HOSPITAL CHRONICLES 2012, 7(2): 113–117

CASE REPORT

Percutaneous Coronary Intervention for Intra-stent Chronic Total Occlusion Assisted by Stent Visualization Enhancement Technology

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KEY WORDS: *coronary artery disease; percutaneous coronary interventions; coronary angioplasty; coronary stenting; drug eluting stent; bare metal stent; stent visualization enhancement*

ABBREVIATIONS
CTO = chronic total occlusion
DES = drug eluting stent
FFR = fractional flow reserve
LAD = left anterior descending (coronary artery)
LCx = left circumflex (coronary artery)
PCI = percutaneous coronary intervention
RCA = right coronary artery

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Manuscript received March 13, 2012; Accepted after revision March 28, 2012

ABSTRACT

A 50-year-old female patient with a history of prior acute inferior myocardial infarction successfully treated 2 years earlier by primary percutaneous coronary intervention (PCI) with thrombus aspiration and implantation of a 3x30 mm bare-metal stent in the proximal right coronary artery (RCA) was submitted to coronary angiography after reappearance of effort angina. An initial coronary angiogram showed a chronic total occlusion (CTO) intra-stent with Rentrop III collateral filling of the RCA originating from distal left anterior descending (LAD). A mid LAD 60% stenosis and a 60% mid circumflex stenosis were considered non-significant since fractional flow reserve (FFR) was measured at 0.84 and 0.90 respectively. After demonstrating inferior wall viability by cardiac magnetic resonance imaging (MRI), a PCI was programmed two months after the initial coronary angiogram. The intra-stent CTO was ≥ 30 mm long, with no blunt stump and at least 2 small branches originating at its proximal cap level. Mid and distal RCA antegrade filling existed due to bridging collaterals. The crossing technique by guidewire exchange and use of a microcatheter is described. After balloon predilatation the RCA was recanalized. The use of a stent visualization enhancement technology (StentViz) helped understand the most probable procedure-related restenosis mechanisms (stent undersizing and underexpansion) and guided the subsequent successful implantation of two drug-eluting stents. The use of this technology is described step by step for this intervention.

INTRODUCTION

Innovations in medical imaging technology are particularly important in interventional cardiology. Assessment of an implanted stent during percutaneous coronary interventions (PCI) is crucial to minimize the risk of adverse events such as thrombosis and restenosis due to technical inadequacies. Conventional fluoroscopic imaging is simple but has inherent limitations. Intravascular ultrasound or optical coherence tomography require further intervention with use of additional and expensive tools and equipment with extra effort and risk. Stent visualization enhancement technology is available in some latest angiography suites, with more characteristic examples the

Conflict of Interest: none declared

StentViz and the StentBoost protocols. A cine run of 3 seconds at 15 fps is acquired with the balloon and stent markers in place. With the press of a button the software automatically detects both the guidewire and the stent markers. Its simplicity offers the possibility of immediate and routine control of stent deployment. We herein describe the use of this novel noninvasive technology in a patient undergoing PCI for a chronic total occlusion (CTO) of the right coronary artery (RCA).

CASE REPORT

A 50-year-old woman having as risk factors active smoking and dyslipidemia was admitted because of reappearance of effort angina. She had a history of acute inferior myocardial infarction 2 years earlier successfully treated by primary PCI with thrombus aspiration and implantation of a 3x30 mm bare-metal stent in the proximal RCA. An initial coronary angiography showed a mid- left anterior descending artery (LAD) 60% stenosis and a 60% mid- circumflex (Cx) stenosis which were both considered non-significant since fractional flow reserve (FFR) was measured 0.84 and 0.90 respectively. The proximal RCA had a CTO intra-stent with Rentrop III retrograde filling via collaterals until its middle segment originating from the distal LAD. The intra-stent occlusion was ≥ 30 mm long, without blunt stump and at least 2 small branches originating at its proximal cap level (Fig. 1 A). Distal RCA antegrade filling was present due to bridging collaterals (Fig. 1 B).

