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Endovascular Therapy in Coronary-Subclavian Steal Syndrome: A Clinical Case

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Abstract: Background: Coronary-subclavian steal syndrome (CSSS) is a clinical condition characterized by the reversal of blood flow in the internal mammary artery in patients who have undergone coronary revascularization using this artery. CSSS develops due to significant stenosis or proximal occlusion in the subclavian artery. It is a rare syndrome that is becoming increasingly significant because of the continuous use of the internal mammary artery in coronary revascularization. It presents clinically with cardiac ischemia and, more rarely, acute myocardial infarction. Objective: The authors describe the case of a patient who underwent coronary revascularization five years ago (in 2012) with the internal mammary artery and two more saphenous vein bridges, and recently (in 2017) presented with recurrent chest pain with irradiation to the back, related to physical activity, mainly involving the upper limbs. Method: On physical examination, he had no axillary, brachial, radial, and ulnar pulses on the upper left limb, and the blood pressure on the upper limbs was significantly different (on the right 130/70 mmHg and on the left 80/60 mmHg). He was diagnosed with CSSS. Myocardial scintigraphy was initially performed with a suggestive finding of an ischemic area on the anterior wall. Cardiac catheterization identified permeability of both bridges and absence of new lesions in the coronary arteries and identified ostial occlusion of the left subclavian artery. Results: He underwent angioplasty and balloon-expandable-stent implantation with complete remission of the symptoms. Conclusion: Therefore, the authors conclude that endovascular therapy with angioplasty and subclavian artery stenting is the treatment of choice for CSSS, due to the high success rates, minimally invasive procedure, and low morbidity and mortality rates, and this condition should always be suspected in patients with a history of myocardial revascularization, clinical angina, and asymmetry between upper limb pulses.

Keywords: Coronary-Subclavian Steal Syndrome, Coronary Bypass, Internal Mammary Artery, Subclavian Stenosis, Myocardial Ischemia

1. Introduction

Coronary-subclavian steal syndrome (CSSS) that was described for the first time in 1974 by Harjola and Valle [1], develops in 0.5% to 2% of patients who undergo coronary artery bypass surgery [2], and should be considered in the differential diagnosis of patients with a clinical history of angina and previous revascularization using the internal thoracic artery (IMA) [3].

It is well known that the use of left internal thoracic artery for coronary artery revascularization has been associated with better long-term patency and patient survival than the use of a saphenous venous graft because in situ has superior patency rate and survival benefit when grafted to the left anterior descending artery [3, 4, 5]. The internal thoracic artery is the most frequently used graft to restore coronary circulation because of its longevity [1-5].

Each subclavian artery has four main branches, the internal

thoracic artery being one of them and represent the most common site of stenosis from atherosclerotic disease [4, 5].

Atherosclerosis is responsible for more than 90% of subclavian artery stenosis. Less common etiologies of subclavian artery stenosis include arteritis (eg. Takayasu arteritis, giant cell arteritis), inflammation, radiation exposure, compression syndromes, fibromuscular dysplasia, and neurofibromatosis [3, 4, 5].

The CSSS should be suspected in patients who have undergone revascularization using the IMA and presenting with pulse and blood pressure differences in the upper limbs and clinical manifestations of angina. Significant stenosis or even occlusion of the subclavian artery proximal to the IMA may lead to a decrease in blood flow to the upper limb, triggering an inversion of the flow in the IMA with a concomitant hemodynamic "steal" of the coronary blood flow to the upper limb [4-9]. The main cause of this syndrome is atherosclerosis and can lead to acute myocardial infarction and thus should be included in the differential diagnosis of angina in patients with previous revascularization [10]. Preoperative angiography or angiotomography of the subclavian artery should be considered in patients with asymmetric upper extremity blood pressures [1, 2, 3].

The objective of this study was to report endovascular therapy with left subclavian artery stenting as a safe, minimally invasive, and effective method to treat CSSS.

2. Clinical Case

The authors describe the clinical case of a 69-year-old male patient, former smoker, with a personal history of hypertension, dyslipidemia, and diabetes. In 2012, he underwent coronary revascularization after an acute myocardial infarction, using the left IMA for revascularization of the anterior descending artery and the internal saphenous vein for the marginal oblique artery.

