Coronary-Subclavian Steal Syndrome Following CABG: a Case Report and Literature Review

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Abstract

Introduction: Coronary-subclavian steal syndrome (CSSS) is not a common complication but it can cause recurrent angina following coronary artery bypass grafting (CABG). CSSS results from proximal subclavian artery stenosis causing reversal of blood flow in a patent in situ internal thoracic artery utilized as a conduit in CABG, leading to myocardial ischemia.

Case Presentation: We present a case of CSSS successfully treated with carotid-subclavian bypass (CSB). A review of articles on the subject has also been conducted.

Conclusions: Although CSSS is not a common condition, it should be strongly considered as a possibility in CABG patients presenting with recurrent chest pain not to be confused with perioperative myocardial infarction (PMI). If indicated, carotid-subclavian bypass may be performed as an effective treatment option with acceptable outcomes.

Keywords: Coronary Artery Bypass, Coronary Subclavian Steal Syndrome

1. Introduction

Since its first use in 1970 by Green et al. (1) the internal thoracic artery is currently the preferred conduit for CABG procedures. As compared to the saphenous vein, it holds superior patency, survival, and is highly resistant to atherosclerosis (2, 3). The internal mammary artery (IMA) arises from the subclavian artery. Therefore, the blood flow in the left internal mammary artery (LIMA) used as a graft could be compromised as a result of proximal subclavian artery stenosis (4).

CSSS, first described by Harjola and Valle in 1974 (5) is a rare condition resulting from stenosis in the left subclavian artery. Occlusion or stenosis of the proximal subclavian artery may culminate in the stealing of flow from the IMA, leading to myocardial ischemia. Clinical manifestations vary from exertional chest pain to unstable angina and in very rare instances myocardial infarction (6). Most of the time, routine aortic arch angiography is not accomplished prior to CABG. Hence, undiagnosed subclavian artery stenosis may result in the recurrence of symptoms at different intervals after the operation (2).

We introduce a CSSS case with recurrent chest pain following CABG, treated with carotid-subclavian bypass.

2. Case Presentation

A 60-year-old male presented with chest pain, left arm cramping, and paresthesia. He had a previous history of three grafts CABG six years ago. Initially, typical chest pain ameliorates after surgery but recurs after a short period of six months. The patient described that the chest pain was stimulated with mild physical activity, radiating to the left arm.

Upon physical examination, weakened pulses on the left brachial and radial arteries along with a marked difference of blood pressure between the two arms (left 85/75, right 115/78) were noted. Carotid pulses were palpable bilaterally. An EKG demonstrated myocardial ischemia in the lateral and precordial leads. Laboratory tests revealed a normal blood cell count, and normal level of cardiac enzymes. Moderate left ventricular systolic dysfunction (LVEF: 40%) and anterolateral and apical hypokinesia were observed in preoperative echocardiography. A myocardial perfusion scan showed considerable ischemia of the apico-septal and anterolateral regions.

The patient was appraised by an aortic arch and coronary angiography study. Coronary angiography revealed triple native vessel coronary disease with a patent graft on obtuse marginal (OM) and retrograde flow through the patent left internal mammary artery (LIMA) to the left anterior descending (LAD) coronary artery (Figure 1), but a totally occluded graft on the posterior descending (PDA) coronary artery. The left subclavian artery was not observed in aortic arch angiography (Figure 2). Left brachial angiography documented total obstruction of the proximal left subclavian artery (Figure 3).

Given the chronic occlusion of the subclavian artery,
the patient was scheduled for left common carotid-subclavian bypass surgery. Before surgery, successful stenting of the right coronary artery (RCA) was performed by a cardiac intervention specialist (Figure 4).

2.1. Surgical Technique

During the operation, the patient was placed in the supine position and surgical exposure of the left subclavian and left common carotid arteries was obtained via a supraclavicular incision. A suitable length of the subclavian artery was released and exposed to the bypass. The identified segment of the subclavian artery was distal to the LIMA. The brachial plexus, located lateral to the dissection plane, was not impinged upon. After exposure of the arteries, the patient was given an intravenous bolus of heparin (30 U/Kg). Clamping of the common carotid and subclavian arteries was obtained by use of partial clamp and occluding tape, respectively. An 8 mm PTFE (Gore-Tex) graft was then first sewn onto the common carotid and then onto the subclavian artery with continuous polypropylene sutures. After releasing the clamps, arterial blood was first redirected to the left arm and finally to the proximal subclavian artery in order to mitigate the hazard of embolization into the vertebral and coronary arteries.

