Reverse diastolic flow in the common carotid artery in severe aortic regurgitation, causing brain ischemia

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D iastolic reverse flow in the common carotid artery (CCA) at duplex sonography can be seen in patients with severe aortic regurgitation (AR). We report a patient with severe AR whose diastolic reverse flow in the right CCA caused transient brain ischemia. To our knowledge, there are no descriptions of diastolic steal volume by AR causing cerebral ischemia. This is the first description of this rare pathophysiologic form of cerebral ischemia.

Clinical Summary

A 70-year-old woman had undergone partial arch replacement and coronary bypass grafting for acute aortic dissection complicated by a large myocardial infarction resulting from the malperfused left coronary system. Although postoperative echocardiography showed mild aortic and mitral regurgitation, AR and mitral regurgitations gradually worsened during the next 8 months, which resulted in repeated hospitalizations for congestive heart failure. The patient had temporary blurred vision in her right eye. This symptom was accompanied by dizziness, headache, motor weakness of the right forearm, and pain migrating from the right shoulder to the right forearm. These symptoms began on sitting up in bed and spontaneously resolved within 10 minutes. Duplex sonography revealed diastolic reverse flow in the right CCA with a peak systolic velocity of 58 cm/s and an end-diastolic velocity of -54 cm/s (Figure 1, C). The velocity time integral of the antegrade flow was 16.7 cm, the velocity time integral of the retrograde flow was 10.2 cm, and the regurgitation rate was 61.1%. Acetazolamide-activated brain perfusion 123 I-IMP single photon emission computed tomography showed severe hypoperfusion to the right middle cerebral artery area. In 43.7% of this region, cerebral blood flow at rest was decreased to less than 15 mL/100 g/min on stereotactic extraction estimation (Figure 2, A). Magnetic resonance angiography of the neck and head demonstrated the absence of the right anterior and posterior communicating arteries as collateral circulation.

Surgery was performed by a right thoracotomy via the fourth intercostal space. Cardiopulmonary bypass was established using ascending aorta and bicaval cannulation with the aid of vacuum-assisted venous drainage. Cardioplegic arrest was achieved by using antegrade and retrograde cold blood cardioplegia. The aortic and mitral valves were replaced by a Carpentier-Edwards (Edwards Lifesciences, Irvine, Calif) bioprosthesis.

The postoperative course was uneventful. The carotid scan demonstrated normal positive diastolic flow in the right CCA (Figure 1, D). The postoperative brain single photon emission computed tomography scan showed the normalization of the cerebral perfusion (Figure 2, B). The patient currently has no neurologic symptoms with New York Heart Association class II.

Discussion

Diastolic reverse flow in the carotid arteries that persists more than 50% of the duration of diastole is an abnormal waveform on carotid Duplex scanning, although identification of a small postsystolic reversal is a normal finding. The mechanism of reverse diastolic flow is the rapid ejection of the increased ventricular volume that exists in AR, producing a suction or Venturi effect within the aorta and its branches.¹ Another possible mechanism is that increased distensibility of the aorta, being replaced with a vascular graft, can cause increased systolic expansion and diastolic recoil of the vessel.² Malaterre and colleagues³ reported reverse flow only in patients with grade III or IV AR. Kallman⁴ reported the same abnormal carotid flow pattern in 3 patients with severe AR who were scheduled for aortic valve replacement. All had normal carotid patterns postoperatively. In the present case, diastolic reverse flow was normalized after aortic valve replacement.

In the present case, duplex sonography, magnetic resonance angiography, and single photon emission computed tomography findings indicated the 3 following facts in addition to diastolic reverse flow. (1) Reverse diastolic flow reduced total antegrade flow in the right carotid arteries. (2) The right middle cerebral artery received its blood flow from only the right internal carotid artery without any collateral supply. (3) The right middle cerebral artery territory was subject to ischemia with its depressed flow reserve. Reverse diastolic flow decreases total antegrade flow as a natural consequence. Reduced total antegrade flow in the right carotid system and an anatomic abnormality of the circle of Willis were attributed to cerebral hypoperfusion in this patient. Moreover, in patients with severe AR the collapsing pulse and maximal reduction of the mean arterial blood pressure cause the reduction of the autoregulatory capacity of cerebral blood flow, which might decrease the tolerance for brain ischemia. These mechanisms are compatible with the fact that brain ischemia was resolved after the disappearance of AR.

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Figure 1. Serial duplex scans of right CCA. Although carotid flow pattern was normal after previous aortic surgery (A), diastolic flow was reversed before aortic valve surgery (B). After aortic valve replacement, diastolic flow pattern was normalized (C). *RT*, right common carotid artery.

Figure 2. A, Rest images of ^{123}I -IMP single photon emission computed tomography. Before aortic valve replacement, cerebral blood flow was impaired in most of the right middle cerebral artery territory. B, After the procedure, whole brain circulation was normalized. Images of stereotactic extraction estimation before (C) and after (D) aortic valve replacement. Staging map images show that resting cerebral blood flow was reduced in the anterior half of the right middle cerebral artery territory before the surgery and was normalized after surgery. *CBF*, Cerebral blood flow.

Conclusions

If a patient with severe AR has any neurologic symptoms, a carotid duplex scan should be performed because of the possibility of brain ischemia caused by diastolic reverse flow.

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