Case Reports

Triple-Guidewire Technique for Treating Stent Underexpansion

in Severely Calcified Coronary Artery Lesions

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Stent underexpansion, a potential complication of percutaneous coronary intervention in severely calcified and stenotic coronary arteries, may result in in-stent thrombosis and restenosis. Different balloon-based and atheroablative techniques have been proposed to reduce the risk of these complications. We describe a simple triple-guidewire technique that we used to treat stent underexpansion in 2 elderly men. ***(Tex Heart Inst J 2020;47(2):155-9)***

Full expansion of stents during percutaneous coronary intervention (PCI) in severely calcified and stenotic coronary arteries can be challenging. Underexpansion can lead to poor procedural outcomes and increase the risk of major adverse cardiac events, in-stent thrombosis and restenosis, and target lesion revascularization.[1,2] Consequently, various strategies and technologies, some more advanced and complex than others, have been developed to prepare target coronary artery lesions for successful implantation and full expansion of stents during PCI. These include use of noncompliant, semicompliant, and cutting balloons; excimer lasers; and atherectomy devices. We describe a simple triple-guidewire technique that we used to treat stent underexpansion in 2 elderly men undergoing PCI.

Case Reports

Patient 1

A 69-year-old man presented with new-onset New York Heart Association (NYHA) class III functional status and shortness of breath of 3 weeks' duration. His medical history included coronary artery disease, type 2 diabetes, hypertension, hyperlipidemia, smoking, and myocardial infarction treated by PCI in the left circumflex coronary artery (LCx) 10 years previously and the right coronary artery (RCA) 12 years previously. Physical examination revealed normal vital signs, jugular venous distention, and rales at the base of the lungs. Laboratory evaluations revealed an elevated brain natriuretic peptide level of 1,277 pg/mL (normal, ≤450 pg/mL) and a normal troponin I level. An electrocardiogram (ECG) revealed sinus rhythm, an old inferior myocardial infarction, and new anterior ST-segment depressions when compared with a baseline ECG. A chest radiograph showed interstitial pulmonary edema. An echocardiogram revealed a left ventricular ejection fraction (LVEF) of 0.35 to 0.40. Because the newly decreased LVEF was accompanied by acute decompensated heart failure, coronary angiography was performed after diuresis. The resulting coronary angiogram showed 30% stenosis in the distal left main coronary artery, 90% in the mid-to-distal left anterior descending coronary artery (LAD) (Fig. 1A), 70% in the ostial first diagonal branch, 30% in the proximal LCx, and 70% in the distal LCx, and a patent stent in the RCA.

Technique. A 6F extra backup 3.5 guide catheter (Medtronic) was inserted through the right radial artery and advanced to engage the left main coronary artery. A Runthrough® NS guidewire (Terumo) was used to cross the mid-to-distal LAD lesion. A 2 × 12-mm Trek compliant balloon (Abbott Vascular) was advanced to the mid-to-distal LAD lesion and inflated at a pressure of 18 atm for 10 s to full expansion. Then, a 3.25 × 15-mm Xience Alpine® stent (Abbott Vascular) was guided across the stenotic lesion, with assistance from a 6F GuideLiner® catheter (Vascular Solutions,

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Inc.). The in-stent balloon was inflated at a pressure of 24 atm for 15 s but did not fully expand, as indicated by the appearance of a waist at the middle of the balloon on a coronary angiogram.

A second, unsuccessful attempt was made to fully expand the stent by inserting a 3.5-mm noncompliant balloon and inflating it at a pressure of 24 atm for 10 s (Fig. 1B). A 3.5 × 10-mm Flextome cutting balloon (Boston Scientific Corporation) was then maneuvered to the stent but could not be moved inside, despite aggressive support with the guidewire and 6F GuideLiner catheter. Consequently, the 6F GuideLiner catheter was retracted and exchanged for 2 Balance Middleweight (BMW) guidewires (Abbott Vascular), which were then maneuvered across the underexpanded stent. Next, a new 3.5 × 12-mm NC Trek noncompliant balloon (Abbott Vascular) was placed on the Runthrough NS guidewire and advanced over the 2 BMW guidewires across the stent (Fig. 1C). The noncompliant balloon was then inflated at a pressure of 24 atm for 7 s, fully expanding the stent with a good final angiographic result (Fig. 1D). At the patient's 3-month follow-up visit, he was doing well and had an LVEF of 0.40 to 0.45.