After a cardiac magnetic resonance imaging study that demonstrated presence of viability in the inferior wall, a PCI attempt to recanalize the RCA was programmed two months after the initial angiogram. The femoral approach was chosen to optimize support and the RCA ostium was cannulated with a 6 French Judkins right-4 guiding catheter. Due to the presence of antegrade mid and distal RCA filling, despite the presence of bridging collaterals, the possibility of microchannel presence in the occlusion led to the choice of a Fielder XT (Asahi Intec, Abbot Vascular) as initial guidewire. After failure to cross, the Fielder XT and a BMW (Abbot Vascular) guidewires were positioned into the two branches originating at the proximal cap level in order to help direct a PILOT 50 (Abbot Vascular) guidewire into the occlusion instead of into those branches. The PILOT 50 crossed the proximal cap but could not be advanced more than 20 mm into the occlusion (Fig. 2 A). After exchanging the PILOT 50 with a CROSS-IT 200 (Abbot Vascular) over a Finecross microcatheter (Terumo Cardiovascular Systems Corp.), the distal cap was crossed but there was evidence of subintimal position of the guidewire in the mid RCA (Fig. 2 B). With the support of the Finecross, the CROSS-IT 200 was exchanged with a BMW which could find the true lumen and was advanced into the distal RCA (Fig. 2 C). After wire crossing simple "dottering" with a 2x20 mm balloon restored RCA antegrade flow and there was evidence of a tight lesion immediately distally to the distal stent edge (Fig. 2 D).

After intra-stent predilatation with the 2x20 mm balloon and intra-coronary nitrates, flow was further improved and the mid and distal RCA diameter was estimated to be 3.5 mm while the initially implanted stent was a 3x30 mm bare-metal stent (Fig. 3 A). An initial image with StentViz further showed

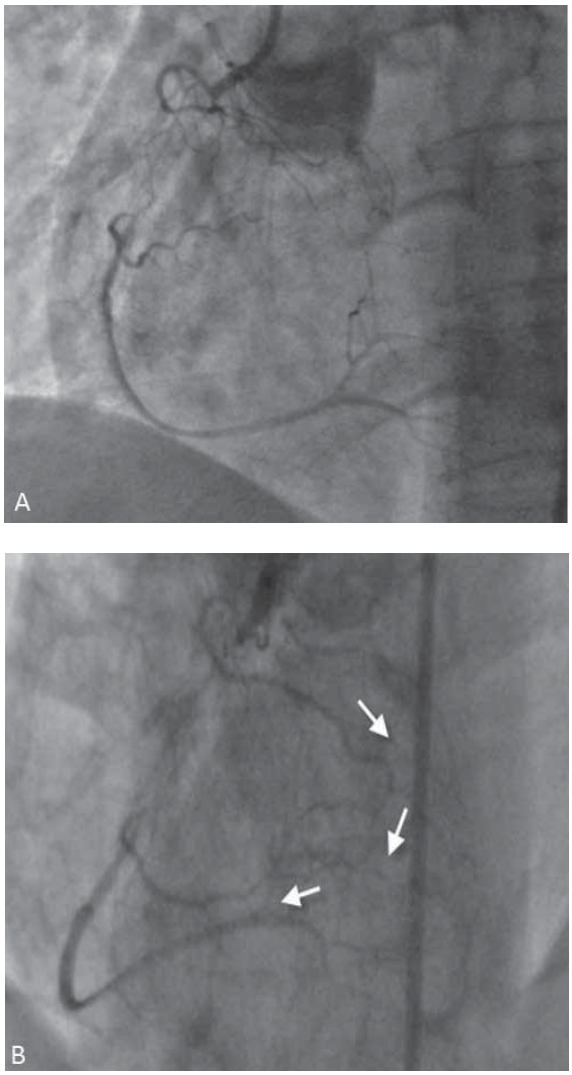

FIGURE 1. A. Left anterior oblique (LAO) view showing a chronic intra-stent occlusion of the proximal RCA. The occlusion is at least as long as the implanted bare-metal stent (30 mm), there is no blunt stump and at least two side branches originate at the proximal cap level. B. Cranial view: slow antegrade flow in the middle and distal RCA by bridging collaterals. A small marginal branch at proximal RCA provides flow to the distal part of a similar marginal branch originating from the middle RCA as shown by the arrows. RCA = right coronary artery

