REVIEW PAPER

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Coronary subclavian steal syndrome

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Abstract

Introduction: Coronary subclavian steal syndrome (CSSS) is a rare occurring clinical problem concerning patients after coronary artery bypass grafting with use of left internal mammary artery (LIMA) with coexistence of significant stenosis or occlusion of left subclavian artery in proximal segment. This uncommon condition may have a significant impact on clinical outcomes of the cardiac surgery.

Aim: Updating current medical knowledge about CSSS.

Material and methods: A systematic review of recent literature on the topic.

Results and discussion: Most cases of CSSS do not cause any symptoms due to other compensating mechanisms. However, in case of reverse flow occurrence in LIMA graft, patient can reveal picture of coronary syndrome, heart failure or arrhythmias. The stenosis of the subclavian artery usually is based on atherosclerosis. The diagnosis is based on clinical symptoms and radiology: ultrasonography, computed tomography and angiography. Most of the cases do not require any intervention. In symptomatic CSSS usually percutaneous angioplasty of subclavian artery is the first choice method of treatment.

Conclusions: Considering growing population of patients after coronary artery bypass grafting and long live expectancy after this treatment, CSSS may be an increasing clinical problem, and still the awareness of it is not common among cardiologists. According to ESC guidelines, all patients referred to coronary artery bypass grafting with coincidence of peripheral atherosclerosis should routinely undergo aimed diagnostics towards potential subclavian artery stenosis.

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1. Introduction

Coronary-subclavian steal syndrome (CSSS) is a rare clinical condition observed in patients who have undergone coronary artery bypass grafting (CABG) using the left internal mammary artery (LIMA), and who also present with significant (≥75%) stenosis or occlusion of the proximal segment of the left subclavian artery.[1–3] This syndrome may be responsible for early failure of surgical treatment for coronary artery disease, when CABG was performed in the presence of pre-existing subclavian artery stenosis[4] or, increasingly, due to progressive subclavian artery narrowing over time under the condition of long-term patency of the LIMA-left anterior descending (LAD) arterial graft after cardiac surgery. The essence of CSSS is the reversal of flow within the internal mammary artery from by-passed coronary artery to supply the left upper limb, resulting in stealing blood from the coronary circulation. Due to close location of the origin of the vertebral and internal mammary arteries, CSSS is frequently associated with more symptoms of vertebral-subclavian steal syndrome, in which upper limb ischemia due to significant stenosis or occlusion of the subclavian artery is compensated for by a reversal of blood flow in the ipsilateral vertebral artery provoking symptoms of brain stem ischemia (mainly vertigo, dizziness, drop-attack, amaurosis, transient ischemic attack, TIA).[5,6]

2. Aim

Updating current medical knowledge on CSSS.

3. Material and methods

A review of recent literature on the topic.

4. Results

4.1. Clinical presentation

Most cases of left subclavian artery stenosis in patients after coronary artery bypass grafting (CABG) using the internal mammary artery are asymptomatic due to several compensatory mechanisms and collateral circulation pathways. However, in cases where flow reversal occurs in the internal mammary artery, the patient may show symptoms of stable coronary artery disease, with anginal symptoms triggered by exertion of the left arm. Cases of acute coronary syndromes, acute or decompensated heart failure, and cardiac arrhythmias have also been reported.[7–9] In patients undergoing CABG with pre-existing subclavian artery stenosis, CSSS may lead to early treatment failure.

Neurological symptoms related to vertebrobasilar insufficiency as well as brachial blood pressure asymmetry, and fingers ischemia, including Raynaud syndrome, claudication, coolness, and microembolization are often present in patients with CSSS.[10–13]

4.2. Etiology

Based on registry data, subclavian artery stenosis is estimated to affect 2% of the general population, approximately 7% of patients with suspected or confirmed peripheral atherosclerosis, and 12% of patients with both peripheral atherosclerosis and coronary artery disease requiring surgical revascularization.[14,15] Despite this, CSSS is rarely recognized, as many patients with even hemodynamically relevant subclavian artery stenosis may have no symptoms or only nonspecific, mild symptoms, and CSSS itself can present as an incidental finding.[5,16,17]

The majority of subclavian artery stenosis/occlusion cases (over 90%) are associated with atherosclerotic processes. Other causes include inflammatory arterial diseases, radiation therapy, compression syndromes (thoracic outlet syndrome, TOS), fibromuscular dysplasia, and neurofibromatosis.[18]

An acute take-off angle of the left subclavian artery promotes turbulent flow at the ostium, increasing the risk of atherosclerotic plaque development in this location. The presence of peripheral artery disease increases the risk of subclavian artery stenosis fivefold. Risk factors for both subclavian artery stenosis/occlusion and CSSS include classic atherosclerotic risk factors such as current or past smoking, uncontrolled hypertension, dyslipidemia, diabetes, and obesity. The risk of subclavian artery stenosis also increases with age, particularly after 30–40 years, due to the lowering of the shoulder girdle and the development of TOS. This risk particularly affects individuals in certain professions (e.g., waiters, hairdressers).

CABG using the LIMA is the most commonly chosen method of surgical revascularization of the left anterior descending (LAD) artery. During CABG, the surgeon leaves the proximal segment of the artery at its natural origin from the left subclavian artery, while the distal segment, after dissection, is anastomosed to the mid portion of the LAD. Among available graft materials, the internal mammary artery has the highest durability, strong resistance to atherosclerosis, and the longest functional patency.

In cases of isolated LAD disease, minimally invasive CABG can be performed without sternotomy.

