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Continuous Mechanical Suction Use During Chronic Total Occlusion Revascularization

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ABSTRACT

Chronic total occlusion (CTO) percutaneous coronary intervention (PCI) is high risk compared to non-CTO PCI. Iatrogenic coronary artery hematoma formation is a common occurrence during CTO PCI, impairing true lumen visualization. We describe the use of a continuous mechanical suction (CMS) device in 2 applications in which it was used for successful subintimal hematoma decompression and distal vessel re-entry. Additionally, we briefly review CMS utilization within the published literature. CMS use during CTO may be a viable technique in future revascularization attempts.

Introduction

Percutaneous coronary intervention (PCI) for chronic total occlusion (CTO) revascularization attempts are complex procedures with increased complication rates. The success rates vary considerably, underscoring the importance of operator skill and familiarity with a broad range of applicable techniques. Antegrade dissection with subintimal tracking and re-entry (ADR) is a frequently employed strategy used after unsuccessful antegrade wire escalation (AWE) and is an important step in the hybrid CTO algorithm[1]; however, it frequently results in subintimal hematoma with resultant luminal reobstruction on coronary angiography.

Cases

Our first case was a 78-year-old Caucasian woman with a medical history of coronary artery disease with prior PCI of her left anterior descending artery (LAD), chronic kidney disease, prediabetes, and hypothyroidism presented for revascularization of a right coronary artery (RCA) CTO. She had been experiencing dyspnea and chest pain at rest refractory to maximally tolerated antianginal medication doses for 15 months.

The proximal RCA was noted to have severe disease with a 20-mm long CTO lesion of the mid-RCA (Figure 1A-C, Videos 1 and 2). Retrograde filling of the distal RCA occurred via predominantly non-interventional epicardial collaterals and poorly developed septal collaterals. Our strategy was AWE followed by ADR. With the support of a 6-8F Trapliner (Teleflex) and a Mamba 135-cm microcatheter (Boston Scientific), the RCA lesion was wired with a FIELDER XT guide wire (ASAHI INTECC) (Figure 1D). The wire punctured the proximal CTO cap, traversing within the extraplaque space (Supplemental Video 1). We then used the ADR approach using a Stingray balloon catheter (Boston Scientific), with further employment of the stick and drive technique utilizing Astato and Gaia third guide wires (both ASAHI INTECC) as well as stick and swap techniques utilizing Mongo (ASAHI INTECC) and Pilot 200 (Abbott) guide wires (Figure 2A). Manipulation within the subintimal space led to hematoma formation, compressing the true lumen of the distal RCA (Figure 2B, Supplemental Videos 2 and 4).

Decompression was attempted between wiring attempts using standard methods of manual suction with a 10 cc Luer-lock syringe locked fully open to create vacuum but was unsuccessful (Figure 2C, Supplemental Videos 3 and 5). A continuous mechanical suction (CMS) device was then utilized for decompression. This comprised an aspiration pump (Penumbra ENGINE) and associated tubing with flow-switch set up in the standard fashion and attached to a Touhy-Borst adapter connected to the central wire port of the Stingray (Figure 3). CMS was utilized to successfully decompress the extraplaque space between and during attempts at re-entry via the Stingray device (Figure 2D, Supplemental Videos 4 and 6).

After CMS use, the Pilot 200 guide wire appeared to have entered the right posterolateral artery branch on retrograde injections. The Pilot 200 wire was exchanged with a SION blue (ASAHI INTECC). Attempts

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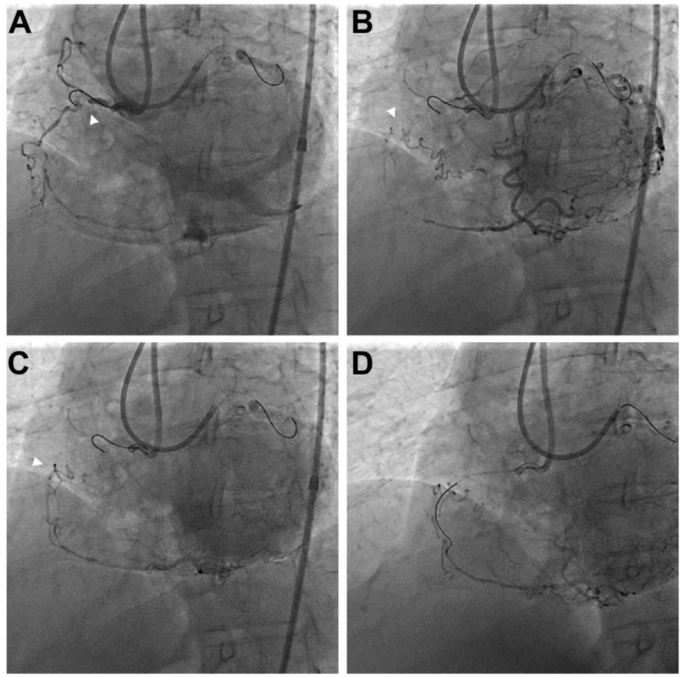