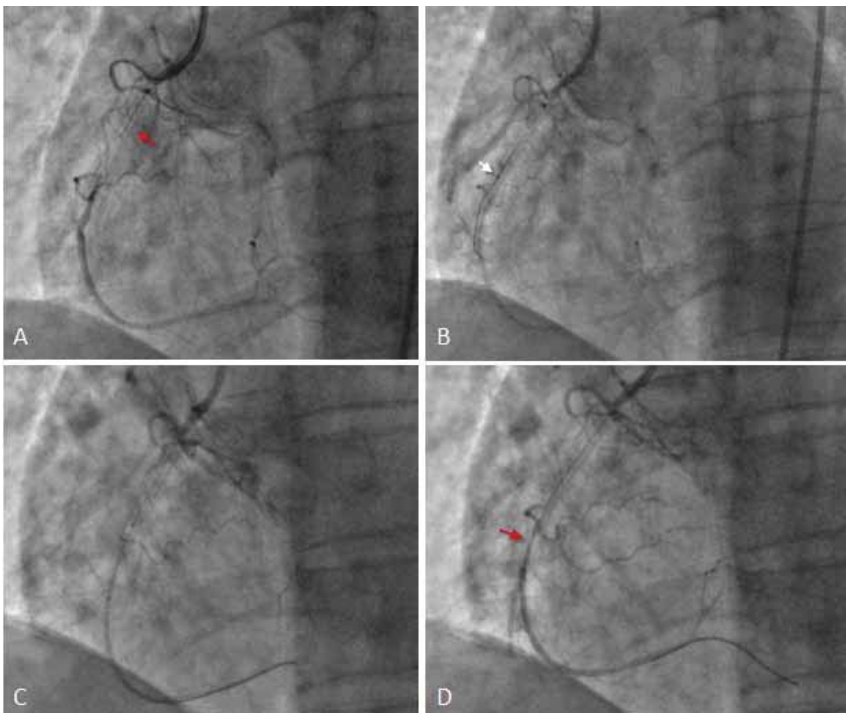

FIGURE 2. A. After failure to cross, a Fielder XT and a BMW guidewires are positioned in two small side branches originating at the CTO proximal cap level. A PILOT 50 crosses and can be advanced midway into the occlusion (red arrow). B. The PILOT 50 can not be further advanced and with the aid of a Finecross microcatheter (white arrow) it is exchanged with a CROSS-IT 200 which crosses the distal cap but is advanced subintimally. C. With the support of the Finecross, the CROSS-IT 200 is exchanged with a BMW wire which finds the true lumen and is advanced into the distal RCA. D. After wire crossing and balloon "dottering" there is flow restoration and evidence of a tight lesion just after the distal stent edge (red arrow). CTO = chronic total occlusion

that the mid part of the stent had a waist area where it was probably underexpanded (Fig. 3 B). Therefore undersizing and underexpansion were two obvious procedure related factors contributing to the diffuse occlusive restenosis process in this case. Subsequent intra-stent pre-dilatation with a 3x15 mm non-compliant balloon at high pressure further ameliorated flow, the tight lesion just distal to the distal stent edge was better depicted and the proximal to mid RCA length to be