The patient recovered uneventfully and the initial presenting symptoms were completely alleviated postoperatively. Postoperative CT angiography confirmed the patency of the graft between the carotid and subclavian arteries (Figure 5). Since then, the patient has remained asymptomatic (six months after surgery).

3. Discussion

The LIMA is the conduit of choice for coronary artery bypass grafting due to its greater long-term patency and its remarkable resistance to atherosclerosis. However, occlusive disease of the proximal subclavian artery can compromise the blood flow in the LIMA, supplying the LAD coronary artery (7).

The mechanism of CSSS has recently been challenged by Marc et al. (2015) in a case study and review of the literature. According to the findings in the paper, besides the decrease of coronary flow as a usual mechanism, ulcerated or complicated atherosclerotic plaques may also play a role.
Figure 4. Selective Right Coronary Artery Angiography Before A, and after B, successful stenting of the RCA

Figure 5. Postoperative CT Angiography (Coronal View), Documenting the Patent Graft Between the Carotid and Subclavian Artery (Indicated by the Arrow)

in the development of CSSS. Therefore, a high dose atorvastatin and ACE inhibitors have been deemed necessary for proper treatment in addition to classic subclavian revascularization and antiplatelet therapies (8).

First reported in 1974, CSSS with reversed blood flow in the LIMA to the LAD bypass graft is an uncommon disorder following cardiac surgery (4, 5). To date, at least 50 cases have been published in the literature (9). Despite these reports, the incidence of symptomatic CSSS after CABG remains low (3, 4) with estimates ranging from 0.5 - 1.1% of patients (2, 6, 9-11) but these rates are likely underestimated (6, 12). For instance, CSSS has been reported in up to 3.4% of patients in other studies (12, 13). Taking into account the advancing age of patients who are candidates for CABG and the increased frequency of cerebrovascular and peripheral vascular disease, it is expected that the incidence rate of CSSS will increase in the near future (6).

The most common cause of CSSS is atherosclerosis (95 - 97% of cases). Radiation therapy for Hodgkin's lymphoma, Takayasu's arteritis, thoracic outlet syndrome, and congenital aortic abnormalities have also been reported as possible etiologies in various studies (4, 9). According to a case report by Gersbach et al. in 1990, an early diagnosed patient with CSSS recovered spontaneously within a few months. The authors concluded that postoperative hematoma or edema caused temporary compression of the subclavian artery, which resulted in CSSS. In most other reports, however, subclavian stenosis was an undiagnosed, asymptomatic condition, existed preoperatively that progressed subsequent to surgery (14). CSSS has also been reported in a patient on hemodialysis with an arteriovenous fistula in the left arm who had undergone CABG (15).

Angina pectoris is the main symptom of CSSS. The intensity of angina is determined by the physical activity of the patient and the extent of subclavian revascularization. Typically, the patient experiences recurrent chest pain after primary amelioration following surgery, and this could be induced and aggravated by physical activity using the left arm. Acute myocardial infarction is rare (4, 13). The time interval between CABG and the onset of symptoms differs widely in various studies, ranging from 10 days to 13 years (mean: 25 ± 37 months) (2, 10).

In a series of 27 patients undergoing pre-coronary bypass evaluation, Doros et al. have shown that stenosis of the left subclavian artery is more commonly encountered than stenosis of the right subclavian artery (16). Significant stenosis of either subclavian artery gives rise to a difference of blood pressure higher than 20 mm Hg between the two arms. This was an important finding in our patient as well. Although reduced blood pressure compared to the contralateral arm in association with absent or weak-
enforced radial pulse is suggestive of inadequacy in subclavian blood flow (4) a normal pulse and blood pressure does not rule out the disease (13). Subclavian and cervical bruises may also be heard upon physical examination (2, 3, 6, 13). Left hand vascular or neurological symptoms and signs (including pain, pale and cold skin, and paresthesia) are not common (4). In fact, even severe subclavian artery stenosis in non-cardiac patients is commonly asymptomatic and surprisingly well-tolerated because of sufficient collateral flow from the brachial arterial supply around the humerus (10). It should also be added that typical symptoms of vertebrobasilar insufficiency, owing to reversed blood flow in the vertebral artery that is noted in subclavian steal syndrome, may be observed as well (4). However, neurological disorders were not found in our patient.

