Rotary atherectomy - method of preparation of heavily calcified coronary artery lesions

Milan Grujić (1), Stefan Živković (1), Aleksandar Davidović (1, 2)

(1) ZVEZDARA CLINICAL HOSPITAL CENTER; (2) FACULTY OF DENTISTRY OF THE UNIVERSITY OF BELGRADE

Summary: Calcified lesions of coronary arteries still represent a major challenge in interventional cardiology. The sign is advanced atherosclerosis, associated with multivessel disease and the presence of complex lesions, including long lesions, chronic total occlusions, and bifurcations. Today, there are several strategies for modifying calcified lesions before percutaneous coronary intervention. They can be divided into strategies without atherectomy and strategies with atherectomy. Non-atherectomy strategies include modification balloons and intravascular lithotripsy. Atherectomy strategies are aimed at physical plaque removal and include rotary atherectomy, coronary orbital atherectomy, and laser coronary atherectomy. Rotational atherectomy is an endovascular procedure during which plaque ablation occurs by advancing a rotating abrasive burr. The use of rotational atherectomy in severely calcified lesions is associated with greater dilatation of vessel diameter, larger lumen cross-section, and fewer final residual stenoses after stent implantation. Heavily calcified ostial and bifurcation lesions are more demanding for percutaneous intervention, with frequent complications such as plaque transfer, acute side branch occlusion, and suboptimal stent apposition or expansion. In such cases, interventions with modification of the calcified plaque with the use of rotational atherectomy have been shown to be more successful, whether only the main branch or both the main and side branches are treated. This paper presents a patient with a calcified lesion of the ostium of the anterior descending artery who refused cardiosurgical revascularization and in whom the initial percutaneous coronary intervention was not successfully performed. After that, percutaneous coronary intervention was performed using rotary atherectomy. An optimal angiographic result with normal coronary flow was obtained. The patient was discharged after the intervention without complications. Carefully performed rotational atherectomy can be successfully used in the treatment of demanding calcified lesions of the ostial segments of the coronary arteries with a high degree of effectiveness and safety.

Key words: calcified lesions, ostial lesions, rotational atherectomy

Introduction

Coronary calcifications occur when calcium builds up in the plaque of the coronary arteries. They are more common in the elderly, in patients with diabetes, renal insufficiency, as well as with previous cardiovascular revascularization [1,2]. Calcified coronary artery lesions continue to represent a challenge in interventional cardiology. Fourteen studies with drug-eluting stents showed that the frequency of moderately to severely calcified lesions is about 30% of the total number of lesions. Calcified coronary arteries are a sign of advanced atherosclerosis, associated with multivessel disease and the presence of complex lesions, including long lesions, chronic total occlusions, and bifurcations [3]. Accumulated mineral content in calcified plaque increases the frequency of complications during the procedure by obstructing passage and leading to asymmetric or incomplete expansion of balloons and stents, also leading to malposition of stents, increasing postprocedural complications such as restenosis and stent thrombosis [4,5].

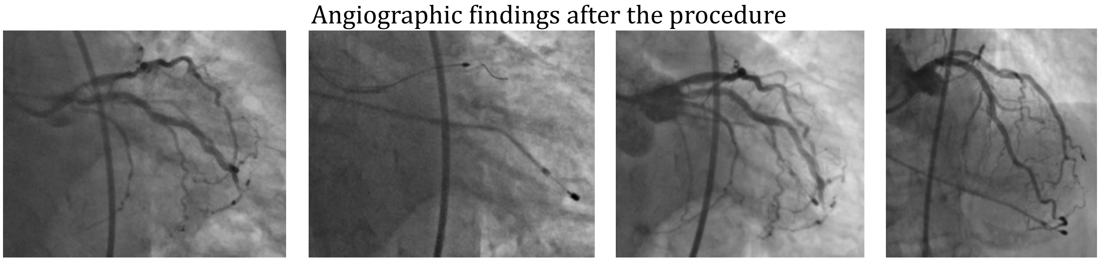
This paper presents a patient with a calcified lesion of the ostium of the anterior descending artery (left anterior descending, LAD) and percutaneous coronary intervention (PCI) with the help of rotational atherectomy (RA).

