*ejpmr, 2018,5(5), 669-673*

SJIF Impact Factor 4.897

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Review Article

ISSN 2394-3211

EJPMR

# OCCURRENCE OF SLOW FLOW/NO REFLOW COMPLICATION DURING ROTATIONAL ATHERECTOMY: A REVIEW

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**Article Received on 14/04/2018** **Article Revised on 04/05/2018** **Article Accepted on 25/05/2018**

## ABSTRACT

Percutaneous coronary intervention (PCI) is most common form of revascularization of symptomatic coronary artery disease in modern age. There are increased chances of calcified coronary disease in elderly, diabetic and renal patients, so rotational atherectomy (RA) can be useful in such kind of calcified lesions. Rotational atherectomy is a technique where calcified lesions are debunked with the high speed rotating burr. Along with many other complications slow flow/no reflow is also a main complication of this procedure. In initial days these complications were reported at large thus decrease in the usage of this technique but with the improvement of technique, usage of pharmacological flush, glycoprotein and drug eluting stents reported decrease in complications and rise of this technique once again while treating calcified lesions. The objective of this study is to know the average occurrence of this complication in difference studies conducted in different settings. Relevant studies and articles were reviewed, analyzed and we came to the conclusion that the complication of slow flow/no reflow is generally low below 2.6 % when following recent treatment techniques and using pre-, intra- and post-procedural pharmacological flush of heparin, nitroglycerine, vasodilator, glycoprotein IIb/IIIb and applying drug eluting stents after procedure.

**KEYWORDS:** Rotational Atherectomy, Slow Flow, no Reflow, Rotablation.

## INTRODUCTION

After immergence of percutaneous coronary intervention (PCI), it became the most common form of revascularization technique for symptomatic coronary artery disease. It is now commonly used technique all over the world and many improvisation has been made since it's development in 1977. This highly sophisticated intervention allowed operator to treat complex coronary lesions with excellent outcomes. Despite significant advances in the treatment of coronary artery disorder (CAD) and improvements in interventional devices and techniques, the subset of obstructive calcified coronary artery disease remains challenging to treat. The definite reason for vascular calcification is still poorly understood but it is common with aging population and people with diabetes and renal impairment. To address the condition of severely calcified lesions and inability to pass guide wire through them, rotational atherectomy (RA) or 'rotablation' was developed in 1989.

Rotational atherectomy (RA) is one of the treatment options in percutaneous coronary intervention (PCI) for calcified lesions that interfere with device delivery or expansion of a balloon or stent.[1,2] The concept of using a speed nickel-coated burr with diamond chips spinning at speed of around 120,000-200,000 rpm driven by nitrogen to clear an artery that is 2-3 mm in diameter is a triumph of engineering ingenuity. It's initial use in human coronary arteries was by Bertrand (Lille, France) and Erbel (Essen, Germany).[3]

Rotational atherectomy minimizes wall stretch and debulks the plaque resulting in smooth lumen which can facilitate further modification with balloon dilatation and stent placement. The principle of rotational atherectomy (RA) is simply pulverizing the calcified plaque to debris in approximate 5 um size, smaller than the red blood cells, which is taken up by the reticuloendothelial system. Main device used for rotational atherectomy is Rotablator© (Boston Scientific, MN USA). The system includes the Rotablator console and foot pedal, the RotaLink Advancer and burr (1.25-2.5 mm) RotaWire floppy or intermediate guidewire, RotaLink burr catheter and nitrogen at 7atm with 140 l/min flow.[4]

The chronic total occlusion (CTO) is encountered in approximately 15% of all percutaneous coronary interventions (PCI).[5,6] Even with experienced hands success rate for these type of occlusions is averaging 65-70%. The main reason of failure in these types of lesions is mainly due to inability to pass through the occlusion. Rotational atherectomy is mean to improve coronary

flow and allow passage by debulking atheromatous plaque for the lumen. Initial trials showed high restenosis rate so the interest to this technique floated around and when newer approaches with pre, intra and post medicines and drug eluting stents (DES) emerged, this technique re-emerged as good option while treating severely calcified lesions. Indications for rotational atherectomy is summarized as in table below.

