Cerebral Hyperperfusion Syndrome Complicated with Acute Renal Failure after Carotid Artery Stenting in a Patient with Undiscovered Renal Artery Stenosis

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Abstract

Atherosclerotic carotid artery stenosis often results in ischemic stroke for which guideline directed therapy with carotid artery revascularization, such as carotid endarterectomy (CEA) and carotid artery stenting (CAS), is recommended forhigh-grade stenotic patients.

For cerebral hyperperfusion syndrome (CHS) arising as a severe complication of post carotid artery revascularization, the suggested treatment is intensive systematic blood pressure control. However, the strict target of controlled blood pressure may only be achieved at the cost of decreasing perfusion to other peripheral organs, leading to further organ injury.

Herein, we introduce a difficult case of a 68 year old man with undiscovered bilateral renal artery stenosis who developed cerebral hyperperfusion syndrome after carotid artery stenting. Thedilemmaposed byneeding to decrease systematic and intracranial blood pressure at the cost of inadequate renal perfusion, which can lead to acute kidney injury, challenges clinical practice and raises concerns about simultaneous coronary, carotid and renal angiography.

Keywords: carotid artery stenosis, carotid artery stenting, cerebral hyperperfusion syndrome, acute kidney injury

Introduction

Atherosclerotic carotid artery stenosiscontributes to ischemic or embolic stroke, resulting in further cognitive and physical impairment. Besides quitting cigarette smoking, the best medical treatment is by anti-hypertensive and anti-platelet drugs and statins for hyperlipidemia with a target of loweringlow-density lipoprotein below 100 mg/dL, and is usually provided to asymptomatic patients and symptomatic patients with stenosis less than 50%.[1] The North American Symptomatic Carotid Endarterectomy Trial (NASCET) and the European Carotid Surgery Trial (ECST) have proved that surgical intervention with carotid endarterectomy (CEA) is of benefit for symptomatic patients with severe stenosis (70-99%).[2] Carotid artery stenting (CAS) as a selective approach with similar long term efficacy and primary outcome for both symptomatic and asymptomatic patients has also been establishedby the Carotid Revascularization

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Endarterectomy vs. Stenting Trial (CREST).[3] A similar recommendation is also put forward in the American Heart Association guideline by which CEA or CAS can be considered for both symptomatic and asymptomatic patients with 70-99% stenosis and symptomatic patients with stenosis greater than 50%.[4]

Cerebral hyperperfusion syndrome (CHS), has been described as a serious complication in patients with carotid artery stenosis after carotid artery revascularizationwith CEA or CAS, and the incidence is not rare. Bouri, S., et al. reported a statistical incidence of CHS post CEA of 1% and proposed four criteria to define post-CEA CHS in a meta-analysis, including (1) occurring within 30 days post-CEA; (2) evidence of hyperperfusion (on TCD, SPECT or CT/MR perfusion imaging) or SBP > 180 mmHg; (3) clinical features such as new headache, seizure, hemiparesis, Glasgow Coma Scale (GCS) < 15 or radiological features such as cerebral edema or ICH; (4) no evidence of new cerebral ischemia, postoperativecarotid occlusion, whether of metabolic or pharmacologicalcause.[5] Another pooled meta-analysis conducted by Huibers, A.E., et al. estimated the overall occurrence rate of CHS after CAS as 4.6%.[6]

The pathophysiology of CHS is not fully clarified and understood. The most frequently proposed concept is dysregulation in cerebrovascular blood flow and baroreceptor dysfunction,[7] resulting in increased intracranial pressure and associated symptoms including headache, disturbance of consciousness, seizure, focal neurologic deficits and intracranial hemorrhage.

Herein, we introduce a difficult case involving a patient with undiscovered bilateral renal artery stenosis who developed cerebral hyperperfusion syndrome after treatment with carotid artery stenting. We faced thedilemmaof needing to decrease systematic systolic and intracranial pressure at the cost of inadequate renal perfusionleading to acute kidney injury, which challenged our clinical practice and raised concerns about simultaneous carotid and renal angiography.