Case report

An 83-year-old female patient was admitted to our institution due to acute myocardial infarction with inferior ST segment elevation . The complaints started an hour before admission. This was the first manifestation of coronary disease. The patient was previously treated for arterial hypertension and diabetes. Immediately after admission, an emergency selective coronary angiography was performed, which registered an occluded right coronary artery (RCA) with a significant calcified lesion of the LAD, as well as the ostium of the ramus intermedius (RI). In the same act, primary PCI RCA was performed with the implantation of two drug-eluting stents with a flap (2.75x12mm, 2.75x18mm). Echocardiographically, hypokinesia of the basal half of the inferior wall and the inferior septum and the apical third of the anterior septum was registered, with preserved global systolic function. The patient was treated with dual antiplatelet therapy, low-molecular-weight heparin, beta blocker, angiotensin-converting enzyme inhibitor, dihydropyridine calcium channel blocker, statin, and antidiabetic therapy was optimized. The medical documentation was presented to the cardiosurgical council, which indicated surgical revascularization of the myocardium with double aortocoronary bypass (LAD and RI), which the patient refused, and PCI LAD and RI was proposed to her. In the second act, during the same hospitalization, PCI was attempted. Predilatation of the RI ostium was performed with a 2.5x15mm semi-compliant balloon. An attempt to predilate the LAD ostium with a non-compliant balloon 3.5x15mm, as well as with semi-compliant balloons 2.0x15mm and 1.5x10mm was not successful, because the balloons did not pass the calcified lesion. Given that no dissection was registered in the left coronary system, that the patient had anginal complaints all the time, was hemodynamically and rhythmologically stable, and electrocardiographically without signs of ischemia, further intervention was abandoned and an attempt at RA of the ostial LAD with eventual PCI of the LAD was indicated.

One month after the acute event, the patient was readmitted to our institution for a planned intervention. The intervention was performed through the right femoral approach. The main stem is cannulated with a guide catheter EBU (Eng. Extra Back-Up) 3.5 7F. A working wire was passed through the lesion and placed in the distal segment of the LAD. Via the microcatheter, the Corsair Pro working wire was replaced with an Extra Support Rota wire. A rotablation of the calcified lesion of the ostium was performed with a 1.5mm LAD burr at 150,000 rpm (eng. rotation per minute) with three repetitions of a maximum duration of up to 15s. Rota wire was replaced by working wire. A second working wire is positioned in the distal segment of the RI for protection. The ostial LAD lesion was then predilated with a non-compliant 3.0x20mm balloon. Two flap drug-eluting stents were implanted from the main stem to the LAD (3.5x22mm, 3.0x30mm) with proximal optimization of the stent in the main stem with a non-compliant balloon 5.0x15mm. An optimal angiographic result with normal coronary flow was obtained. The patient was discharged on the third day of hospitalization without complications.

Pictures 1. Angiographic findings before the procedure; 2. RA calcified lesions of the LAD ostium; 3. and 4. Angiographic findings after the procedure



1. 2. 3. 4.

Discussion

Several non-invasive and invasive methods can be used to diagnose calcified lesions of the coronary arteries: computed tomography coronary angiography (CTCA), selective coronary angiography, intravascular ultrasound (IVUS) and optical coherence tomography tomography, OCT). Selective coronary angiography often underestimates calcified lesions, and with this method it is not possible to assess the depth of calcium in the plaque [6]. On fluoroscopy, coronary calcification is radio-opaque, it is observed before contrast injection, and it is mostly a circumferential lesion [7]. IVUS and OCT are two invasive methods that provide better data on the depth and distribution of calcium in the plaque. The characteristics of the lesion that we can obtain using OCT, which may suggest that treatment with RA will be needed, are: maximum circumference of the calcification >180°, maximum thickness >0.5mm, length >5mm [8]. An indication for RA can be the impossibility of passage of the lesion with balloons or insufficient expansion of the balloon when preparing the lesion for PCI.

Today, there are several strategies used to modify calcified lesions before the PCI procedure and can be divided into non-atherectomy and atherectomy strategies. Strategies without atherectomy include modification balloons (non-compliant, so-called scoring, so-called cutting balloons) as well as intravascular lithotripsy. These methods treat the lesion by fracture, cutting, or targeted dissection. Atherectomy strategies are aimed at physical plaque removal and include RA, coronary orbital atherectomy, laser coronary atherectomy [9].