**Table. 1. Indications for rotational atherectomy.[4]**

| |
|---|
| *Classic indications (plaque debulking)* |
| Densely calcified lesions |
| Lesions with inadequate balloon expansion |
| *Widened indications (lesions preparation, plague modification)* |
| Long diffuse disease |
| Small vessels (<2.5 mm) |
| Diffuse in-stent restenosis |
| Ostial lesions |
| Bifurcating lesions |

The inability to cross CTO with a balloon catheter occurs is 7% of all the CTOs that are successfully crossed with a guidewire. In this frustrating situation, rotational atherectomy is successful in 95.5% of cases.[7] Though beneficial for beneficial for calcified lesions, rotational atherectomy does come with complications which can be both immediate and late complications. Most of the complications are immediate and occur more directly to the efficacy of the handler. Major complications of rotational atherectomy are: dissection, perforation, acute closure, need of urgent coronary artery bypass surgery (CABG), slow flow/no reflow, myocardial infraction and death. We will be discussing mainly on slow flow/no reflow (also termed as 'slow reflow and no flow) phenomenon in rotational atherectomy (RA) technique. It is usually any of two i.e. slow flow/no reflow though we will be using the term slow flow/no reflow throughout. Slow flow/no reflow is considered as common complication of rotational atherectomy.

Slow flow/no reflow are defined as the impairment and loss, respectively, of antegrade blood flow after PCI in the absence of a residual obstructive lesion in the conductance (epicardial) vessel. This complication may lead to as much as 10-fold increase in the incidence of both in-hospital death and or acute myocardial infraction.[8-10] Various causes have been stipulated for the cause of no flow and slow reflow but main reason seems to be microvascular vasoconstrictions.

Angiographic definition of slow flow and no reflow are: 1. Angiographic No-Reflow is defined as the presence of TIMI 0-1 in absence of dissection, spasm, stenosis or thrombus of the epicardial vessel. 2. Lesser degree of reduction of coronary flow (i.e. TIMI 2 flow) is defined as Slow-flow.

During initial stage of introduction of rotational atherectomy, the incidence of no flow and no reflow was at high and once this procedure deemed to be lesser in use due to this complication. Later improvement on technique and different approaches with pre, intra and post procedural pharmacology and stents helped this technique to revive and used frequently for calcified lesions. The expected complication of no flow/no reflow were reported to be around ≤16% in rotational atherectomy.[11] This was older data with the studies done in 2007. Recent study suggested, combined with meticulous technique, optimal antiplatelet therapy, vasodilators, flush solution, and provisional use of atropine, temporary pacing, vasopressors, and mechanical support may prevent slow-flow/no-reflow, which in contemporary series is reported in 0.0% to 2.6% of cases.[1]

## METHODS AND METHODOLGY

A review of previous studies that investigated the occurrence of slow flow/no reflow was performed. Literature published in English were considered for the purpose of this review article. We tried to use more recent articles (post 2000 A.D.) but few older articles have also been included. Medical literature searches engines Pubmed, Embase and Medline used for the search of previous studies. Previous articles were searched using MESH terms; 'rotational atherectomy' and 'no flow' and 'no reflow'. Keyword searches were also used as a secondary search strategy to ensure most of the necessary articles were included. All the articles were initially evaluated and their findings were analyzed. The main purpose of this study was to find out basic information about rotational atherectomy and occurrence of it's no flow/no reflow complication. So articles were selected irrespective of their study and treatment differences. Due to limited study in the field of slow flow/no reflow complication, there were other studies mainly on all major of complications and we complied and analyzed the complication of our concern i.e. slow flow/no reflow.

## RESULTS

The main purpose of this review article is to know the approximate number or percentage of occurrence of slow flow/no reflow. Data collected in our study included the studies where rotational atherectomy was preformed and drug eluting stents were placed thereafter. Those data were collected, analyzed and the tabulated result are shown in the table below.

**Table. 2. Reported complication of no flow and no reflow of rotational atherectomy (RA) in % followed by drug eluting stent (DES).**

| Trial/First Author | Year | Number | Slow flow/no reflow |
|---|---|---|---|
| Rotaxus.[12] | 2013 | 120 | 0.0 |
| Abdel-Wahab et al.[13] | 2013 | 205 | 1.9 |
| Benezet et al.[14] | 2011 | 102 | 0.0 |
| Garcia de Lara et al.[15] | 2010 | 50 | 0.0 |

The table above shows the study done regarding the percentage of slow flow/no reflow complication of rotational atherectomy. The highest percentage of slow flow/no flow was reported to be 1.9% in the studies we selected. These studies show the occurrence of no flow and no reflow complication. These are the studies carried out in recent years and carries the most recent techniques and approaches available. After analyzing these study, we can simply ascertain that the chances of occurring of slow flow/no reflow complication is below 2% in recent times when using DES after the procedure. In the studies shown in the table above drug eluting stent were implanted post rotational atherectomy. Tomey et al.[1] suggested, combined with meticulous technique, optimal antiplatelet therapy, vasodilators, flush solution, and provisional use of atropine, temporary pacing, vasopressors, and mechanical support may prevent slow-flow/no-reflow, which in contemporary series is reported in 0.0% to 2.6% of cases.