Direct subclavian artery and aortic arch arteriography are the methods of choice for diagnosing subclavian artery stenosis or occlusion. Coronary angiography demonstrates filling of the LAD and retrograde flow along the LIMA graft. A CT scan or MRI, duplex ultrasonography, and Doppler echocardiography have been described as alternative diagnostic procedures (4, 13). Diagnosis was further confirmed in our case with left brachial arteriography all the way to the left subclavian artery, showing occlusion at its origin (Figure 3).

Recently, positron emission tomography (PET) with rubidium has been recommended for diagnosis of the disease. In some cases, it may provide more reliable information about the myocardial ischemic territory and the coronary flow reserve (17). Again, multimodality imaging has been advocated as an effective method of diagnosis. In a case report by Toprak in 2015, 3D reconstruction of CT angiography was used to diagnose occlusion of the left subclavian artery, and Doppler sonography was used to confirm the reversal of blood flow in the LIMA graft (18).

Thus far, the treatment of choice for patients with concurrent coronary and subclavian artery disease or CSSS has not been substantiated. Classically, subclavian artery occlusion has been managed with surgical revascularization using either an intra or an extrathoracic approach. Intrathoracic approaches involving thoracotomy and then either subclavian endarterectomy or aorto-subclavian bypass have a reported mortality and morbidity rate of 18-23%. Carotid-subclavian bypass grafting using a synthetic conduit (Dacron or PTFE) is the most common extrathoracic operation. According to several reports, it has acceptable long term patency. Angioplasty and stenting have been introduced more recently to treat subclavian stenosis or short, fresh obstructions. They have a low morbidity and mortality rate with good short term results. However, long term outcomes remains to be established. The option for interventional versus operative procedures is determined by the anatomic distribution of the disease and the individual risk factors (6, 7). To date, no randomized trial has been performed to compare surgery with angioplasty in the management of subclavian stenosis (13).

Pharmacologic therapy has also been reported in the treatment of CSSS. According to these reports, patients with full-blown CSSS should receive invasive management (surgery or angioplasty). However, in patients with asymptomatic or intermittent CSSS, a combination of two antiplatelet drugs (acetylsalicylic acid (Aspirin) plus ticlopidine) can be used (19).

Despite the controversies, it is wise to assume that percutaneous transluminal angioplasty with an intraluminal stent placement is the treatment of choice in the case of stenosis or recent obstruction of the subclavian artery (4). Angioplasty of the subclavian artery was first outlined by Bachman and Kim in 1980 (20) but the first report of successful treatment of coronary steal syndrome with percutaneous transluminal angioplasty (PTA) was published in 1986 (21). Since then, it has gained increasing popularity over the last few decades due to the lesser extent of invasiveness (10), decreased complications, and avoidance of general anesthesia in this high-risk group of patients (3). Considering total ostial obstruction of the left subclavian artery, our case was not an eligible candidate for angioplasty of the vessel. If an interventional technique is not feasible as in cases of chronic total occlusion, surgical revascularization through carotid subclavian bypass can be performed. Endarterectomy of the subclavian artery (with or without patch repair) may also be needed.

Recently, bifurcation T-stenting using a coronary drug-eluting and self-expandable bare metal stent has been utilized for subclavian revascularization in a CSSS patient with severe bifurcation stenosis of the left subclavian and vertebral artery (22). In rare circumstances, particularly when other regions of the myocardium need to be revascularized, redo CABG can also be considered as an alternative treatment option. During the procedure, the LIMA may be cut in the proximal portion and utilized as a free graft, thereby interrupting its inflow dependency upon the subclavian artery. Alternatively, saphenous vein grafting onto the LAD could be considered. A major drawback of this approach is that it merely relieves myocardial ischemia, and other problems due to stenosis of the subclavian artery cannot be dealt with during the operation (4).

