtronic	Cobalt–chromium	91	Out-of-phase, peak-to-peak	2
Resolute Integrity	Medtronic	Cobalt–chromium	91	Out-of-phase, peak-to-peak	2
Promus/Taxus Element	Boston Scientific	Platinum–chromium	81	Offset peak-to-peak	2

This phenomenon was evaluated in two bench studies. Ormiston et al,⁶ subjected seven commonly used stent platforms for longitudinal compression and elongation forces. With 0.5 N compressive force, Driver (Medtronic, Santa Rosa, California) and Omega (bare-metal platform of Promus and Taxus Element [Boston Scientific, Natick, Massachusetts]) shortened the most. Vision and MultiLink (Abbott Vascular, Santa Clara, California) stents shortened little and Cypher Select (Cordis, Miami, Florida) did not shorten. Similarly, with elongation force of 0.5 N, the Cypher select did not elongate. The Liberte stent (Boston Scientific, Natick, Massachusetts) elongated by 2 mm, Vision and MultiLink-8 by 1 mm with minimal distortion, Driver by 5 mm with severe distortion and Omega by 5 mm with major disruption of architecture. In another study, Prabhu et al,⁷ had similar observations. From these studies, it was concluded that longitudinal integrity is the property of the number and orientation of the connectors, the stents with three or more connectors have good longitudinal strength and stents with two connectors and particularly when the connection is offset peak-to-peak (Omega stent) have poor resistance to longitudinal compression.

The true incidence of longitudinal compression might be little more than actually reported because we were neither aware of this complication nor tuned to recognize it. Longitudinal compression is better recognized with more radio-opaque stent platforms such as platinum–chromium than with stents which are more radiolucent.⁶

Longitudinal deformation may be associated with serious clinical consequences. It may also interfere with further device passage through the stent. The deformed stent with resulting malapposition might be a focus for stent thrombosis. With both stent compression and elongation, the vessel is no longer uniformly scaffolded which might compromise the drug delivery and predispose to restenosis.^{2,3,6,7} In a clinical study, Micro-Driver deformation was associated with 38% incidence of major adverse cardiac events.⁴ Stent deformation once recognized should be corrected by further balloon dilatation to overcome luminal obstruction and apposition of the stent to the vessel wall. In case of geographic miss, a further stent should be deployed.^{5,7}

In our case, passage of post dilatation balloon in the presence of wire bias toward the outer border might have predisposed to longitudinal compression. As the deformed stent fully covered the lesion, only balloon dilatation was done to appose the struts.

4. Conclusion

Longitudinal deformation may occur with newer stents with less longitudinal integrity. It is clinician's responsibility to be aware of this complication and employ due care during device manipulation. It is also important to timely recognize this complication and treat it appropriately to avoid serious clinical consequences.

Disclosures

None.

Conflicts of interest

All authors have none to declare.

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