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## Mechanism and management of burr entrapment: A nightmare of interventional cardiologists

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### Abstract

Entrapment of the burr within calcified lesion is an uncommon, but serious complication during rotational atherectomy and usually needs surgical retrieval. We report a case series of this complication and also review the possible mechanisms, such as kokesi phenomenon or insufficient pecking motion with decreased rotational speed. We also review the potential techniques ever proposed to rescue this complication percutaneously, including simple manual traction, balloon dilation to release the trap, snaring the burr as distal as possible for forceful local traction and wedging the burr with a child catheter to facilitate retrieval. Gentle pecking motion of the burr for sufficient ablation and shortening the run less than 15 s may avoid such complications. Interventional cardiologists using the rotablator should be familiar with the tips and tricks to avoid and rescue this complication.

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## 1 Introduction

Rotational atherectomy (RA) is an irreplaceable modality for heavily calcified lesions in current percutaneous coronary intervention (PCI).<sup>[1–3]</sup> Since incomplete stent expansion is a well-known predisposing factor for further in-stent restenosis<sup>[4]</sup> and thrombosis,<sup>[5]</sup> lesion preparation using RA prior to stent deployment in balloon heavily calcified undilatable lesion is mandatory. However, some complications may be encountered during RA procedure, including slow or no reflow, coronary spasm, distal embolization, coronary dissection, coronary perforation, fracture of the guide wire (GW),<sup>[6]</sup> or the drive shaft<sup>[7]</sup> and entrapment of burr. Among

these complications, burr entrapment occurs rarely with a reported incidence of 0.4%. It occurs more frequently in off-label use<sup>[8]</sup> and usually needs surgical removal.<sup>[9]</sup> Here we report a case series of burr entrapment and discuss the mechanism and management of this complication.

## 2 Case series

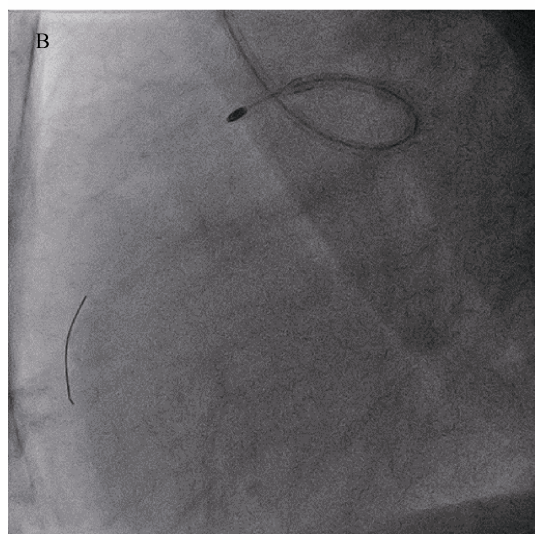
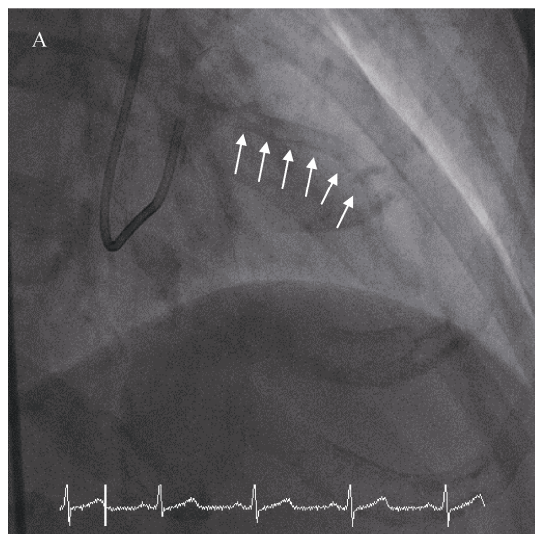
Case 1 was a 60-year-old lady with lupus nephritis complicated with end stage renal disease under regular hemodialysis for decades. Rotablation for the heavily calcified left anterior descending artery (LAD) (Figure 1A) was performed by 1.5 mm rotablator burr initially and followed by another 1.75 mm one. During the pecking motion of the 1.75 mm burr at 160,000 r/min, it was suddenly stuck at the distal LAD and could not be activated even after intracoronary nitroglycerin injection (Figure 1B). A hydrophilic Fielder FC wire (Asahi Intech, Japan) and a stiff Conquest wire (Asahi Intech, Japan) were tried to pass the entrapped burr for dilation of the segment that entrapped it, but both