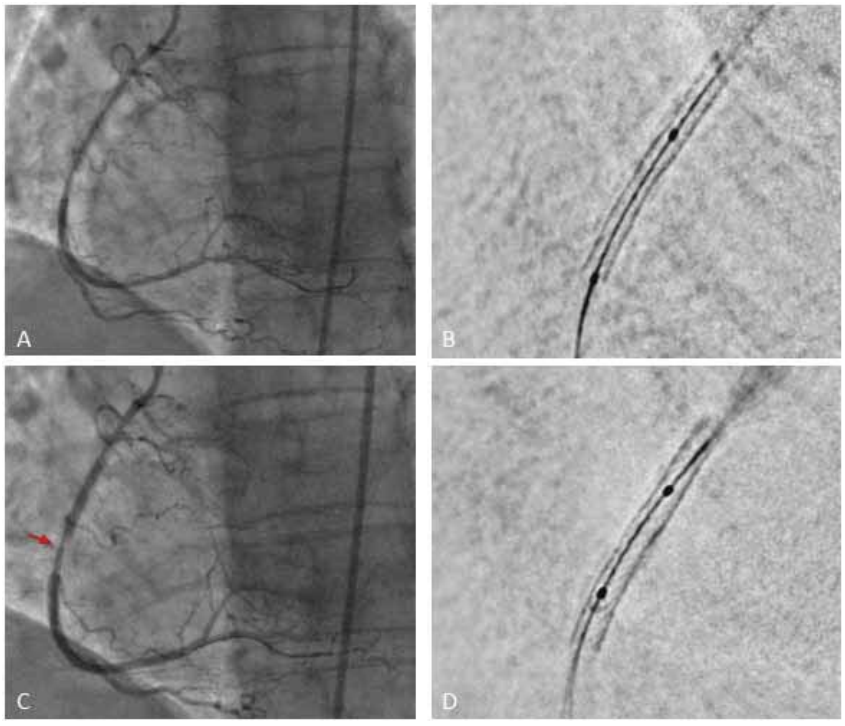

FIGURE 3. A. Angiographic image after intra-stent pre-dilatation with a 2x20 mm balloon. The RCA reference diameter seems to be 3.5 mm, while the implanted stent was a 3x30 mm BMS. B. StentViz after pre-dilatation with the 2x20 mm balloon: the stent has a waist at its mid part (underexpansion area). C. Angiographic image after further intra-stent pre-dilatation with a 3x15 mm non-compliant balloon at high pressure. The red arrow shows the tight lesion just distal to the distal stent edge. The artery seems definitely to have a reference diameter of 3.5 mm, so the initial stent was undersized. D. StentViz after pre-dilatation with the 3x15 mm non-compliant balloon: the waist at the stent mid-part has disappeared and there is a diameter gain compared to B. RCA = right coronary artery

stented with drug-eluting stents (DES) was estimated to be about 50 mm (Fig. 3 C). StentViz imaging after predilatation with the 3x15 mm balloon showed that the waist at the stent mid-part had disappeared and that there was a diameter gain at this zone (Fig. 3 D).

Since using a DES of 3.5 mm diameter seemed appropriate, there was further predilatation with a 3.5x15 mm non compliant balloon, at high-pressure intra-stent and at nominal pressure on the tight lesion after the distal stent edge, with further improvement of the angiographic result (Fig. 4 A). A TAXUS Element (Boston Scientific) 3.5x38 mm DES was subsequently implanted to completely cover the old stent and the proximal part of the mid RCA lesion (Fig. 4 B). StentViz after the long DES implantation depicted the proximal and the distal edges of the two-layer stent area which was more opaque (Fig. 4 C). The long DES was not sufficient to cover the post-stent mid RCA lesion and a TAXUS 3.5x12 mm overlapping stent was also implanted under StentViz control to ensure accurate positioning with a minimal 1-2 mm overlapping zone, while avoiding the inadvertent implantation too proximally which would create an undesired three-layer stent zone. StentViz after the second DES implantation showed that the second DES was implanted as intended (Fig. 4 D). Final post-dilatations intra-stent for the whole stented area followed with the 3.5x15 mm non-compliant balloon at high pressures (up to 24 Atm). StentViz was used before and after each post-dilatation in order to ensure adequate stent expansion at all levels (Fig. 5 A, B and C). The final angiographic result was optimal (Fig. 5 D).

DISCUSSION

Breakthroughs in medical imaging technology are especially important in interventional cardiology since they increase diagnostic confidence as well as intervention planning and performance. Post-implantation stent assessment during angioplasty procedures is crucial to minimize the risk of future events such as restenosis and thrombosis. However, conventional fluoroscopic imaging has limitations and is inadequate for this purpose. Stent visualization enhancement technology is available in some latest angiography suites, with more characteristic examples the StentViz (GE Healthcare) and the StentBoost (Philips) protocols. A cine run of 3 seconds at 15 fps is acquired with the balloon and stent markers in place. With the press of a button the software automatically detects both the guidewire and the stent markers and performs an elastic registration that allows the system to compensate for non-rigid stent deformation. Its simplicity offers the possibility of immediate and routine control of stent deployment.