RA is an endovascular procedure during which plaque ablation occurs by advancing a rotating abrasive burr. This method has been around for three decades, but is extremely rarely used in clinical practice. According to the available data, the use of RA in Europe and the USA is in 1-3% of the total number of PCI procedures [10]. Although randomized trials with both metal [11] and drug-eluting stents [12,13] did not show a reduced incidence of long-term ischemic events with the routine use of RA, the use of RA in severely calcified lesions is associated with a higher by expanding the diameter of the blood vessel, with a larger cross-section of the lumen and with fewer final residual stenoses after stent implantation [14]. In 2018, the results of the PREPARE-CALC study were published, which showed the non-inferiority of RA compared to modification balloons in terms of in-stent lumen loss nine months after PCI with the implantation of modern drug-eluting stents, as well as the superiority of RA in terms of procedural success [15].

The main indication for the use of RA is the modification of severely calcified coronary lesions with the aim of preparing the lesion for further angioplasty and stent implantation. It is more often used during re-intervention, but retrospective comparisons have shown that, if RA is used as the primary method, the duration of the procedure is reduced (average reduction 19 min), fluoroscopy time (average reduction 18 min), as well as the volume of iodine contrast medium used (average reduction reduction 70ml) [16]. Absolute contraindications for this method include CTO that prevents wire passage, vein graft, acute thrombosis, shock and hypotension. The presence of coronary artery dissection is not an absolute contraindication. Care should be taken with severe left ventricular dysfunction, severe coronary disease, disease of the unprotected main stem, lesion length over 25mm, and lesion angle >45° [17].

As for ostial and bifurcation lesions, they are often more demanding to work with, with possible plaque transfer, acute side branch occlusion, and suboptimal stent apposition or expansion. In such cases, interventions with the modification of the calcified plaque with the use of RA have been shown to be more successful, whether only the main branch or both the main and side branches are treated [18,19,20,21].

When choosing a guide catheter, the 6F system is adequate for a burr size of 1.75 mm and smaller. A 7F guide catheter is required for a larger burr. The transradial approach is associated with a similar success rate as the transfemoral approach [22,23]. Passage of the lesion with a Rota wire is possible but challenging. An initial passage with a working wire that can then be replaced via a microcatheter with a Rota wire is an easier way to pass the lesion itself. If it is not possible to pass the lesion with a microcatheter, then you should try primarily to pass the lesion with a Rota wire, and then, in case of successful passage, do the RA with the smallest burr of 1.25 mm. Rota wires are available in two versions, Extra Support and Floppy. Extra Support Rota wire is used in ostial and distal lesions for better support [24]. The size of the burr for RA is determined by the size of the blood vessel in which the lesion is located. The results of the STRATAS and CARAT studies indicate that a smaller burr (burr size ratio: coronary artery <0.7) enables angiographic and procedural success equivalent to a larger burr, with fewer complications [25,26]. It is recommended to use a burr in which the ratio of the size to the size of the artery to be treated is 0.4-0.6 [24]. In addition to choosing the optimal size, a successful procedure also requires an adequate rotation speed of the burr (140000 to 150000 rpm), with short ablations (<20s) and pauses between ablations, as well as avoiding a drop in rotation speed for more than 5000 rpm. The RA is considered complete when the last burr maneuver passes without resistance. After successful RA, implantation of a drug-eluting stent is recommended. A follow-up of 1176 patients treated for RA from 2002 to 2013 showed that patients treated with drug-eluting stents had a >50% lower risk of a major adverse cardiovascular event [27].

In our institution, about 20 RAs are performed per year, with a success rate of 95%. All procedures are indicated after previously unsuccessful attempts at PCI. In this case, RA was performed after an unsuccessful attempt to pass the smallest balloon through the calcified lesion of the ostial LAD. The procedure was performed through a transfemoral approach using a 7F guide catheter, Extra Support Rota wire, a 1.5mm burr with a rotation speed of 150000 rpm. After successful RA, drug-eluting stents were implanted.

CONCLUSION

Carefully performed rotational atherectomy can be successfully used in the treatment of demanding calcified lesions of the ostial segments of the coronary arteries with a high degree of effectiveness and safety. The use of other complementary methods together with rotary atherectomy increases the success of the procedure.