Patient 2

An 80-year-old man presented with substernal angina and associated shortness of breath of one month's duration. His medical history included hypertension, hyper-

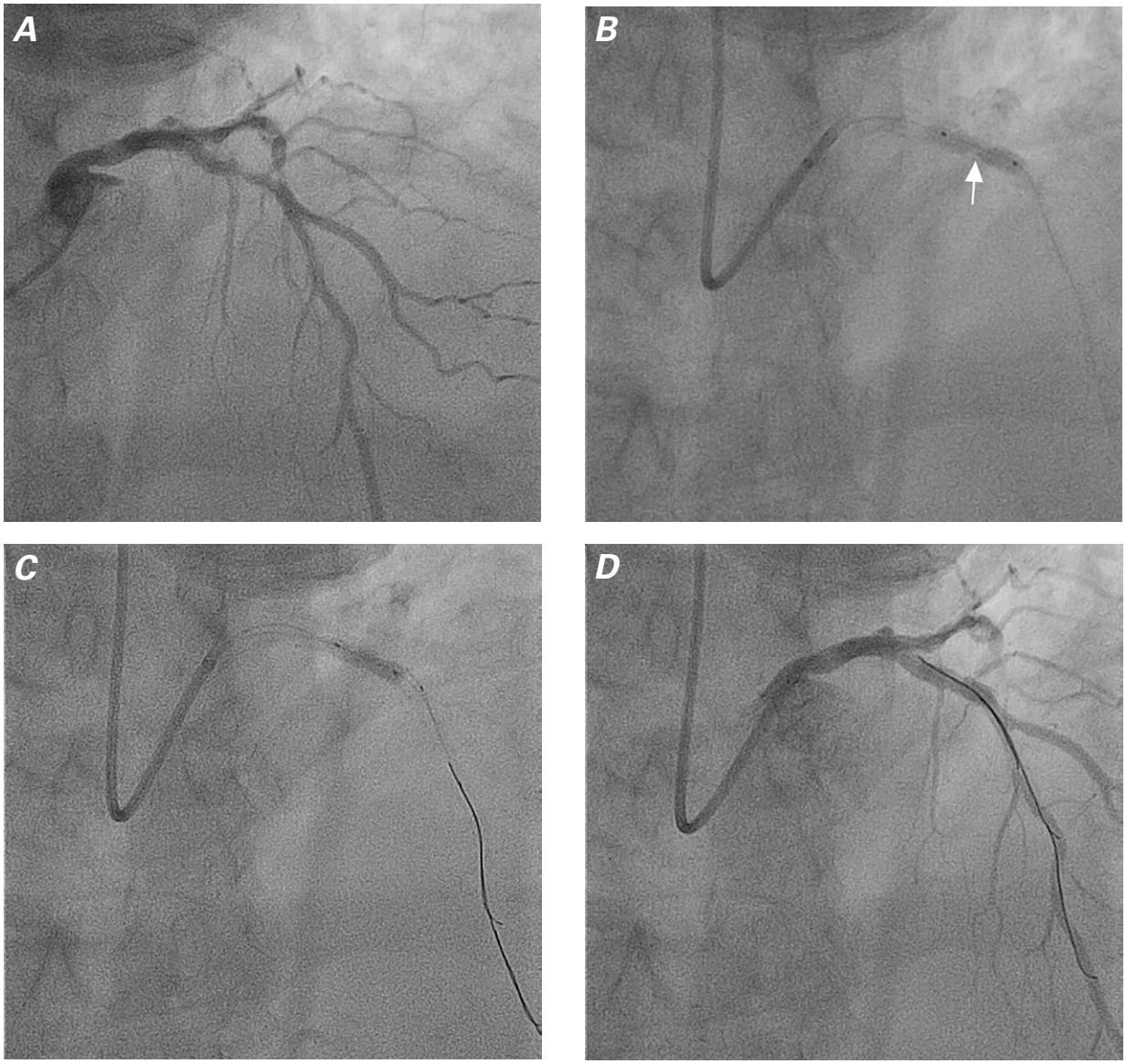

Fig. 1 *Patient 1. Coronary angiograms (right anterior oblique cranial views) show **A**) a calcified lesion with 90% concentric stenosis in the mid-to-distal left anterior descending coronary artery (LAD), **B**) the waist of an underexpanded stent (arrow) after an unsuccessful attempt to fully expand it by inflating a noncompliant balloon, **C**) the 3 guidewires positioned in the LAD, and **D**) the stent fully expanded after inflation of a noncompliant balloon with a good final result.*

lipidemia, and type 2 diabetes. An ECG revealed new ST-segment depressions of 1 mm in leads V_5 and V_6 and T-wave inversions in leads I and aVL when compared with a previous normal ECG. A transthoracic echocardiogram showed an LVEF of 0.65 to 0.70 and no regional wall-motion abnormalities. A coronary angiogram revealed 90% stenosis of the proximal-to-mid LCx, 80% of the distal LCx, 90% (calcified) of the proximal RCA, and 70% (calcified) of the mid-to-distal RCA. The patient underwent successful complex angioplasty of the LCx and placement of 2 drug-eluting stents (Synergy™, Boston Scientific) in the proximal-to-mid LCx. The patient was then scheduled for staged PCI in the RCA in one month.

Technique. A 6F Amplatz left 0.75 guide catheter was inserted through the right radial artery and advanced to engage the RCA. A Runthrough NS guidewire was used to cross the RCA lesion. A 2 × 20-mm NC Trek noncompliant balloon was advanced first to the mid RCA and inflated at a pressure of 18 atm for 10 s, then pulled back to the proximal RCA and inflated at a pressure of 20 atm for 10 s. A 3 × 38-mm Resolute Onyx™ stent (Medtronic) was guided across the mid-to-distal RCA, with assistance from a 6F GuideLiner catheter. The in-stent balloon was inflated at a pressure of 18 atm for 7 s, fully expanding the stent. Then, a 3 × 30-mm Resolute Onyx stent was guided across the proximal RCA, with assistance from a 6F GuideLiner catheter. In this case, the in-stent balloon was inflated at a pressure of 20 atm for 12 s but did not fully expand the stent, as revealed on the angiogram.