In the present case StentViz was initially useful in order

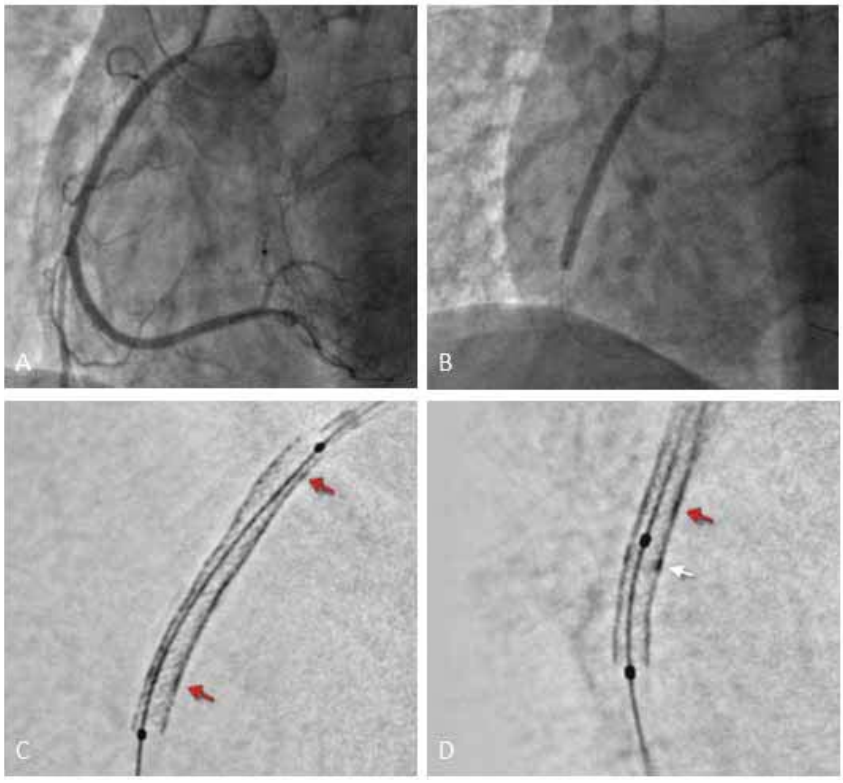

FIGURE 4. A. Angiographic image after intra-stent and post-stent lesion further pre-dilatation with a 3.5x15 mm non-compliant balloon. B. A TAXUS Element 3.5x38 mm DES is implanted to cover the old BMS. C. Stent Viz after B. The red arrows show the proximal and the distal edges of the two-layer stent area which is more opaque. D. The long DES was not sufficient to entirely cover the post-stent mid RCA lesion and a TAXUS 3.5x12 mm stent was also implanted under StentViz control to ensure accurate positioning and a minimal 1-2 mm overlapping zone. After the second stent implantation Stent Viz shows here the two TAXUS stents small overlapping zone (white arrow) and the distal end of the proximal two-layer stent area (red arrow). BMS = bare metal stent; DES = drug-eluting stent

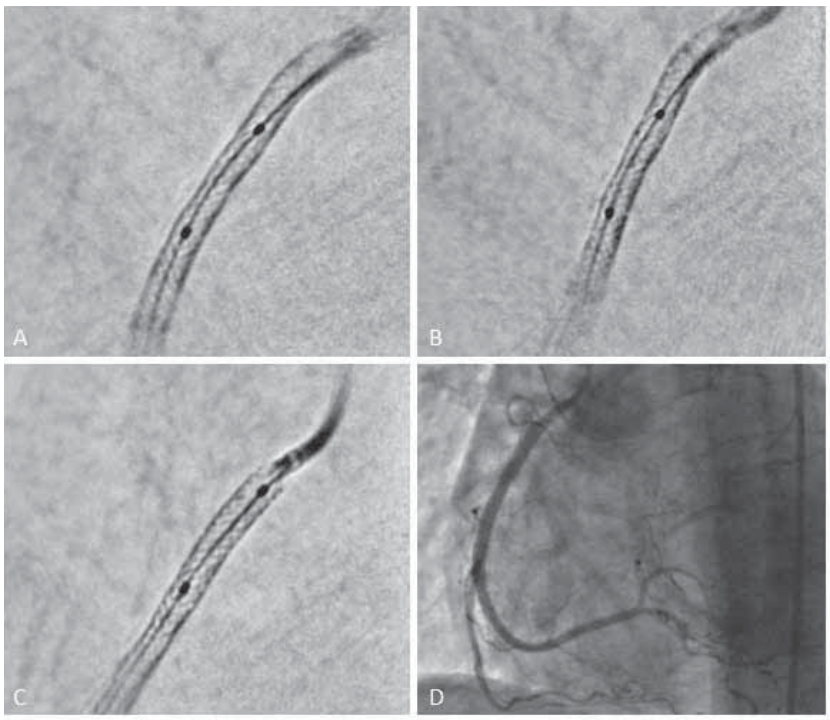

FIGURE 5. A. Stent Viz before and B. After intra-stent post-dilatation with the 3.5x15 mm non-compliant balloon at high pressure. C. Proximal stented zone after post-dilatation at high-pressure. D. Final angiographic result.

to assess the old stent after wire and balloon crossing. Stent undersizing and underexpansion were present, which are both known as procedural factors linked to restenosis.[1, 2] Subsequently it was used to ensure sufficient predilatation prior to the first long DES deployment and to accurately implant it in order to entirely cover the old stent. Furthermore, it was used to accurately position and implant the second DES in order to achieve a minimal overlap zone of the two DES, since DES overlapping is related to delayed arterial healing, inflammation persistence and potential late DES thrombosis.[3, 4] Finally, it was used to control intra-stent high pressure post-dilatation in order to ensure optimal stent expansion.

In conclusion, novel stent visualization enhancement technology is a practical tool that when available it permits routine post-implantation accurate stent assessment, which can be especially useful in complex PCI cases involving multiple stents.

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