LITERATURE:

1. Tomey MI, Kini AS, Sharma SK. Current status of rotational atherectomy. JACC Cardiovasc Interv 2014;7:345–53.
2. Sharma SK, Tomey MI, Teirstein PS, et al. North American Expert Review of Rotational Atherectomy. Circ Cardiovasc Interv 2019;12:e007448.
3. Carlotta SD, Giulia N, Francesca R, Alessio M, Brunilda H, Carlo DM. Contemporary Approach to Heavily Calcified Coronary Lesions. Interventional Cardiology Review 2019;14(3):154–63.
4. Takebayashi H, Kobayashi Y, Mintz GS, Carlier SG, Fujii K, Yasuda T, Moussa I, Mehran R, Dangas GD, Collins MB, Kreps E, Lansky AJ, Stone GW, Leon MB, Moses JW. Intravascular ultrasound assessment of lesions with target vessel failure after sirolimus-eluting stent implantation. Am J Cardiol. 2005; 95:498–502. doi: 10.1016/j.amjcard.2004.10.020
5. Kobayashi Y, Okura H, Kume T, Yamada R, Kobayashi Y, Fukuhara K, Koyama T, Nezuo S, Neishi Y, Hayashida A, Kawamoto T, Yoshida K. Impact of target lesion coronary calcification on stent expansion.Circ J.2014 ; 78:2209–2214.
6. Wang X, Matsumura M, Mintz GS, et al. In vivo calcium detection by comparing optical coherence tomography, intravascular ultrasound, and angiography. Am J Coll Cardiol Imaging 2017;10:869–79.
7. Moussa I, Ellis SG, Jones M, Kereiakes DJ, McMartin D, Rutherford B, Mehran R, Collins M, Leon MB, Popma JJ, Russell ME, Stone GW. Impact of coronary culprit lesion calcium in patients undergoing paclitaxel-eluting stent implantation (a TAXUS-IV sub study). Am J Cardiol.2005; 96:1242–1247.
8. Fujino A, Mintz GS, Matsumura M, Lee T, Kim SY, Hoshino M, Usui E, Yonetsu T, Haag ES, Shlofmitz RA, Kakuta T, Maehara A. A new optical coherence tomography-based calcium scoring system to predict stent underexpansion. .EuroIntervention.2018; 13:e2182–e2189.
9. Tanush G, Michael W, Mark G, Antonio C, Azeem L. Rotational Atherectomy: A Contemporary Appraisal. Interventional Cardiology Review 2019;14(3):182–9.
10. Barbato E, Carrie D, Dardas P, et al. European expert consensus on rotational atherectomy. EuroIntervention 2015;11:30–6.
11. Dill T, Dietz U, Hamm CW, Küchler R, Rupprecht HJ, Haude M, Cyran J, Ozbek C, Kuck KH, Berger J, Erbel R. A randomized comparison of balloon angioplasty versus rotational atherectomy in complex coronary lesions (COBRA study) . Eur Heart J. 2000; 21:1759–1766.
12. Abdel-Wahab M, Richardt G, Joachim Büttner H, Toelg R, Geist V, Meinertz T, Schofer J, King L, Neumann FJ, Khattab AA. High-speed rotational atherectomy before paclitaxel-eluting stent implantation in complex calcified coronary lesions: the randomized ROTAXUS (Rotational Atherectomy Prior to Taxus Stent Treatment for Complex Native Coronary Artery Disease) trial.JACC Cardiovasc Interv.2013; 6:10–19.
13. de Waha S, Allali A, Büttner HJ, Toelg R, Geist V, Neumann FJ, Khattab AA, Richardt G, Abdel-Wahab M. Rotational atherectomy before paclitaxel-eluting stent implantation in complex calcified coronary lesions: two-year clinical outcome of the randomized ROTAXUS trial. Catheter Cardiovasc Interv. 2016; 87:691–700.
14. Hoffmann R, Mintz GS, Popma JJ, Sattler LF, Kent KM, Pichard AD, Leon MB. Treatment of calcified coronary lesions with Palmaz-Schatz stents. An intravascular ultrasound study. Eur Heart J. 1998; 19:1224–1231.
15. Mohamed Abdel-W, Ralph T, Robert AB, Walker G, Mohamed El-M, et al. High-Speed Rotational Atherectomy Versus Modified Balloons Prior to Drug-Eluting Stent Implantation in Severely Calcified Coronary Lesions. The Randomized PREPARE-CALC Trial. Circulation: Cardiovascular Interventions. 2018;11:e007415. https://doi.org/10.1161/CIRCINTERVENTIONS.118.007415
16. Kawamoto H, Latib A, Ruparelia N, Boccuzzi GG, Pennacchi M, Sardella G, Garbo R, Meliga E, D'Ascenzo F, Moretti C, Rossi ML, Presbitero P, Ielasi A, Magri C, Nakamura S, Colombo A. Planned versus provisional rotational atherectomy for severe calcified coronary lesions: insights from the rotate multi-center registry. Catheter Cardiovasc Interv. 2016; 88:881–889.
17. Boston Scientific Corporation. Rotational Atherectomy System Reference Guide. in 2014
18. Karvouni E, Di Mario C, Nishida T, Tzifos V, Reimers B, Albiero R, Corvaja N, Colombo A. Directional atherectomy prior to stenting in bifurcation lesions: a