Case Presentation

The 68 year old male patient hada medical history of coronary artery disease post coronary artery stenting, gastroesophageal reflux disease, chronic kidney disease (baseline serum creatinine 2.0 mg/dL), hyperlipidemia and hypertension under medication control with amlodipine, valsartan and bisoprolol in another hospital. He was admitted to our neurology ward under the tentative diagnosis of transient ischemic attack presenting with numbness and weakness over the left upper limb for two months. There were no positive neurological deficits, with normal deep tendon reflex and muscle power preserved. Initial dual antiplatelet treatment was given with aspirin 100 mg QD and clopidogrel 75 mg QD. Laboratory data at admission issummarized in Table 1, and is consistent with chronic kidney disease (creatinine 2.32 mg/dL), prediabetes (HbA1C 5.9%), and hyperlipidemia (LDL-C 191 mg/dL, T-Cholesterol 267 mg/dL, Triglyceride 246 mg/dL).

Table 1. Laboratory data upon admission

	Results	Reference range
Serum chemistry profile		
AST (U/L)	28	5-35
Creatinine level (mg/dL)	2.32	0.5-1.3
HbA1C (%)	5.9	<5.7
HDL-C (mg/dL)	37	23-92
LDL-C (mg/dL)	191	0-130
T-Cholesterol (mg/dL)	267	0-200
Triglyceride (mg/dL)	246	0-150
CBC		
White blood cell count (10^3/uL)	8.1	3.8-10
Hemoglobin level (g/dl)	16.2	11-16
Segmented neutrophil (%)	73.2	37-75

Abbreviation: AST, aspartate aminotransferase; HbA1C, hemoglobin A1C; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; T-Cholesterol, total Cholesterol; CBC, complete blood count.

Further extracranial Doppler ultrasound (ECD) examination revealed 90% stenosis of his right common carotid artery (CCA). Non-contrast brain magnetic resonance angiography showed atherosclerotic stenosis at the right distal CCA, bilateral proximal cervical internal carotid arteries (ICA), left V2, V3, V4 segmentsand the left paraclinoid ICA segment, along with a recent infarct at the right posterior temporal area. He was referred to the cardiovascular department for carotid angiography which revealed: (1) right CCA - 96% stenosis (Figure 1), (2) left CCA arising from the right innominate artery - proximal 40% stenosis, (3) left ICA - 70% stenosis, (4) left vertebral artery middle shaft - 80% stenosis. At the same time, up to 90% stenosis was also detected in the bilateral renal arteries (Figure 2).

A carotid artery stent (Sterling 6.0X20 mm) was then deployed smoothly to the right CCA (Figure 1), after which the patient was transferred to the neurology intensive care unit (ICU). However, the patient complained of severe headacheover the left supraorbital area with excessive tearing at the ICU and his blood pressure was measured high with 204/83 mmHg. Cerebral hyperperfusion syndrome was diagnosed based on the clinical criteria of SBP > 180 with new headache post procedure without other