Figure 1.
(A) Left anterior oblique (LAO) view. Contrast through right coronary artery (RCA). Occlusion of the RCA is seen (arrow). (B) LAO view. Contrast through left coronary artery. Collateralization of the inferior heart via the left anterior descending artery is seen (arrow). (C) LAO view. Contrast through left coronary artery, delayed. Collateralization of the inferior heart via the distal left anterior descending artery is again seen (arrow). (D) LAO view. Wiring of lesion with FIELDER XT guide wire.

were made to re-enter the right posterior descending artery over a SASUKE dual lumen microcatheter (ASAHI INTECC), which were unsuccessful. Extraplaque modification was then performed with a 2-mm balloon from the right posterolateral artery branch into the proximal RCA, with intravascular ultrasound confirming extraplaque wire position. The patient continued dual antiplatelet therapy postoperatively with no complications on follow-up.

Our second case involves a 76-year-old Caucasian man with history of coronary artery disease, systolic heart failure, hypertension, hyperlipidemia, and hypothyroidism. He presented for CTO revascularization of his proximal left circumflex (LCx) coronary artery and the first diagonal branch of his LAD. Prior to revascularization, his ejection fraction was 45% to 50%, and his symptoms were consistent with New York Heart Association class III. The LCx CTO

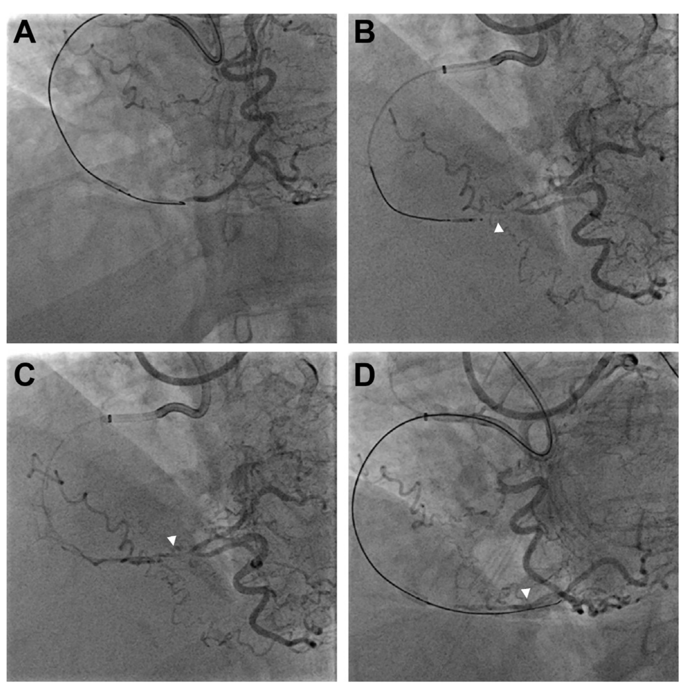

Figure 2.
(A) Left anterior oblique (LAO) view. The antegrade dissection technique with use of knuckled Mongo guide wire is employed. (B) LAO cranial view. A subintimal hematoma has occurred, with loss of distal lumen visualization on angiography (arrow). (C) LAO cranial view. Hematoma decompression with use of manual suction, with partial visualization of the distal lumen (arrow). (D) LAO view. Hematoma decompression with use of continuous mechanical suction. Visualization of the true lumen is improved (arrow).

Figure 3.
Intravenous tubing attached to 3 cc syringe with plunger opening connected to Penumbra ENGINE (left). Layout of connections. At the bottom, a guide catheter with the Stingray catheter inserted (right). The side port (arrow) of the Stingray catheter is attached to an endoflator, with guide wire port (arrowhead) attached to a Tuohy-Borst Y connector, with the side port of the Tuohy-Borst valve (star) connected to Penumbra tubing.