A second, unsuccessful attempt was made to fully expand the stent by reinflating the balloon at a pressure of 26 atm for 10 s. The in-stent balloon was then retracted and exchanged for a new 4 × 15-mm NC Trek noncompliant balloon. The noncompliant balloon was advanced over the Runthrough NS guidewire across the proximal RCA stent and inflated at pressures of 16 atm and 14 atm for 10 s each, with no improvement in the angiographic appearance of the waist (Fig. 2A–B). Consequently, the 6F GuideLiner catheter and NC Trek balloon were retracted and exchanged for 2 BMW guidewires. Then, the same NC Trek balloon was placed on the Runthrough NS guidewire, advanced over the 2 BMW guidewires across the underexpanded proximal RCA stent, and inflated at a pressure of 26 atm for 10 s (Fig. 2C). The stent was fully expanded with a good final angiographic result (Fig. 2D). At the 3-month follow-up visit, the patient reported having had no further episodes of angina or shortness of breath.

Discussion

Stenting and completely dilating a complex calcified coronary artery lesion can be challenging and may result in stent underexpansion.[3,4] Two major complications of stent underexpansion are acute or subacute stent thrombosis and in-stent restenosis. Thrombosis in underexpanded stents can be more severe and diffuse than in-stent restenosis and usually involves the stent's proximal part.[4] In a large retrospective study of post-PCI intravascular ultrasound (IVUS) findings in 7,484 patients, Cheneau and colleagues[5] identified 23 stented lesions in which subacute thrombosis occurred; stents were underexpanded in 18 (78%). In a smaller study of IVUS findings from 50 patients, Taherioun and colleagues[6] noted suboptimal stent deployment in 11 patients (22%), even after adjunctive postdilatation with a noncompliant balloon; stent underexpansion was noted in 7 of those 11 patients. In addition, narrower stents (≤2.75 mm in diameter before deployment) were more likely to be underexpanded. Other studies of drug-eluting stent thrombosis have produced similar findings.[7-9]