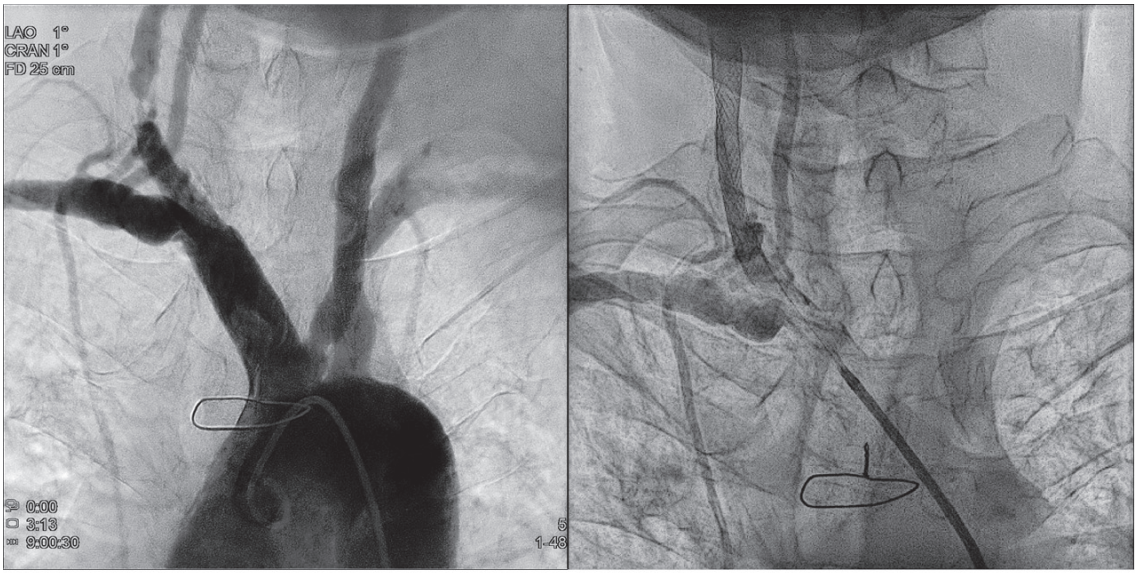

Figure 1. Right CCA stenosis and post stenting.

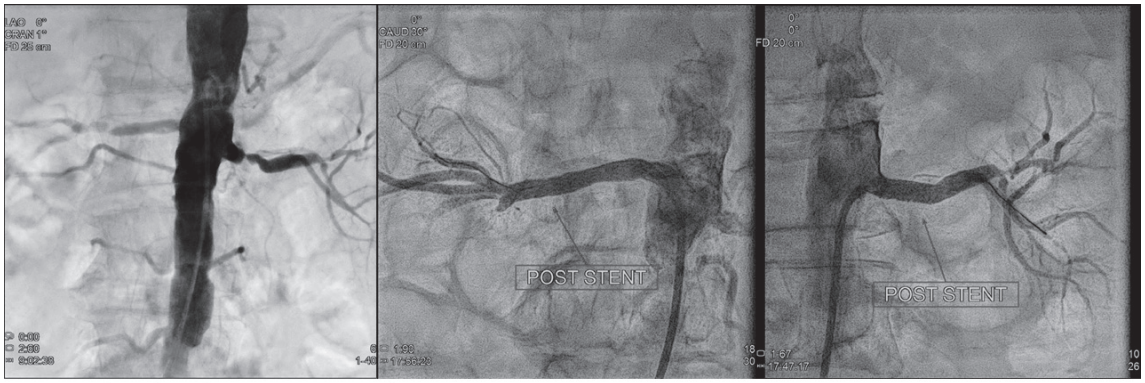

Figure 2. Bilateral renal arteries stenosis and post stenting.

causes. He also developed symptoms of mild shortness of breath, chills and blurred vision. Medication with calcium channel blocker (IV form nicardipine, oral form amlodipine) and alpha blocker (terazosin) was given to control his systolic blood pressure at a target of 120-140 mmHg. Angiotensin converting enzyme inhibitors and angiotensin receptor blockers were avoided due to the severe stenosis of the bilateral renal arteries. We also managed his dyslipidemia aggressively with oral atorvastatin, ezetimibe and subcutaneous alirocumab. Nevertheless, he later developed oliguria, pulmonary congestion and acute deterioration of his renal function (serum creatinine level reached 4.59 mg/dL), for which the IV diuretics furosemide and bumetanide were prescribed and up-titrated.

To treat the patient's cerebral hyperperfusion syndrome, his blood pressure should be lower, but to maintain renal perfusion, his blood pressure should be higher in order to overcome the bilateral renal artery stenosis. The balance between avoiding cerebral hyperperfusion and keeping adequate renal perfusion was adjusted prudently, according to his blood pressure and urine output. The patient's headache improved gradually and urine output also increased with creatinine level slightly above his baseline, and he was discharged from our hospital 4 days later (serum creatinine level at discharge 2.86 mg/dL). Nine days later this patient was re-admitted toour ward for bilateral renal artery stenting (Figure 2), after which his renal function improved further below his baseline level (serum creatinine level at OPD 1.92 mg/dL).