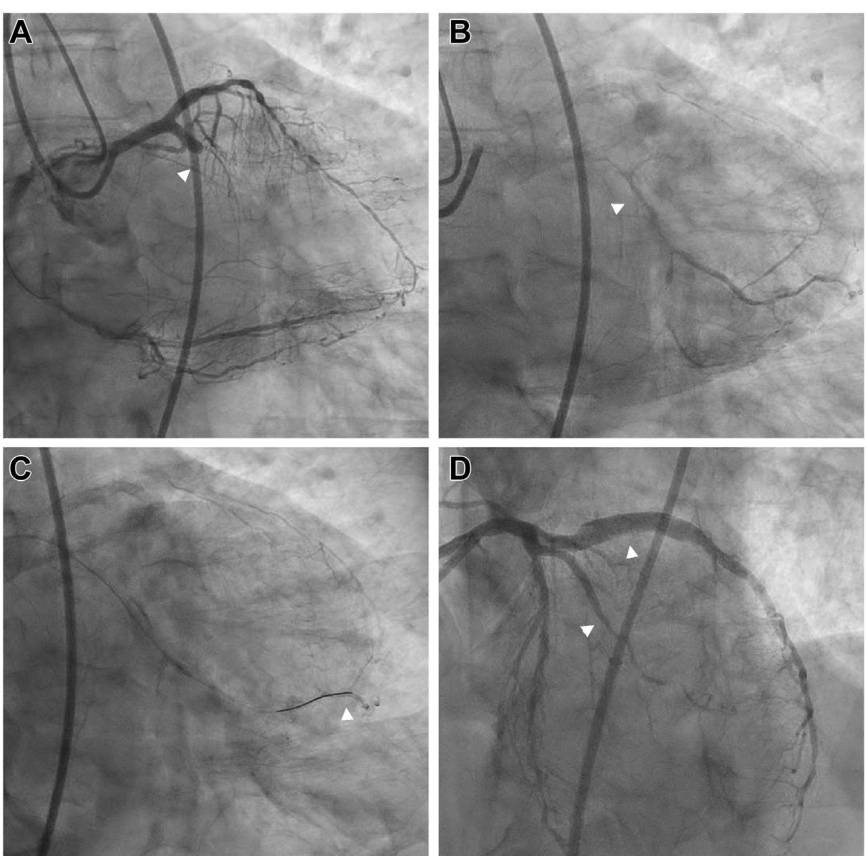

Figure 4.
(A) Caudal view. Chronic total occlusion of the left circumflex artery (LCx) is seen (arrow). (B) Caudal view, delayed. Collateral supply of the LCx via collateral channels is seen (arrow). (C) Caudal view, delayed. Successful re-entry into the distal branch of the LCx artery with retrograde contrast flow seen through the distal vessel bed (arrow). (D) Left anterior oblique cranial view. Angiography after successful revascularization of the LCx and first diagonal branch of the left anterior descending artery with brisk flow seen in areas of prior occlusion (arrows).

was relatively short (10-15 mm) and tortuous (Figure 4A-B, Supplemental Video 5).

When attempting the proximal LCx CTO, a run-through wire loaded in a Mamba microcatheter was advanced into the proximal LCx. AWE was attempted with Mongo, Gaia second and Gaia third, all of which were unsuccessful. Therefore, we employed use of a MiracleBros wire and proceeded with ADR utilizing a Stingray catheter. The Stingray was positioned appropriately under fluoroscopy after which an Astato wire was used for re-entry, which was initially within the extraplaque space. An extraplaque hematoma developed, which was successfully decompressed with use of CMS. After repositioning the Stingray balloon ("bobsled" technique), the Astato wire successfully punctured into the true lumen (Figure 4C, Supplemental Video 6). Using intravascular ultrasound, the vessel underwent balloon angioplasty and placement of overlapping 2.75 × 24 mm and 3 × 28 mm everolimus-eluting SYNERGY XD stents (Boston Scientific), after which the stents were postdilated with 3.0 × 20 mm and 4.0 × 15 mm noncompliant balloons. The first diagonal branch of his LAD was successfully revascularized via the AWE technique, undergoing balloon angioplasty and placement of a 2.25 × 32 mm SYNERGY XD stent. Upon completion, brisk flow was observed through both distal CTO vessel beds with no evidence of complication (Figure 4D, Supplemental Video 7). Echocardiography 3 months later showed improvement in ejection fraction to 60%, with resolution of chest pain and dyspnea.

Discussion

When attempting CTO PCI, AWE is often unsuccessful, and extraplaque tracking and re-entry is frequently employed as a secondary strategy. An important limitation of the technique is the development of hematoma resulting from extraplaque dissection.

A variety of methods are currently employed to prevent and manage compressive extraplaque hematomas obscuring the true lumen during antegrade dissection and re-entry.[2] Typically, to prevent subintimal hematoma during dissection, a guide catheter extension is deeply intubated antegradely to reduce flow into the extraplaque space, followed by efficient delivery of the Stingray balloon to the site. To decompress the hematoma, the most common approach is the subintimal transcatheter withdrawal technique with negative manual suction.[3] The subintimal transcatheter withdrawal technique often fails to decompress extraplaque hematoma.

As shown, CMS accomplished extraplaque hematoma decompression when conventional manual suction failed, in addition to its successful use as part of the ADR technique. Given its demonstrated efficacy for management of iatrogenic extraplaque hematoma formation during CTO PCI, CMS may also be useful in management of iatrogenic severe occlusive dissection occurring during routine angiography or PCI, especially in populations with elevated risk of dissection (CTO PCI, spontaneous coronary artery dissection patients). CMS is primarily used for intravascular aspiration of thrombus, such as pulmonary embolism, coronary artery thrombosis, and acute anterior circulation ischemic stroke. Other novel documented uses of CMS include iatrogenic cardiac tamponade management during catheter ablation.[4] A limited in vitro study has shown CMS is comparable to manual suction when measuring produced static suction forces on simulated thrombus and vessel wall, but this has not been studied in vivo.[5]

Conclusion

CTO revascularization is technically challenging, requiring mastery of numerous techniques to adapt to the unique challenges each case poses. Use of continuous mechanical suction for extraplaque hematoma decompression and subintimal tracking and re-entry attempts is a useful strategy for interventionalists when managing intraprocedural complications during coronary angiography procedures.

Declaration of competing interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethics statement and patient consent

Standard institutional ethical guidelines were adhered to during the publication process; patient consent was obtained prior to submission in compliance with local IRB policies.

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