Various strategies and technologies have been developed to address the poor procedural outcomes and major adverse cardiac events related to stent underexpansion in complex coronary artery lesions. These include the use of noncompliant balloons; semicompliant, nitinol-reinforced balloons; cutting balloons; excimer lasers; and atherectomy devices.

Raja and colleagues[10] used a high-pressure, twin-layer noncompliant balloon catheter (OPN NC®, SIS Medical) to treat 4 cases of heavily calcified lesions prone to stent underexpansion. Use of this balloon counteracted stent "dog-boning." In another study, Diaz and associates[11] used noncompliant balloons to fully deploy underexpanded stents in 5 patients. In a nonrandomized observational study in patients undergoing elective PCI with first-generation drug-eluting stents,[12] stents that were predilated with a semicompliant, nitinol-reinforced AngioSculpt® scoring balloon (Philips) expanded more fully than did stents that were predilated with a traditional semicompliant balloon or not at all. Balan and colleagues[13] used a 3.5-mm cutting balloon inflated to a pressure of 8 atm to expand an underexpanded stent 4 months after it had been deployed through the struts of a previously placed stent in the LCx ostium.

In a prospective, multicenter, observational pilot study based on the ELLEMENT (Excimer Laser Lesion Modification to Expand Non-dilatable Stents) Registry,[14] high-energy excimer laser coronary angioplasty (ELCA) was successfully used to prepare balloon-resistant lesions for expansion of underexpanded stents in 27 of 28 patients (96.4%). Noble and Bilodeau[15] reported use of a high-energy excimer laser to successfully prepare a calcified, balloon-refractory coronary plaque for full expansion after a previously implanted underexpanded stent had in-stent restenosis. Lam and colleagues[16] successfully used a 0.9-mm ELCA catheter (Spectranetics) to fully expand a stent refractory to multiple balloon dilatations.