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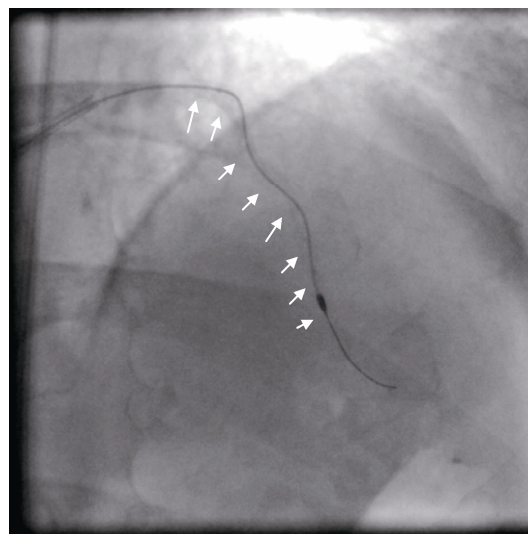


**Figure 1. Heavily calcified left anterior descending artery (arrows) (A) with entrapped burr at middle to distal LAD (B).**

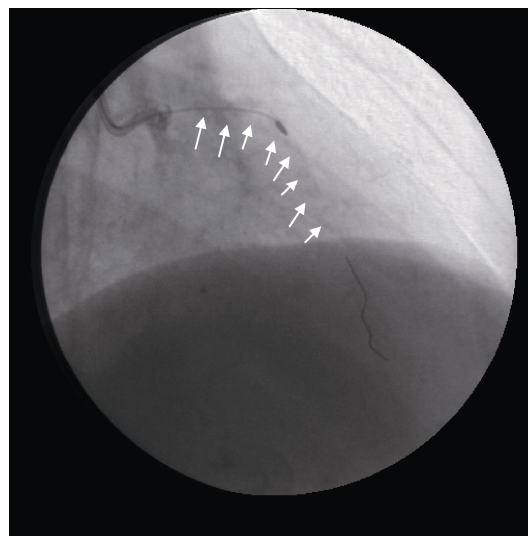
failed. The burr was re-activated after increased the speed up to 180,000 r/min and could be advanced distally followed by successful retrieval.

Case 2 was a 65-year-old gentleman with type 2 diabetes and dyslipidemia, who was admitted for PCI because of unstable angina. Heavily calcified from proximal to distal LAD was revealed by both angiography and intravascular ultrasound. Rotablation using a 1.5 mm burr was performed at a speed of 180,000 r/min. The burr was entrapped at the distal LAD during a long run of more than 10 s (Figure 2). The stuck burr was retrieved by pulling vigorously on the guiding catheter (GC), GW and rotablator burr simultaneously. However, it resulted in a spiral dissection and acute closure at the distal LAD, which was successfully rescued by re-wiring and stenting.

Case 3 was a 69-year-old woman who was admitted due to stable angina. Long calcified LAD with acute angulation



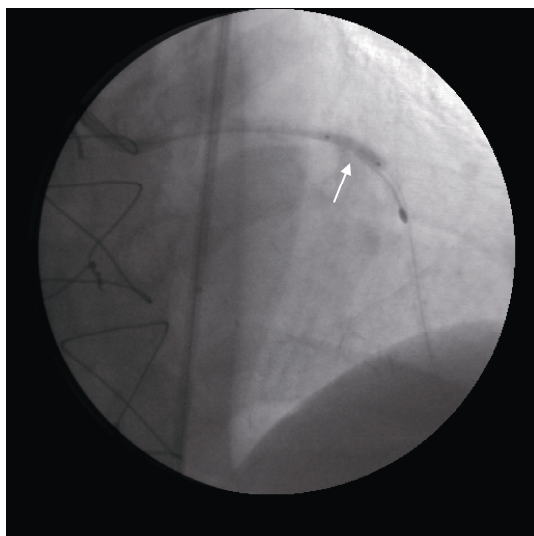
**Figure 2. Heavily calcified left anterior descending artery (arrows) with entrapped burr at distal.**



**Figure 3. Long and angulated left anterior descending artery with calcification (arrows) and an entrapped burr after the angulation.**

at its middle part was observed during PCI. RA was performed using a 1.5 mm burr, which was entrapped after passing the angulated segment during the first run (Figure 3). Despite all efforts, the burr could not be retrieved successfully and the patient was sent for emergent surgery to retrieve the burr.