matched comparison study with stenting alone. Catheter Cardiovasc Interv.2001; 53:12–20.
19. Tsuchikane E, Aizawa T, Tamai H, Igarashi Y, Kawajiri K, Ozawa N, Nakamura S, Oku K, Kijima M, Suzuki T; PERFECT Investigators. Pre-drug-eluting stent debulking of bifurcated coronary lesions. J Am Coll Cardiol.2007; 50:1941–1945.
20. Nageh T, Kulkarni NM, Thomas MR. High-speed rotational atherectomy in the treatment of bifurcation-type coronary lesions. Cardiology. 2001; 95:198–205.
21. Ito H, Piel S, Das P, Chhokar V, Khadim G, Nierzwicki R, Williams A, Dieter RS, Leya F. Long-term outcomes of plaque debulking with rotational atherectomy in side-branch ostial lesions to treat bifurcation coronary disease.J Invasive Cardiol.2009; 21:598–601.
22. Kotowycz MA, Khan SQ, Freixa X, Ivanov J, Seidelin PH, Overgaard CB, Džavík V. Rotational atherectomy through the radial artery is associated with similar procedural success when compared with the transfemoral route. Coron Artery Dis. 2015; 26:254–258.
23. Watt J, Oldroyd KG. Radial versus femoral approach for high-speed rotational atherectomy. Catheter Cardiovasc Interv. 2009; 74:550–554.
24. Samin S, Matthew T, Paul T, Annapoorna K, Arthur R, Arthur L, Philippe G, Jeffrey C, Cindy G, Stevan H, Craig T, Ian M, Aparna B, Jeffrey M. North American Expert Review of Rotational Atherectomy. Circulation: Cardiovascular Interventions Vol. 12, No. 5, 2019;12:e007448.
25. Whitlow PL, Bass TA, Kipperman RM, Sharaf BL, Ho KK, Cutlip DE, Zhang Y, Kuntz RE, Williams DO, Lasorda DM, Moses JW, Cowley MJ, Eccleston DS, Horrigan MC, Bersin RM, Ramee SR, Feldman T Results of the study to determine rotablator and transluminal angioplasty strategy (STRATAS).Am J Cardiol.2001; 87:699–705.
26. Safian RD, Feldman T, Muller DW, Mason D, Schreiber T, Haik B, Mooney M, O'Neill WW. Coronary angioplasty and rotablator atherectomy trial (CARAT): immediate and late results of a prospective multicenter randomized trial. Catheter Cardiovasc Interv. 2001; 53:213–220.
27. Kawamoto H, Latib A, Ruparelia N, Ielasi A, D'Ascenzo F, Pennacchi M, Sardella G, Garbo R, Meliga E, Moretti C, Rossi ML, Presbitero P, Magri CJ, Nakamura S, Colombo A, Boccuzzi GG. In-hospital and midterm clinical outcomes of rotational atherectomy followed by stent implantation: the ROTATE multicentre registry.EuroIntervention.2016; 12:1448–1456.