In January 2017, he presented with retrosternal thoracic pain with dorsal irradiation, which was relieved with rest. He was admitted to the intensive care unit with the diagnosis of acute coronary syndrome because of recurrent pain at hospitalization. The analytical study showed an increase in markers of myocardial necrosis, with no ST elevation on the electrocardiogram. He associated the pain with physical activity, mainly involving the upper limbs. He denied symptomatology of lower limb claudication, dizziness, or syncope. Physical examination showed absence of axillary, brachial, radial, and ulnar pulses on the left upper limb, and the blood pressure on the upper limbs was significantly different (130/70 mmHg on the right and 80/60 mmHg on the left). He did not have supraclavicular or carotid artery murmurs, and the arterial pulses on the right upper limb were normal.

Myocardial scintigraphy was initially performed and an ischemic area was noted in the anterior wall. Cardiac catheterization identified permeability of both bypasses, absence of new lesions in the coronary arteries, ostial occlusion of the left subclavian artery (Figure 1), and reverse flow in the IMA to the left subclavian artery (Figure 2); thus, the patient was diagnosed with CSSS. Doppler examination of the carotid and vertebral arteries confirmed subclavian steal syndrome showing inversion of flow in the left vertebral artery. Considering this diagnosis, endovascular therapy was proposed for left subclavian artery sub-occlusion. Thus, by left brachial access, passage of a guidewire, subsequent predilation of the sub-occlusion, and balloon-expandable-stent implantation (8.0 × 30 mm) were performed (Figure 3).

Figure 1. *Sub-occlusion of subclavian artery*

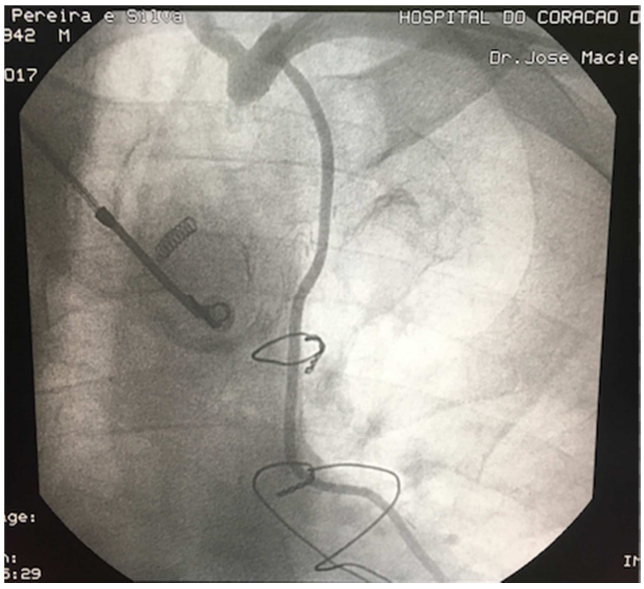

Figure 2. *Reverse flow in the IMA to the left subclavian artery.*

Figure 3. *Stent in the subclavian artery.*

The procedure was uneventful, and in the postoperative period, there was complete remission of symptoms and no tension differences between the upper limbs: 130/70 mmHg on the right and 120/60 mmHg on the left, with recovery of arterial pulses on the left upper limb. The patient continues to receive dual antiplatelet therapy with acetylsalicylic acid and clopidogrel, and after 6 months of follow-up, the patient remains clinically asymptomatic, with symmetrical pulses and no significant tension differences between the upper limbs.

3. Discussion

The mammary artery was first used for myocardial revascularization in 1970 by Green et al. [11] and, due to its excellent long-term permeability estimates, has become the preferred approach for coronary revascularization [12]. Therefore, CSSS, although a rare condition, presents significant morbidity and possible complications and should always be suspected in patients who have undergone myocardial revascularization with IMA and present with recurrence of precordialgia-like symptoms, especially when the symptoms are triggered by physical activity [3, 13]. So, the clinical variability of CSSS should be include exercise angina, silent ischemia or even AMI with or without electrocardiographic changes [2, 6].

Atherosclerosis is the most common cause and the incidence in patients with atherosclerotic disease is around 3%. The presence of peripheral vascular disease is the best predictor of its occurrence. On the other hand, subclavian stenosis or occlusion is a marker for atherosclerotic disease elsewhere, such as in the coronary, carotid, and peripheral arteries. So, its prevalence is difficult to determine, because many patients show no symptoms, owing to the development of a supplementary collateral network [3, 6].

On examination, simultaneous palpation of the bilateral radial pulses can reveal delayed or decreased amplitude. Our patient had a significant difference in brachial systolic blood pressure between arms, precisely more than 15 mm Hg [3, 4, 5].

The Duplex ultrasound is a first-line screening test for diagnosing subclavian artery stenosis. It's possible to identify atherosclerotic plaque in the subclavian and brachiocephalic arteries, and in patients with CSSS typically show systolic reversal of flow in the ipsilateral vertebral artery. But this method is limited in evaluating the deeper areas of proximal subclavian because of insufficient visualization [3-7, 11, 12]. So, in some cases you need to perform angiography, angioresonance or angiotomography [3-9].