Extrathoracic carotid-subclavian bypass was first reported in 1967 by Diethrich et al. to diminish the high complication rate of intrathoracic bypass approaches (23). In the few initial reports, a complication rate of 15-25% had been reported, including stroke, thrombosis, neck lymph fistula, Horner’s syndrome and phrenic nerve palsy (6). However, numerous recent studies have shown its excel-
lent long-term results (3). For instance, an overall ten-year patency rate of 92% has been reported by Abu Rahma et al. in a review of carotid-subclavian bypass cases with Gore-Tex performed for symptomatic subclavian artery occlusion or stenosis (24).

In the present case, we favored carotid-subclavian bypass in our patient because of complete ostial obstruction of the subclavian artery. In general, aside from sporadic reports of successful treatment of subclavian occlusions, the results of percutaneous treatment have not been as good as those of other interventions for stenotic disease (3). We preferred using a prosthetic conduit over the vein for the bypass. The superior patency of the prosthetic conduit in these reconstructions has been attributed to better artery-to-conduit size match, as well as a decreased chance of the conduit kinking and less tension (3). It is worth noting that in the original operation in 1974, carotid-subclavian bypass was performed with the saphenous vein (5).

More recently, eversion subclavian endarterectomy with subclavian-carotid transposition has been proposed as an alternative surgical treatment for these patients. In this method, after subclavian endarterectomy, the left subclavian artery is cut from the proximal part and then anastomosed to the left common carotid artery in an end-to-side fashion (25). In a review of 126 consecutive patients treated with this technique, Duran et al. reported a rate of 95% complete relief of symptoms, with patency rates of 100% at 30 days and 96.3% within a mean follow-up of 53.8 months (26). Such advantages as superior hemodynamics and the avoidance of complications pertaining to the graft itself have been attributed to this method (25).

In summary, bypass operations using prosthetic grafts are the treatment of choice for chronic complete obstructions of the subclavian artery, but surgery may not be imperative in patients with subclavian artery stenosis. Instead, percutaneous interventions through femoral or brachial approaches can be executed for subclavian artery stenosis. The advantages of angioplasty as compared to surgery include reduced hospital cost, shorter length of stay, and obviating the need for general anesthesia. Even though a success rate of 85% to 93% has been reported for percutaneous angioplasty, such undesirable factors such as ostial lesions, total obstruction, extensive stenosis, and lesion calcification may incur prohibitive risk on the procedure. In the above-mentioned situations, bypass surgery should strongly be considered due to the infeasibility of angioplasty in these high risk cases (6).

The most crucial fault in this patient to debate was the lack of arteriography of the aortic arch and its branches before the first surgery six years ago. Consequently, some investigators have emphasized prevention of this disease (13, 27). Thanks to the improvements in medical care, the life expectancy in cardiac patients has steadily increased. The risk of systemic atherosclerosis rises with advancing the age of patients, and as a result, the implementation of screening strategies to diagnose subclavian artery disease play a pivotal role in the preoperative management of CABG candidates, especially when the use of LIMA is predicted (10). Routine auscultation for subclavian bruits and the measurement of blood pressure in both arms are deemed to be effective screening methods which should alert the physician to the possibility of subclavian stenosis (11). In patients with arm claudication, carotid or subclavian bruits, or differences in the systolic blood pressure between the arms of more than 20 mm Hg preoperatively, arch angiography with selective views of the greater vessels should be performed (3). This could prevent the use of the ipsilateral IMA as a graft or indicate the need for prophylactic treatment of the stenosis (11). Routine angiography of the LIMA and subclavian artery in all cases scheduled for CABG has been proposed by some authors. However, this routine strategy may be unwarranted and could compromise the integrity of the LIMA. Most authors advocate an aortic arch angiography only once subclavian artery stenosis is suspected based upon clinical findings (6).

4. Conclusion

Since asymptomatic subclavian artery occlusive disease is commonly existent prior to CABG, preoperative screening of these patients is strongly recommended (10). Measuring the blood pressure in both arms and auscultation for subclavian bruits should be performed routinely before CABG using the IMA (11). If suspicious clinical findings are noted based on medical history and physical examination, then selective subclavian angiography or arch aortography should be performed in advance of CABG (6).

The results of the present case corroborate the efficacy of carotid-subclavian artery bypass as it has been discussed in previous studies. Percutaneous interventions should be used initially in the treatment of CSSS. However, when this is not possible because of complete occlusion, the extent of the disease in the subclavian artery, or stent failure, extrathoracic (extra-anatomic) bypass reconstruction provides a durable treatment option (3).

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Footnote

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References