Case Report

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Successful percutaneous treatment of coronary steal syndrome with the amplatzer vascular plug 4 and coil embolization

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Summary **The left internal mammary artery (LIMA) is widely used in coronary artery bypass grafting surgery due to its long term perfect patency rates. However, coronary steal syndrome can occur because of unligated LIMA side branches and it causes blood flow from coronary artery to LIMA. Even though the optimal therapy of coronary steal syndrome is still controversial, some percutaneous and surgical treatment modalities can be used in the treatment of steal phenomenon for relieving angina and resolving ischemia. It was demonstrated that percutaneous treatments such as the use of gelatin sponge particles or drug-eluting stents with covered stent, and coil and vascular plug embolization were used to treat this phenomenon successfully. Several studies revealed that these percutaneous treatments can reduce the ischemic area and results in prevention of blood flow from coronary artery to LIMA side branches. Supporting these findings, we herein present a 48-year-old male patient with objective ischemia with coronary steal syndrome treated successfully with the Amplatzer vascular plug (AVP) 4 and coil embolization in the same procedure. To the best of our knowledge, the combined therapy has not been described in the literature yet. Supporting the literature findings, successful treatment of LIMA side branches in our case with two different percutaneous modalities results in improvement of coronary flow and a reduced ischemic area and angina.**

Keywords: Coil embolization, coronary steal syndrome, left internal mammary artery, vascular plug embolization

1. Introduction

The left internal mammary artery (LIMA) is widely used in coronary artery bypass grafting (CABG) surgery due to its long term perfect patency rates and having better clinical outcomes than saphenous grafts (*1*). Despite being an excellent conduit, unligated side branches of the LIMA can cause coronary ischemia due to coronary steal syndrome. Although the benefit of treatment of unligated side branches is shown, optimal therapy for coronary steal syndrome is controversial. Several methods have been described to treat coronary steal syndrome with perfect clinical benefits such as coil (*2*) and vascular plug embolization (*3*), the use of gelatin sponge particles or drug-eluting stents with covered stent (*4*) and surgical ligation of side branches (*5*). It was demonstrated that occlusion of unligated side branches is related to ischemia and angina regression (*6*). However, in a study coronary steal syndrome was evaluated with coronary flow measurements at rest or following adenosine hyperemia and left arm exercise, and there was not any clear evidence of true coronary steal phenomenon (*7*). Even though mentioned methods have been used in the treatment of coronary steal syndrome successfully, to the best of our knowledge using two different percutaneous treatments together in the same procedure has not been described in the literature yet. We herein present a case of successful

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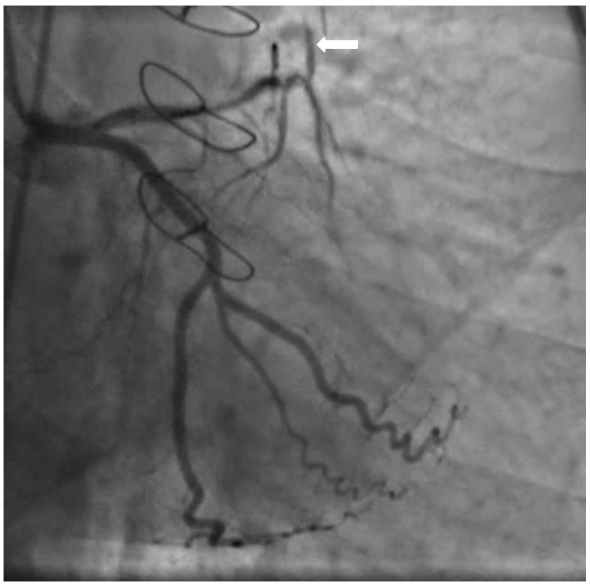

Figure 1. Coronary steal syndrome. It was demonstrated by coronary angiography with arterial blood flow from LAD to LIMA (arrowhead).

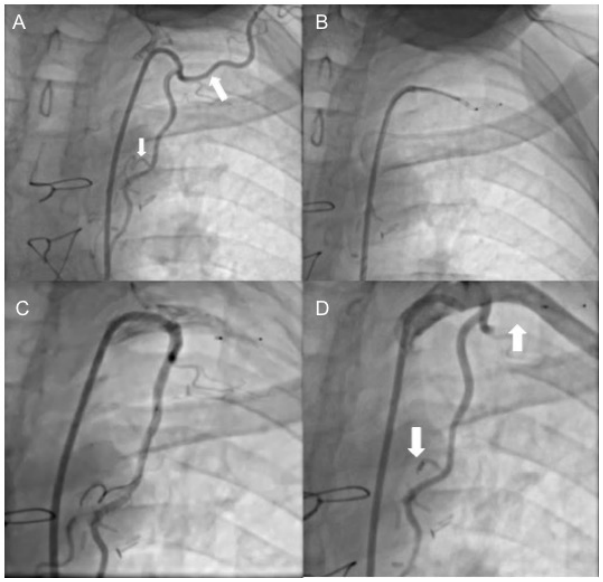

Figure 2. Percutaneous treatment of coronary steal syndrome. (A), Coronary angiography revealed that LIMA had two separate unligated side branches (arrowheads); **(B)**, The 4x10mm Amplatzer vascular plug 4 was released into the proximal side branch; **(C)**, The 2 × 3 mm coil was released into the small caliber side branch; **(D)**, The procedure was terminated showing complete flow cessations into the mentioned arteries (arrowheads).

percutaneous treatment of coronary steal syndrome with the Amplatzer vascular plug (AVP) 4 and coil embolization in the same procedure.

