Laser Atherectomy for Balloon Failure in Chronic Total Occlusion

When the Going Gets Tough

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SUMMARY

Excimer laser coronary atherectomy (ELCA) is based on ultraviolet energy and is capable of disintegrating atheroma, without burning or grossly fragmenting it. ELCA has proven effective in the percutaneous treatment of a variety of complex lesions, including chronic total occlusions (CTO) and severely calcified lesions, in case of balloon failure-to-cross or failure-to-expand. Here we present a case of a successful CTO recanalization with ELCA after balloon failure, review the literature on this topic, and present an algorithm outlining the management of this challenging clinical scenario. (Int Heart J 2014; 55: 546-549)

Key words: Laser-assisted angioplasty, Coronary occlusion, Percutaneous coronary intervention

Excimer laser coronary atherectomy (ELCA) has been proven to be effective for the percutaneous treatment of a variety of complex lesions, including chronic total occlusions (CTO) and severely calcified lesions when conventional ballooning techniques have failed, stent restenosis, saphenous vein graft debulking, and thrombus vaporization in acute coronary syndromes.¹⁾

ELCA has been shown to be both safe and effective for plaque modification in severely calcified plaques and CTO, in which balloons have failed to cross or expand the lesion.^{2,3)}

However, when tested against balloon angioplasty, stenting and rotational atherectomy (RA), ELCA failed to show superiority for efficacy and safety.^{4,5)} Subsequently, especially after the introduction of drug-eluting stents (DES), use of ELCA has become quite limited. Nevertheless, in well-defined clinical settings ELCA still represents a valid – and sometimes the only – alternative. Here, we present the case of a successful CTO recanalization with ELCA, after failure to cross with multiple coronary devices.

CASE REPORT

A 34-year-old man presented to a referring hospital's emergency room with multiple episodes of prolonged chest pain at rest. His prior medical history included heterozygosis for Factor V Leiden mutation with documented pulmonary embolism 4 years earlier. He also had an important family history of premature coronary artery disease (CAD). After screening tests ruled out pulmonary embolism and despite a lack of dynamic EKG changes, a diagnosis of non-ST elevation myocardial infarction motivated the decision to refer the patient for cardiac catheterization. Prior to transfer to our institution, aspi-

rin and clopidogrel were preloaded. Coronary angiography showed left dominance and two-vessel disease (Figure 1): a thrombotic, 85%, type B2, bifurcation lesion in the proximal circumflex (Medina 1, 0, 1), followed by a 60%, diffuse, type C lesion in the mid circumflex; and a CTO of the mid left anterior descending (LAD) artery, which received Werner collateral connections grade 2 from the right coronary artery (RCA) and circumflex artery, through septal and epicardial vessels. Thrombectomy in the circumflex was performed. Balloon dilatation was followed by the implantation of two IntegrityTM (Medtronic Inc., Minneapolis, MN) bare-metal stents (a 3.0 × 30 mm stent in the mid circumflex overlapped with a 3.0 × 12 mm stent between the proximal and mid circumflex), with kissing balloon and optimal final result. The remainder of his hospital stay was unremarkable and the patient was discharged with aspirin, prasugrel, bisoprolol, ramipril, and atorvastatin.

At follow-up a MIBI scan showed signs of ischemia in the anterior wall with moderate left ventricular dysfunction (ejection fraction of 45%). Subsequently, the decision was made to refer the patient for recanalization of the LAD CTO (Figure 2). The approach to CTO PCI at our institution follows the algorithm proposed by Brilakis, *et al.*⁶⁾ Dual vascular access was performed (right femoral and right radial arteries) to perform PCI assisted by contralateral coronary injections. The rationale to initially proceed in an antegrade fashion was that the occluded segment was short and the "landing zone" did not have major side branches, was large and adequately visualized by contralateral injection. Furthermore, as the Japanese Multi-center CTO Registry of (J-CTO) score⁷⁾ was 0/4, it was felt that wire passage would not have been excessively challenging. A 6 French XB 3.5 guide catheter was used to engage the left main, offering good support. A Fielder XTTM guidewire crossed the lesion in 20 minutes. However, subsequent at-

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Figure 1. Baseline angiography. **A** shows a thrombotic, 85%, type B2, bifurcational lesion in the proximal circumflex (Medina 1,0,1), followed by a 60%, diffuse, type C lesion in the mid circumflex. **B** displays a chronic total occlusion of the left anterior descending (LAD) artery, immediately distal to the origin of the first diagonal. **C** shows a right coronary artery (RCA) without significant lesions. **D**, **E** and **F** display Werner collateral circulation type 2 to the LAD. In **D**, septal (black arrow) and epicardial (white arrow) collaterals from the RCA are observed. The distal bed of the LAD appears to have a good diameter (**E**). Also the circumflex provides the LAD with collateral circulation (asterisk in **F**).