**Table. 3. Potential mechanism of slow flow/no reflow during rotational atherectomy and associated strategies for prevention and treatment.[17]**

| *Mechanism* | *Therapeutic Strategy* |
|---|---|
| Atheromatous debris embolism | Small burr sizing<br>Intermittent ablation<br>Avoidance of significant decelerations |
| Platelet activation, aggregation and lysis | Optimum antiplatelet therapy, including use of glycoprotein IIb/IIIa inhibitor |
| Microcirculatory vasospasm | Vasodilators<br>Liberal use of flush solution |
| Neurohumoral reflex bradycardia | Atropine, Temporary venous pacemaker (especially for lesions in a dominant right coronary artery) |
| Intraprocedural hypotension | Vasopressors (in particular, phenylephrine) intra-aortic balloon counterpulsation |

Recommend technique for rotational atherectomy is also very helpful in lowering its complications especially slow flow/no reflow. Recommended technique for rotational atherectomy as under.

**Table. 4. Importantly, optimal RA technique is tailored to serve as a complication avoidance strategy and mainly consists of the following components.[1,17,18]**

| | |
|---|---|
| 1. | burr/artery ratio 0.5 to 0.6, while primarily using small burrs (1.25 and 1.50 mm) for plaque modification, with the aim of avoiding angiographic complications, such as no reflow.[19] |
| 2. | lower than traditional ablation speed (140 000–150 000 rpm), based on the findings that burr speed is linearly associated with platelet aggregation.[20] |
| 3. | avoidance of decelerations of >5000 rpm for cumulative >5 s because the loss in speed was associated with increased rate of periprocedural MI and restenosis.[21] |
| 4. | burr advancement using pecking motion in short ablative runs of 15 to 20s to avoid excessive damage to the vessel wall and minimize the risk of burr entrapment. |
| 5. | continuous intracoronary flushing with nitroglycerine, heparin, and verapamil or nicorandil or adenosine to avoid spasm and no-reflow.[22,23] |

## DISCUSSION

When rotational atherectomy first introduced in 1989 it showed significant complication of slow flow/no reflow that limited the use of this technique. Later after different strategies like flush cocktails of vasodilator, glycoprotein IIb/IIIa and drug eluting stents (DES), this complication gradually decreased. In the ROTAXUS[12] trial, 240 patients were selected which they divided into two groups in halves. Half of the patient were given rotational atherectomy + paclitaxel-eluting stents (PES) whereas half of the patient were treated with PES without rotational atherectomy, labelled as Standard Therapy. Reported complication of no flow and no reflow were 1.1% of 120 patients. No any patient showed complication of slow flow/no reflow shown in RA+PES group but only 1 patient in Standard Therapy group showed this complication. In Abdel-Wahab et al.[13] study which was published in 2013 performed RA on 205 patients. Total number of lesions were 261. The percentage of no slow and no reflow was 1.9. DES was implanted post RA.

In Benezet et al.[14] study conducted in 2011 total 102 persons were performed RA and no any case of slow flow/no flow were reported. In Gracia et al.[15] study 50 patients were selected for the study. All patients received acetylsalicylic acid (150-300 mg/day) and clopidogrel (300 mg of load, 75 mg/day) from at least 24 hours preoperative. None case of no flow and slow reflow were reported during the procedure. Above table shows the

number of patient with slow flow/no reflow post RA and all of them went through DES. There are not much studies that are more related to the incidence of slow flow/no reflow post RA procedure. In a study conducted by Sakakura et al.[16] in 2016 found the slow flow/no reflow cases in higher number while treating chronic total occlusion with different speed. Total 100 patients were treated with rotational atherectomy in which half of them were treated with high speed and half with high speed rotational atherectomy. Speed of rotational atherectomy burr was at 140,000 rpm in low speed atherectomy whereas high speed atherectomy was at 190,000 rpm. Result showed 24% incidence of slow flow phenomenon on both groups. As seen numbers of incidence seems lower at most of the studies, it can be due to use of different medicines pre, intra and post procedure. Use of adenosine, vasodilator and glycoprotein IIb/IIIa has decreased the incidence of slow flow/no reflow. There are many causes of slow flow/no reflow in rotational atherectomy. Common mechanism of slow flow and no reflow and approach to the complication is summarized in the table below.

## CONCLUSION

Rotational atherectomy seems successful in treating calcified coronary vessels. Slow flow/no reflow was considered major complication in the past which caused decline in its use but after availability of different approaches like flush of heparin, vasodilator, glycoprotein IIb/IIIa, drug eluting stents and improvement in techniques has made this technique very useful nowadays while treating calcified coronary vessels during PCI. The total incidence of slow flow/no reflow seems to be at lower side below 2.6 % when following recent pharmacological flush, recommended techniques and drug eluting stents.

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