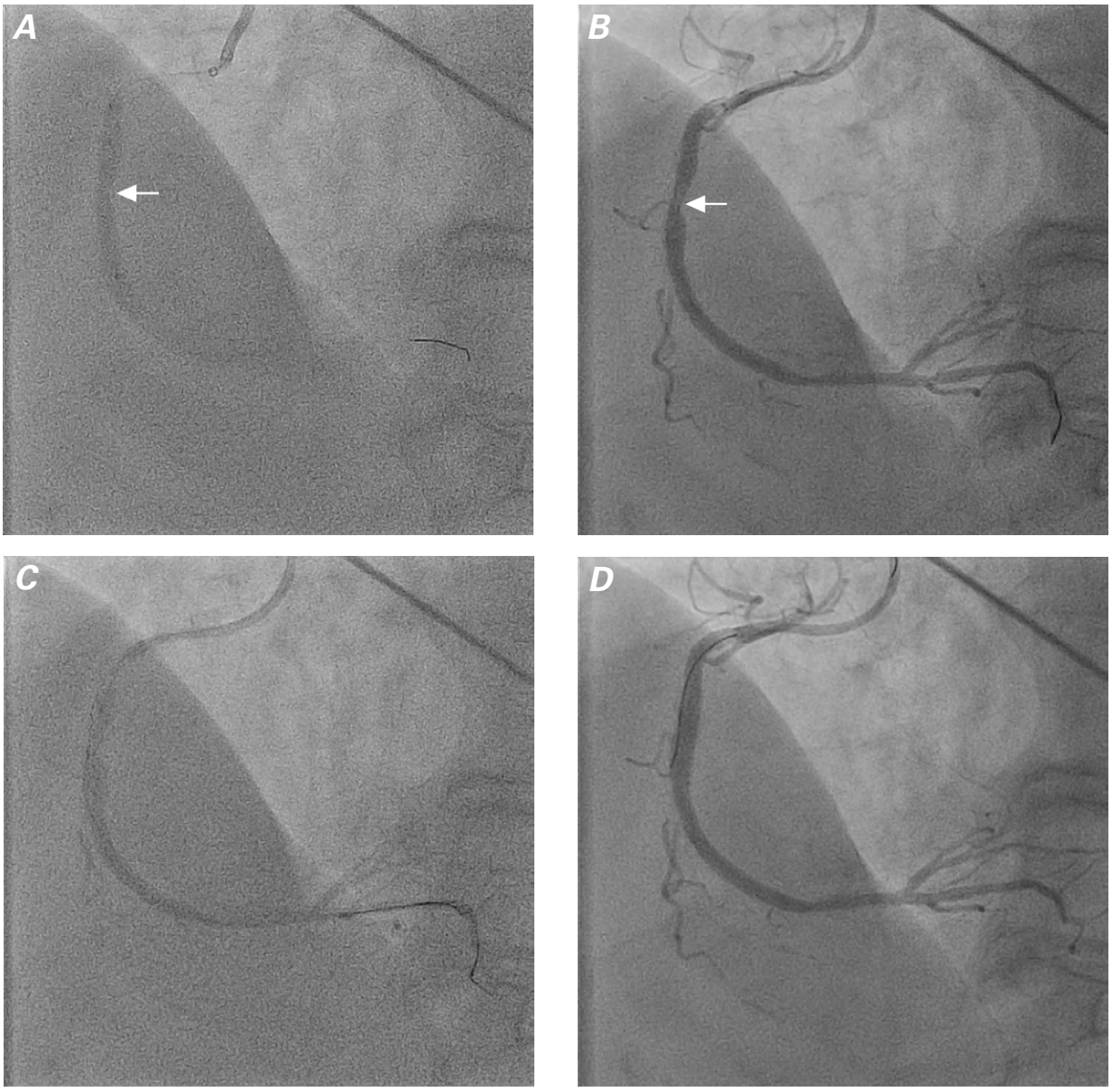

Fig. 2 *Patient 2. Coronary angiograms (left anterior oblique cranial views) show* ***A****) the waist on a noncompliant balloon (arrow) after inflation inside an underexpanded stent in the proximal right coronary artery (RCA),* ***B****) a persistent waist on the underexpanded stent (arrow) after a second attempt at inflation with a noncompliant balloon,* ***C****) the 3 guidewires positioned in the RCA, and* ***D****) the stent fully expanded after inflation of a noncompliant balloon with a good final result.*

Atheroablative alternatives include rotational and orbital atherectomy. In a small retrospective series of 16 patients,[17] rotational atherectomy with a Rotablator™ (Boston Scientific Corporation) was safely used to expand balloon-undilatable underexpanded stents, resulting in satisfactory clinical outcomes at 1 year. Orbital atherectomy with the Diamondback 360® (Cardiovascular Systems, Inc.) is approved for treating de novo, severely calcific stenosis in coronary arteries before stent deployment.[18]

Our alternative technique is relatively simple. In our 2 patients, we fully opened an underexpanded stent with the use of 3 guidewires and a noncompliant balloon. This followed unsuccessful attempts with a noncompliant balloon catheter and cutting balloon in Patient 1 and a noncompliant balloon in Patient 2. Three factors may have influenced the success of our technique. First, the 3 guidewires may distribute force more evenly across a stenotic lesion during balloon inflation. Second, during inflation, the stiff shafts of the 2 guidewires outside the balloon may help distribute longitudinal force along the stent struts more effectively than simple focal balloon expansion can. Third, the 3 guidewires and balloon may more easily cross an underexpanded stent because, together, they are less bulky than other devices, such as a cutting balloon or nitinol-reinforced balloon.

Conclusion

Our simple yet novel triple-guidewire technique effectively treated underexpanded stents in 2 patients who had severely calcified and stenotic coronary arteries, and it may reduce the risk of stent thrombosis and in-stent restenosis in such cases. Further studies in a larger series of patients are warranted.

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