Figure 2. Percutaneous coronary intervention on the left anterior descending (LAD) chronic total occlusion (CTO). After contralateral injection (**A**), the occluded segment in the LAD appears to be short (< 20 mm). The stump is tapered, there are no signs of calcification or bending > 45°: this confers the procedure a Multicenter CTO Registry of Japan (J-CTO) score⁷⁾ of 0/4 (easy: guidewire crossing within 30 minutes). Indeed, the lesion was crossed in 20 minutes. However, different balloons could not be advanced throughout the entire length of the lesion, and balloon dilatation failed (**B**). Laser atherectomy (**C**) was then attempted and succeeded in achieving plaque modification (**D**). After predilatation, two drug-eluting stents were delivered in the mid LAD (**E** shows the implantation of the proximal stent) and postdilated. Final result was optimal (**F**).

Figure 3. Management of balloon failure-to-cross and failure-to-expand lesions at our institution. Generally, no more than 5 to 10 minutes should be spent in a stagnant mode without technique adjustments being made.⁶⁾ OTW, over-the-wire; ELCA, excimer laser coronary atherectomy.

tempts of advancing different balloons (Apex Push OTW™ 1.5 × 12 mm (Boston Scientific Corp., Natick, MA), Apex Flex™ 1.5 × 12 mm (Boston Scientific Corp.), Sprinter Legend™ 1.25 × 12 mm (Medtronic Inc.), MiniTrek™ 1.5 × 12 mm (Abbott Vascular Inc., Santa Clara, CA), NIC Nano® 0.85 × 10 mm (Schwager Medica AG, Winterthur, Switzerland), Apex Flex OTW™ 1.5 × 8 mm (Boston Scientific Corp.)) through the lesion failed. Attempts at proximal cap cracking (a technique also known as “grenadoplasty”)⁸⁾ failed. Unfortunately, there was no Tornus® (Asahi Intecc Co.) available on that day at our catheterization laboratory, and a Corsair® microcatheter (Asahi Intecc Co.) could not be advanced beyond the proximal cap. Finally, as the lesion did not appear heavily calcified, the decision was made to not use rotational atherectomy but instead to attempt laser atherectomy. Excimer laser (CVX-300™) through a 0.9-mm X-80™ catheter (both by Spectranetics Corp., Colorado Springs, CO) was used. Two successful passages of ELCA were performed (6 seconds/train, fluence of 40 mJ/mm², frequency of 40 Hz). Following plaque modification, a 2.5 × 15 mm Sprinter Legend™ balloon (Medtronic Inc.) was easily advanced and inflated at 15 atm to optimize lesion predilatation. Implantation of two everolimus-eluting stents was performed: a 2.75 × 38 mm Xience Prime LL™ (Abbott Vascular Inc.) was deployed in the proximal segment of the lesion with an overlapping 2.5 × 15 mm Xience V™ (Abbott Vascular Inc.) delivered more distally. Postdilatation with a 3.0 × 12 mm non-compliant balloon (NC Quantum Apex™, Boston Scientific Corp.) was performed throughout the stented segments, up to 22 atm. The final angiographic result was considered optimal and the patient was discharged the following day.

DISCUSSION

ELCA is based on ultraviolet energy (308 nm wavelength) and is delivered by a xenon-chlorine pulsed laser catheter (0.9-2.0 mm), with fluence of 30-80 mJ/mm² and pulse frequency of 25-80 Hz. The underlying principle is that the excimer laser uses energy to disrupt and disintegrate the molecular bonds within the atherosclerotic plaque in a highly controlled manner, thereby acting through ablation rather than burning. Briefly, intracoronary saline irrigation is performed to flush blood and contrast, in order to decrease vapor bubble formation. Lasing is then applied, usually in 5-to-10-second “trains”, while constantly flushing with saline. Trains can be repeated, with saline flushing in between, until the desired result is achieved. After each lasing train, the operator should wait 5-10 seconds, to allow the plaque by-products to collapse and be swept downstream. For an optimal result, advancement of the catheter during laser emission must be very slow (0.2-0.5 mm/s) as the penetration depth of the excimer lasers is only 35-50 μm.^{1,9)}

Balloon failure-to-cross after successful guidewire crossing is the second most common cause for CTO PCI failure, occurring in up to 7% of cases.¹⁰⁾ ELCA has been demonstrated to be both a valid alternative and an adjunctive therapy to RA in severely calcified lesions and CTOs, in cases of failure-to-cross/expand.⁹⁾

There are several alternatives available to the interventionalist who is faced with such a scenario. In Figure 3 we outline a potential management algorithm to deal with failure-to-cross and failure-to-expand cases.