A separate risk group for CSSS includes dialysis patients with a brachiocephalic or brachiobasilic arteriovenous fistula, which significantly increases arterial blood flow to the upper limb. In the presence of subclavian artery stenosis or occlusion, a patent subclavian-coronary bypass using the internal mammary artery increases the risk of developing CSSS.[19–21]

4.3. Diagnostic process

The basis of CSSS diagnostics is the clinical examination of the patient. A difference in blood pressure between the upper limbs of at least 15 mmHg should lead to further diagnostics for subclavian artery stenosis. Comparative blood pressure measurement is unreliable in the case of bilateral subclavian artery stenosis. Other assessment methods include bilateral pulse examination (delay, reduced amplitude), auscultation of the supraclavicular fossae (bruit), and evaluation for signs of hand ischemia.

Imaging diagnostics include Doppler ultrasound, computed tomography, magnetic resonance imaging, and angiography.

Ultrasound is a non-invasive and widely available method, with an acceptable sensitivity of 88% and specificity of 94%.[22] Visualization of reversed flow in the vertebral artery suggests significant stenosis or occlusion of the subclavian artery. Imaging of the internal mammary artery and assessment of its flow using this method is difficult and often impossible.

Contrast-enhanced computed tomography allows detection and evaluation of subclavian artery stenosis with a sensitivity of 90% and specificity of 95%.[23] The limitations of this method include motion artifacts and unreliable assessment in cases of significant calcifications. Magnetic resonance imaging is an effective diagnostic method with a sensitivity of 90% and specificity of 95%, though its limitations include limited availability and high cost.[2,24]

Digital subtraction angiography (DSA) is the gold standard diagnostic tool. Subclavian artery stenosis should be visualized in two projections. Invasive diagnostics also allows measurement of the pressure gradient through stenosis after administration of nitroglycerin to induce hyperemia.[25] DSA is no longer used routinely for diagnosis; it is mainly reserved for cases with inconclusive or discrepant non-invasive imaging and is commonly performed as part of the endovascular procedure to confirm lesion severity and guide treatment.[14]

The presence of retrograde flow in the LIMA-LAD graft following contrast injection into the native left coronary artery confirms the diagnosis of CSSS.

4.4. Treatment

In most cases, subclavian artery stenosis is mild and asymptomatic. Treatment is indicated only in symptomatic cases (upper limb symptoms, cardiac symptoms, or neurological symptoms). In cases of significant stenosis of the left subclavian artery – even in the absence of flow reversal in the LIMA-LAD graft – delayed inflow may be observed, which can have clinical significance. Therefore, in asymptomatic patients with significant left subclavian artery stenosis who have undergone or are planned for CABG, revascularization of the subclavian artery is also recommended.

Treatment includes controlling atherosclerotic risk factors and the use of aspirin and statins. In symptomatic CSSS, beta-blockers, calcium channel blockers, and nitrates are recommended.

Upper limb revascularization can be performed using either endovascular or surgical methods. Due to a lower risk of complications, endovascular treatment with balloon angioplasty and stent implantation is preferred. Balloon-expandable stents are generally favored.[26–28]

Due to the rarity of CSSS, large-scale studies comparing the efficacy of various treatment methods are not available. Surgical treatment, most commonly involving the creation of a carotid-subclavian bypass, is associated with a higher rate of complications, longer hospitalization, and the need for general anesthesia. However, it provides a more durable outcome in terms of long-term vessel patency compared to endovascular methods.[28]

5. Discussion

CSSS is rarely diagnosed. However, given the growing population of patients after CABG and the long-term survival of individuals with multivessel coronary artery disease, CSSS may become an increasingly common issue in clinical practice. It is likely that CSSS is underrecognized as a potential cause of a patient's clinical symptoms, especially in cases of worsening angina despite a stable angiographic appearance of the coronary arteries.[29]

Proximal left subclavian artery stenosis is being detected with increasing frequency as an incidental finding during coronary angiography performed via the left radial approach in patients with prior CABG.

According to the guidelines of the European Society of Cardiology (ESC) on myocardial revascularization and the ESC guidelines for management of peripheral arterial and aortic diseases, in patients referred for CABG using the ipsilateral internal mammary ar-

tery with coexisting peripheral atherosclerosis and inter-arm blood pressure asymmetry, the investigation of subclavian artery stenosis should be performed.[14,30,31] If significant left subclavian artery stenosis is detected, revascularization (angioplasty with stent implantation or surgery) or alternative solutions (e.g., use of a free internal mammary artery graft with the proximal segment anastomosed directly to the aorta) should be considered.[14,31,32] Therefore, during diagnostic coronary angiography prior to CABG qualification, angiographic assessment of the left subclavian artery should be considered.[33]

A key prerequisite for the occurrence of CSSS is preserved blood flow in a stenosed LAD artery supplied by a graft. In cases of complete LAD occlusion, flow reversal in the internal mammary artery (LIMA) is unlikely. In such cases, assuming normal cerebral circulation, vertebral-subclavian steal syndrome becomes a more probable outcome.[34]

It might also be hypothesized that the occurrence of CSSS symptoms requires the coexistence of left subclavian artery stenosis with significant stenosis of the ipsilateral vertebral artery or insufficient vertebrobasilar circulation on the left side, which could prevent cerebral blood flow supply to the upper limb via the vertebral circulatory system. However, no studies are currently available that definitively address or resolve this issue.

6. Conclusions

Considering the long life expectancy after CABG due to modern pharmacological treatment and prevention strategies, CSSS may be an increasing clinical problem, and still, the awareness of it is not widespread enough among cardiologists. According to ESC guidelines, all patients referred to CABG with the coincidence of peripheral atherosclerosis and inter-arm blood pressure difference should undergo aimed diagnostics towards potential subclavian artery stenosis. It may also be beneficial to extend routine coronary angiography to include imaging of the initial segment of the subclavian artery before referring the patient to CABG.

CONFLICT OF INTEREST

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ETHICS

Not applicable.

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