In our case angiographic findings performed by Judkins technique were confirmed by selective catheterization of the left subclavian artery via the femoral artery. During an attempt to catheterize the mammary artery, we observed occlusion of the left subclavian artery, which helped to clarify the clinical setting: angina caused by ischemia of the left ventricular anterior wall.

More proximal subclavian artery obstructive plaques may compromise the anterograde flow in the IMA, a situation that may trigger subclavian vasodilation distally and may be intensified with physical activity in the upper limbs, causing the reversal of the flow in the IMA. In total obstruction, the flow in the IMA can be reversed even without activity, causing a persistent circulatory steal in the region of the anterior descending artery [14,]. Therefore, development of this syndrome is primarily due to the progression of atherosclerotic disease, with involvement of the subclavian artery after coronary artery bypass surgery and the nonrecognition of pre-existing lesions in patients who have undergone myocardial revascularization [15].

Therefore, despite the rarity of this syndrome, it is crucial for all patients with a history of myocardial revascularization surgery to undergo an objective and thorough physical examination, including measurement of the systolic blood pressure in the upper limbs, palpation of the pulses, and auscultation of the supra- and infraclavicular regions. In case of significant alterations, it is necessary to perform tests for diagnostic confirmation, such as echocardiography, angiotomography, and/or angiography [10].

Abdul Jabbar et al. [05] reported that treatment options for complete remission of symptoms in subclavian artery stenosis include surgical bypass, percutaneous angioplasty, and stenting. While surgical bypass has previously been the favored option, good initial success rates and effective long-term primary patency with endovasccular stenting have established percutaneous therapy as the favored approach [4, 5]. In addition, previous studies [15, 17] have been described lesions in subclavian artery with heavy calcified stenosis that can result in dissection after predilatation. So, endovascular approach can be used to treat CSSS but the occurrence

of potentially lethal complications is possible and needs prompt correction with open surgery.

Over the last decades, endovascular therapy of the subclavian artery has presented high technical success rates (97%) and excellent long-term permeability rates (89–95%, after 5 years), with faster recovery, shorter hospital stay, and lower morbidity and mortality rates (4.5%) compared to conventional surgery. Thus, the interventional technique, with stent implantation, became the preferred method to correct CSSS [8-10, 16-18]. As with all comparisons between percutaneous endovascular procedures and surgical revascularization, primary patency rate is lower with endovascular techniques but has improved dramatically with the introduction of stent support in addition to balloon angioplasty [4, 5]. However, conventional surgical correction is still the approach to be adopted if it is not possible to transpose the lesion during angioplasty in long or calcified occlusive lesions where there are significant risks of embolization for either cerebral circulation, the upper limb, or even the IMA [8, 10, 16].

Subclavian steal usually appears around three years after revascularization surgery. Cases of earlier presentation generally result from a hemodynamically significant pre-existing lesion in the proximal section of the subclavian artery [19, 20]. The standard treatment for subclavian steal is by percutaneous transluminal angioplasty of the subclavian artery or by carotid-subclavian bypass. In our case, percutaneous revascularization was performed without technical problems.

The measures to avoid the appearance of CSSS begin with an adequate preoperative assessment: evaluating the presence of symptoms of claudication in the arms, auscultation of the supraclavicular area and taking of arterial pressures in both arms and symmetry of brachial pulses. If any finding suggests occlusive disease of the subclavian artery, angiography or angiotomography is mandatory during the diagnostic study [3-9, 16-19].

This patient had the classic presentation for coronary-subclavian steal. His noninvasive blood pressure, diminished left upper extremity pulses, and left clavicular bruit in a patient with known peripheral vascular obstructive disease like were all consistent with the diagnosis [8, 10].

Thus, patient follow-up is essential, to not only perform noninvasive examinations to detect new lesion but also suggest lifestyle changes that minimize cardiovascular risks and potential progression of atherosclerotic disease.

4. Conclusion

Considered to be an unusual cause of recurrent myocardial ischemia. it's existence is becoming more significant thanks to the bypass surgery in the left internal thoracic artery. The prevalence of CSSS has been underestimated and duplex ultrasound, angiotomograph or angiography of the subclavian artery should be considered in all patients with clinical finds like asymmetric upper extremity blood pressures and clinical manifestation. Endovascular therapy with angioplasty and subclavian artery stenting is currently the treatment of choice for CSSS, because of its high success rates and mainly because it is minimally invasive and presents low morbidity and mortality rates.

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