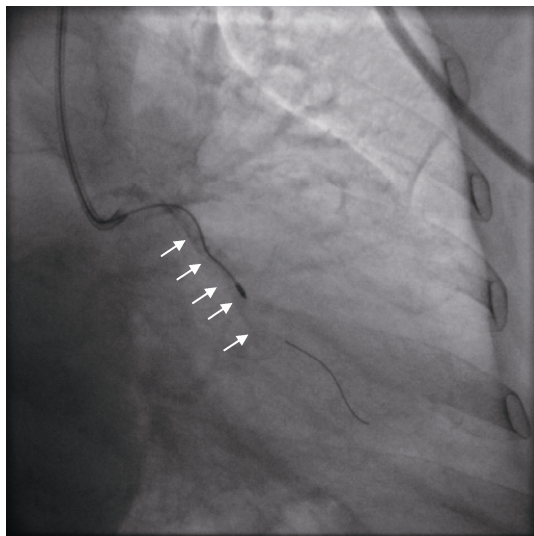
Case 4 was a 74-year-old male with left main (LM) bifurcation disease and received bypass surgery years ago. PCI for the LM bifurcation and calcified LAD lesions was performed because all the bypass grafts were occluded. RA for the heavily calcified LAD was attempted using a 1.5 mm burr. However, it was stuck beyond a stenotic calcified lesion. A Conquest wire was passed distally followed by 2.5 mm



**Figure 4. Entrapped burr at distal left anterior descending artery and rescued by balloon inflation (arrow) at the proximal stenotic lesion.**

balloon inflation at the stenotic lesion to retrieve the entrapped burr successfully (Figure 4). After stenting for the LAD, the LM bifurcation was successfully treated by simultaneous kissing stenting.

Case 5 was a 72-year-old woman who was admitted for stable angina. Heavily calcified LAD and left circumflex artery (LCX) were found and a 1.25 mm burr was employed first for the LCX lesion. During the pecking motion of rotablation, the burr was suddenly trapped at middle LCX and could not be retrieved (Figure 5). The entrapped burr was removed by manual traction of the burr and guide wire, which resulted in injury and acute closure at the ostium of LCX. Intra-aortic balloon pump was inserted for hemodynamic support and antegrade flow of LCX was restored by successful re-wiring and stenting.



**Figure 5. The left circumflex artery was heavily calcified (arrows) and the burr was entrapped at middle part.**

### 3 Mechanisms of burr entrapment

The burr is olive-shaped and has diamond coating at its distal surface for antegrade ablation, but the proximal part was smooth without diamonds, which prohibits backward ablation. If a burr was advanced beyond a tight calcified lesion or embedded in a long, angulated and heavily calcified lesion, it can be entrapped.

Two mechanisms have been proposed previously. First, a small burr can be advanced beyond a heavily calcified plaque before sufficient ablation, especially when the burr is pushed firmly at high rotational speed. During high speed rotation, the frictional heat may enlarge the space between plaques.<sup>[9]</sup> Meanwhile, the coefficient of friction during motion is less than that at rest, which may facilitate the burr to pass the calcified lesion easily without debulking a significant amount of calcified tissue. In this situation, the ledge of calcium proximal to the burr may prevent burr withdrawal. This phenomenon was named “kokesi” after the Japanese doll by Kaneda *et al.*<sup>[9]</sup>

Second, the burr can be entrapped within a severely calcified long lesion, especially angulated and concomitant coronary spasm.<sup>[10]</sup> When a large burr was pushing vigorously against such lesion without sufficient pecking motion, the rotational speed may decrease significantly and this type of entrapment may occur.

### 4 How to retrieve the entrapped burr?

An emergent open surgery would be the most reliable and always the last option for removing the entrapped burr, just as the case 3 we reported. However, surgical removal is invasive, time consuming and usually not immediately available, especially for hemodynamic unstable cases. Before sending the patient to surgery, several non-surgical techniques may be tried to retrieve the stuck burr. In order to prevent thrombosis, sufficient heparinization and glycoprotein IIb/IIIa are recommended before these attempts.<sup>[9,11]</sup> To relief spasm and facilitate antegrade coronary flow, intracoronary nitroglycerin and/or verapamil injection are also suggested.<sup>[9,12,13]</sup>

The simplest method to retrieve the entrapped burr is pulling back the rotator system manually. In some cases, as the case 2 and 5 of our series, the stuck burr can be withdrawal successfully by manual traction with on-Dynaglide or off-Dynaglide rotation but the vessel may perforate and proximal segment may be injured.<sup>[14]</sup> Extreme force on the burr and burr shaft may also result in shaft fracture. Disengaged the GC from vessel ostium and sending another GW deep into aorta may prevent vessel injury by avoid deep seating of GC during traction. In some cases, set the rotabla-



tion speed up to 200,000 r/min and try to advance the burr into the distal lumen may successfully withdrawal the burr while spinning,<sup>[13]</sup> just as our case 1.