In failure-to-cross/expand cases, a first option would be aimed at increasing system support, such as upsizing the guide catheter,⁶⁾ and the “mother-and-child”,¹¹⁾ “buddy-wire”⁶⁾ and anchoring (traditional,¹²⁾ distal¹³⁾ and subintimal⁸⁾ techniques. Combinations of the aforementioned techniques have also been described.¹¹⁾ Use of non-compliant, double-coated, and cutting balloons can also be considered if passage of the balloon can be achieved. A potential useful technique is “grenadoplasty”,⁸⁾ which consists of advancing small balloons into the proximal cap of the CTO and attempting to “rupture” them in order to modify plaque morphology. Switching to a retrograde approach might be another effective strategy, if suitable collaterals exist.⁶⁾

More technically demanding alternatives include rotational atherectomy (RA) or laser atherectomy.¹⁴⁾ In the former, if wire passage is challenging, a hydrophilic-coated polymer guidewire should be considered to subsequently permit passage of either a microcatheter (such as the Corsair®) or a 1.25- or 1.5-mm over-the-wire balloon system. Exchange of the guidewire for a RotaWire™ (Boston Scientific Corp.) is then performed, thus allowing RA.¹⁰⁾ Alternatively, the Tornus® penetration catheter could be used to create a channel through the lesion, thus allowing balloon passage.¹⁵⁾ There exists only scant literature on a direct comparison between RA and the Tornus® system. In a small retrospective series, Fang, *et al.* reported significantly higher success rates (95% versus 77%, $P = 0.024$) and shorter procedural times (115 minutes versus 144 minutes, $P = 0.01$) when the RA strategy was the favored approach.¹⁵⁾ Conversely, ELCA might represent an interesting alternative, due to its lower profile (from 2.0 to 0.9 mm) and ease of use (it can be delivered on a standard 0.014” guide-

wire). Several series on the safety and efficacy of ELCA in CTO have been published. Globally, both have increased over the past two decades, reflecting the technical improvements of the device and a learning-curve effect. Badr, *et al*³⁾ recently published their experience with ELCA in different clinical settings ($n = 119$ patients, 124 lesions). In the CTO group ($n = 32$), the ELCA success rate was 93.8% and the angiographic success rate was 90.6%. Regarding ELCA-related complications, they observed 3 dissections, 1 perforation, and 1 thrombus formation (for a total of 15.6%). Fernández, *et al*⁹⁾ studied 58 patients treated with ELCA, of whom 18 were CTO patients. The success rate was 88.9% (ELCA failed to cross the lesion in two cases), with no ELCA-related complications.

Limitations and hazards of ELCA include the risk for coronary dissection and perforation. This issue is especially relevant in CTO PCI when subintimal dissection techniques are used: in this setting, ELCA can further extend the dissection and even perforate the vessel. These risks can be minimized by adequate training before starting an ELCA program, using intravascular imaging techniques to confirm the position of the guidewire in case of doubt, and maintaining sufficient ELCA case volume at the institution (eg, 20 cases per year).

In the aforementioned patient, the support offered by the guide catheter was excellent. Guidewire exchange for RA was not possible, because a Corsair[®] microcatheter could not cross the lesion. The Tornus[®] system was not available in our catheterization laboratory at the moment of the procedure. The retrograde CTO PCI approach was not deemed to be necessary and was kept as a back-up strategy if an aggressive attempt by antegrade approach resulted in failure. Finally, as there are experienced operators at our center, ELCA was felt to be a safe and effective strategy (less time-consuming and with less radiation exposure) for this young patient. Indeed, with only two trains of pulses, the ELCA catheter quickly crossed the lesion, and permitted us to proceed with proper lesion preparation with conventional ballooning techniques followed by stent delivery and appropriate deployment. Intravascular imaging was not deemed necessary in light of the excellent angiographic result and the fact that the patient was completely asymptomatic, making the risk of coronary perforation or dissection unlikely.

Conclusion: Success of CTO PCIs has greatly increased in recent years. Hard-to-cross/hard-to-dilate CTOs still remain a challenge. Laser atherectomy can complement the interventionalist's toolbox and can be part of the contingency plan to successfully manage this subset of CTOs.

DISCLOSURE

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