Discussion

With recent advances in intervention skill and technique the usage of CAS has increased dramatically with improved clinical outcomes. Although CAS is recommended in the systematic review as a safer alternative modality, compared to carotid endarterectomy, and offers advantages with fewer surgical complications,[8] AbuRahma, A.F., et al. conclude that symptomatic patients with carotid artery stenosis and moderate/severe chronic renal insufficiency (GFR < 60 mL/min/1.73 m^2 / GFR < 30 mL/min/1.73 m^2) have a higher chance of late major adverse events including stroke, death, and myocardial infarction after CAS.[9] Besides cerebral infarction and vessel injury, CHS is another adverse event of serious concern which may further evolve into lethal cerebral hemorrhage.[10]

To prevent the development and progression of CHS, simultaneous bilateral revascularization of the carotid arteries is avoided to prevent sudden expansion and excessive brain blood flow.[10] Mori, T., et al. attempted a novel strategyof gentle carotid artery stent placement without balloon postdilation, intentionally leaving a residual stent stenosis in patients with high-grade stenosis in order to prevent CHS. This was feasible and followed by spontaneous stent expansion within 4 months.[11] In 2016, Mo, D., et al. proposeda two-stage CAS treatment involving stent deployment with embolic protection device 1 month after initial balloon angioplasty in patients with severe ipsilateral carotid artery stenosis, which was shown to reduce the risk of developing CHS.[12]

Despite remaining controversial for routine survey of renal artery stenosis in patients undergoing elective coronary angiography, the American Heart Association has recommended simultaneous coronary and renal angiography for patients with multiple vessel disease or peripheral artery occlusive disease, due to a higher prevalence of significant renal artery stenosis in this group.[13] Similarly, in 2007, a high prevalence of concomitant arterial stenotic disease including coronary artery, renal artery and limbs artery disease was documented in 73% of patients with significant cervical carotid artery stenosis in Taiwan, among whom 20% were found to have concurrent renal artery disease.[14] Among those with overlapping arterial atherosclerotic diseases, patients with renal artery stenosis are more prone to have moderate to severe occlusion of the carotid circulation.[15] Such a high prevalence and

interrelationship of combined multiple arterial atherosclerotic diseases demands consideration of simultaneous angiography of coronary, carotid, and renal arteries.

Dilemma of cerebral and peripheral perfusion

Strict control of systematic systolic blood pressure below 140 mmHg to prevent cerebral hyperperfusion after carotid artery stenting inevitably carries some perfusion sacrifice and potentially results in ischemic injury to some organs, especially in patients with other atherosclerotic arterial diseases, making the balance between cerebral and peripheral perfusion even more difficult to achieve. In our patient, acute exacerbation of chronic kidney disease as a result of inadequate renal blood blow was the pricepaid for the treatment and prevention of cerebral hyperperfusion syndrome.

Conclusion

The similar pathophysiology of different arterial atherosclerosis conditions raises the question of additional screening requirements for other concurrent arterial atherosclerotic diseases in patients with carotid artery stenosis. Simultaneous carotid, coronary and renal artery angiography before treatment with CAS and CEA may be considered in clinical practice to optimize the revascularization strategy and prevent further ischemic complications resulting from inadequate perfusion in other organs affected by arterial atherosclerosis. Efforts must be made not only to reach the goal of decreasing cerebral hyperperfusion but also to maintain adequate blood flow to other organs. Some recommendations to prevent the occurrence of cerebral hyperperfusion include avoidance of simultaneous bilateral revascularization, gentle stent placement without post balloon dilation or two-staged angioplasty with initial balloon dilation and delayed stent deployment.

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