Second, if simple manual traction failed, passing a second GW beyond the entrapped burr followed by balloon dilatation for the calcified lesion proximal to it may create a crack between the burr and vessel wall to retrieve it.<sup>[12,13,15,16]</sup> The lesion surrounding the entrapped burr is always heavily calcified and usually need a hydrophilic-coated wire to pass it<sup>[16]</sup> and sometimes stiffer wire such as Conquest wire may be needed to pass the adjacent hard plaque<sup>[10,13,15]</sup> as the case 4 of our series. However, the profile of the rotablation drive shaft sheath is 4.3 Fr, which may prohibit introducing of a balloon catheter (mostly 3 Fr in diameter) into the GC if it is a 6 or 7 Fr one. In this situation, introducing another GC via another vascular access may be needed for the second GW and balloon.<sup>[12,13]</sup> Alternatively, the GC may be exchanged to a 8 Fr one after cutting off the burr and sheath near the advancer.<sup>[10,13,15]</sup> Sakura *et al.*<sup>[16]</sup> demonstrated a novel idea to remove the drive shaft sheath after cut off the system near the advancer. After retracting the sheath and leaving the transected uncoupled burr, a second GW and balloon catheter can easily pass through the GC even it is a 6 Fr one.

Third, a snare was reported to remove an entrapped burr successfully by Parsan *et al.*<sup>[11]</sup> The rotablation system was cut at the hub as described above, which allowed direct access of the snare to the burr shaft. After encircled the burr shaft by the snare and the noose tightened immediately proximal to the entrapped burr, the burr was successful withdrawal by simultaneously retracting on the snare and the GC. Applying the traction force locally to the entrapped burr is a more controlled manner and may reduce the risk of proximal vascular trauma. This technique was inspired by pacemaker lead extractors used to remove infected pacing wires.

Fourth, using a child catheter was also reported to retrieve the stuck burr either by over-the-wire 5Fr 120-cm straight GC (Heartrail ST01, Terumo, Japan)<sup>[10]</sup> or monorail 5 Fr Guideliner (Vascular Solutions, Minnesota, USA) GC.<sup>[17]</sup> After cut off the drive shaft and sheath near the advancer, the child catheter can be inserted through the remaining rotablation system to the entrapped burr. By simultaneous traction on the burr shaft and counter-traction on the child catheter, the catheter tip can act as a wedge between the burr and the surrounding plaque, which may exert a larger and more direct pulling force to retrieve the burr. Furthermore, the child catheter may protect the proximal vessel on coronary tree and facilitate following interventional procedures after successful removal of the burr by taking advantage of the child-in-mother technique.

## 5 How to prevent burr entrapment?

The burr entrapment can usually be avoided by gentle pecking motion and short runs of rotablation (< 15 s). When a smaller burr was employed, more slowly advancement to ablate the plaque of proximal lesion sufficiently was recommended,<sup>[9]</sup> and too high a burr speed should also be avoided to prevent “kokesi phenomenon”.<sup>[9,13]</sup> A larger burr was advocated to remove more tissue during the initial pass.<sup>[12]</sup> It was also suggested that the speed of rotation per minute should not be drop more than 10% during burr advance to avoid a too large amount of debris being produced within a short time,<sup>[13]</sup> which may not occur if push gently. If the burr was push aggressively, it may become stalled and embedded in the calcified lesion; especially when the lesion is long, heavily calcified, low elastic and high angulated.<sup>[9,10]</sup> Continuous high pressure flushing of nitroglycerin and verapamil can also avoid severe vessel spasm and slow/no reflow.<sup>[13]</sup> Furthermore, using a stiffer wire to straighten the narrowing to lessen resistance was also been proposed.<sup>[9]</sup> A stiffer GW dose not always produce an unfavorable bias but sometimes makes favorable bias which may help a sufficient ablation of angulated heavily calcified lesion.<sup>[9]</sup> Since the burr was diamond-coated only at the distal part, some entrapped burrs may be successful retrieved if the proximal part was also coated by its manufacturer.

## 6 Conclusions

Burr entrapment is a rare but serious complication during RA and often necessitates open surgery to retrieve the trapped burr. The mechanisms for such complication include kokesi phenomenon or insufficient pecking motion for long, heavily calcified and angulated lesion. Several bailout techniques other than surgery have been proposed to retrieve the stuck burr such as simple manual traction, passing another GW followed by balloon inflation to release the trap, using a snare immediate proximal to the burr for forceful local traction or a child catheter to facilitate the successful retrieval. Gentle pecking motion with shorter runs of ablation may prevent such complication. A stiffer wire may be used to straighten the lesion to lessen the resistance unless unfavorable wire bias was observed. Interventional cardiologists using rotablator should be familiar with these tips and tricks to avoid and rescue this complication.

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