2. Case Report

A 48-year-old male patient was admitted to department of cardiology one year ago with worsening angina that had been ongoing for 2 months. He had undergone a coronary artery bypass surgery 10 years ago and percutaneous coronary intervention to the left anterior descending (LAD) artery 3 years ago. He had no property on physical examination. Electrocardiography indicated normal sinus rhythm with anterior T wave negativity. Echocardiography imaging revealed apical hypokinesia with a normal ejection fraction. Myocardial perfusion scintigraphy showed extensive ischemia in the anterior wall and then coronary angiography was performed. It was shown that there was an instent restenosis into the proximal LAD artery before surgical anastomosis site and the LIMA-LAD grafting was patent. However, coronary steal syndrome was detected due to unligated LIMA side branches from LAD to the LIMA artery (Figure 1). Also there was no significant lesion in the left circumflex artery or the right coronary artery. The patient was evaluated by our cardiology and cardiovascular council and percutaneous treatment of unligated LIMA side branches was planned. Digital subtraction angiography was performed *via* the right common femoral artery using 7-French (F) femoral sheath. LIMA was selectively cannulated with an internal mammary artery (IMA) 7F guiding catheter (Medtronic, New York, NY). It was demonstrated that LIMA had two separate side branches (Figure 2A). The large branch arose from the proximal LIMA and the small one arose from the mid LIMA. The proximal side branch was selectively cannulated with a Judkins Right (JR) 5F guiding catheter (Medtronic, New York, NY) through the IMA guiding catheter. The 4 × 10 mm AVP 4 was released into the proximal side branch *via* JR 5F guiding catheter and flow was ceased (Figure 2B). Then, a 0.014" wire (Fielder XT, Asahi Intecc) was passed into the mid side branch. The microcatheter (Codman Prowler, Johnson&Johnson) was then advanced over the wire into the side branch. The 2 × 3 mm coil was released into the side branch *via* microcatheter (Figure 2C). The procedure was terminated showing complete flow cessations into the mentioned arteries (Figure 2D). The patient was discharged from the hospital 2 days later after intervention with no symptoms. The patient follow-up visits were done every 3 months. He is still being followed-up without any symptoms and also myocardial perfusion scintigraphy showed regression of ischemia.

3. Discussion

LIMA is still preferred as a graft for surgical myocardial revascularization with an excellent long term patency (*1*). However, some factors can cause acute or long term graft malfunction. Intraoperative technical problems, spasm or stretch of the graft are related to acute graft malfunction. Contrary to the mentioned reasons, progression of atherosclerosis, kinking of graft, competitive flow and steal due to unligated side branches are some of the factors to determine long

term graft patency. Although sternal, intercostal and perforating branches of the LIMA are small caliber arteries and generally do not create ischemia, the lateral internal thoracic artery is the large side branch of the LIMA with a prevalence of 10% in the main population and is found to be associated with clinically evident ischemia (*8*). Thus, unligated side branches of the LIMA are potential facilitative factors for coronary ischemia. Obese patients and patients treated with minimal invasive CABG surgery are having low success rates for ligation of LIMA side branches (*9,10*). In the literature analysis, ischemia is observed more commonly in the myocardial perfusion scintigraphy in these patients having unligated LIMA side branches (*11*). Conversely, Guzon *et al*. demonstrated that there was no clear evidence of ischemia in patients with coronary steal syndrome (*7*).

The optimal treatment of coronary steal syndrome due to unligated side branches of the LIMA is still controversial. Percutaneous or surgical treatment can be performed in patients with progressive worsening angina that is clearly related to competitive run off into the side branches and having objective evidence of ischemia. It was demonstrated that generally anginal symptoms improve and ischemia resolves after occlusion of LIMA side branches (*6*). Percutaneous treatment options such as stent grafts, coil and vascular plug embolization have some advantages and disadvantages. The use of drug-eluting stents with covered stent seems to have high success rates. However, high long term restenosis rates with an incidence of 31.6% is the main disadvantage of the procedure (*12*). Coil embolization is a safe and effective modality having a rapid occlusion time. While coil embolization is a preferable method, it cannot be a suitable option to treat large caliber vessels. The distance between the coil and exit of the vessel, the number of coils used and the coil diameters and features are the responsible factors for recanalization after occlusion of LIMA side branches. The AVP 4 is a self-expanding Nitinol mesh occlusion device having the ability to safely remove the problem. The AVP device has some advantages such as ease of delivery, wide range of device sizes, shorter operation time, lower radiation rates and lower risk of recanalization. On the other hand, small caliber vessels are not suitable to occlude with the AVP. Mentioned treatment modalities were successfully done in different cases in the literature. However, in these cases, generally a large side branch of LIMA was treated and relatively small caliber vessels were ignored. Although we treated our patient with percutaneous intervention like other cases in the literature, the major difference was the usage of two different percutaneous treatments for both the large and the small caliber side branches together in the same procedure. While the AVP was used to treat the large caliber side branch, coil embolization was used to treat the small one. This approach provided complete resolution of coronary steal phenomena. We also demonstrated that blood flow cessation of all unligated side branches are important to reduce ischemia and angina. To the best of our knowledge, our strategy was the first study of percutaneous treatment of all side branches unexceptionally. However, large-scale studies are needed to evaluate optimal therapy and selection of suitable cases.

In conclusion, coronary steal syndrome is one of the most important reasons for ischemia and anginal symptoms in patients undergoing CABG surgery. Although the optimal therapy is controversial, percutaneous treatment modalities such as coil and AVP embolization seem to have a broad use to treat these patients with higher procedural success and lower complication rates.

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