

# Cerebral vasoconstriction after carotid endarterectomy

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## ABSTRACT

Carotid endarterectomy carries the risk of several complications. We report a 55-year-old woman with recurrent cerebral vasoconstriction postoperatively. She had bilateral high-grade internal carotid artery stenosis and underwent right endarterectomy because of transient left-sided sensory symptoms. She developed a reperfusion syndrome with severe right-sided headache, right frontotemporal oedema and increased velocities in transcranial Doppler ultrasound. Given her gradual increase of velocities and Lindegaard index, together with fixed left sensory and motor deficits, we performed CT angiography, which suggested cerebral vasoconstriction syndrome. A subsequent left carotid endarterectomy triggered a similar cerebrovascular response. We highlight the need for continuous monitoring of cerebral haemodynamics following carotid endarterectomy.

A 55-year-old woman presented with transient sensory symptoms in the left face and upper limb. She was a heavy smoker with a history of hypertension, dyslipidaemia, migraine and panic attacks. She took paroxetine, rosuvastatin, aspirin and atenolol. Doppler ultrasound scan showed severe internal carotid artery stenosis on the left (75%–80%, European carotid surgery trial (ECST) method) and moderate stenosis on the right (65%–70%). MR brain imaging showed right middle and anterior cerebral artery watershed infarctions. She underwent right carotid endarterectomy without complications and was discharged home after 48 hours. She was asymptomatic, her neurological examination was normal and blood pressure was 117/56 mm Hg.

Three days after surgery she developed episodes of severe, recurrent right-sided headache, with progressively worsening apathy and somnolence. On readmission to hospital on the eighth

postoperative day, her blood pressure was 183/63 mm Hg, her pulse was 67 beats per minute and she was afebrile. Neurological examination was normal apart from somnolence (National Institutes of Health Stroke Scale (NIHSS) 1).

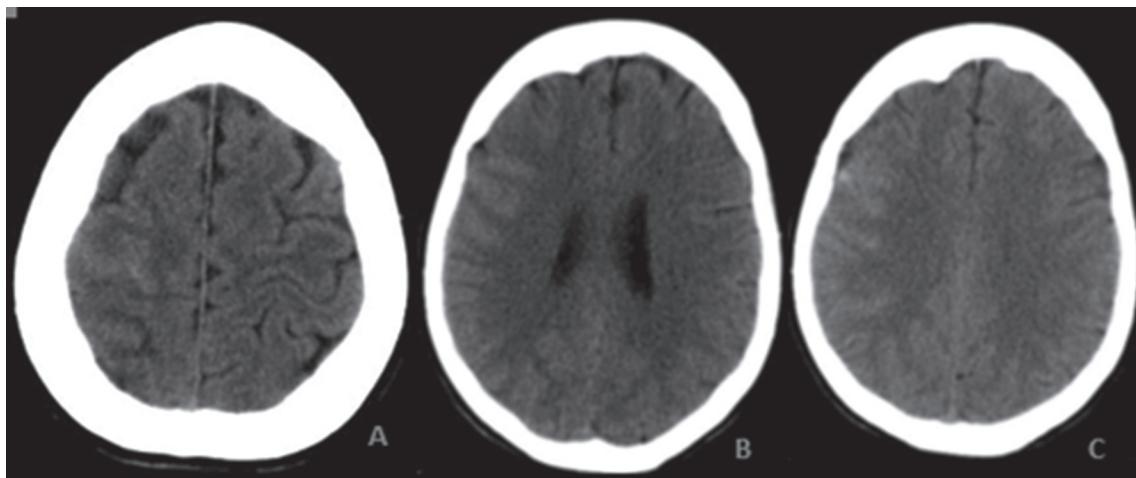
CT scan of head showed moderate right cortico–subcortical frontotemporal oedema, with effacement of the adjacent sulci, and haemosiderin in the right frontal and perisylvian sulci (figure 1A–C). Full blood count and serum chemistry were normal. Her erythrocyte sedimentation rate was 57 mm/hour and serum C reactive protein 13.5 mg/L (moderately raised). Coagulation tests were normal. Cervical and transcranial Doppler ultrasound excluded restenosis, but blood flow velocities were increased in the right middle and anterior cerebral arteries, indicating hyperaemia. She was transferred to the stroke unit with the diagnosis of probable reperfusion syndrome, based on the headache, somnolence and imaging findings.

Two days later, the CT scan appearances had stabilised. Her headache subsided and her mental status normalised, having received antihypertensive drugs and acetaminophen. However, by the 13th day post surgery, she began to experience transient episodes of sensorimotor abnormalities on the left side of her face and left hand. Initially, these were mild and short lasting, but they became increasingly frequent, and were persistent by the 16th day. Her blood pressure was 110/52 mm Hg. Electroencephalogram and repeat CT scan of head were normal.

Serial transcranial Doppler traces showed a gradual increase in middle cerebral artery mean blood flow velocities ( $V_{MCA}$ ) and of Lindegaard index (LI) (figure 3). Although LI can distinguish hyperaemia from spasm in subarachnoid haemorrhage, we found it useful to monitor haemodynamic changes in this patient. Initially, this profile was



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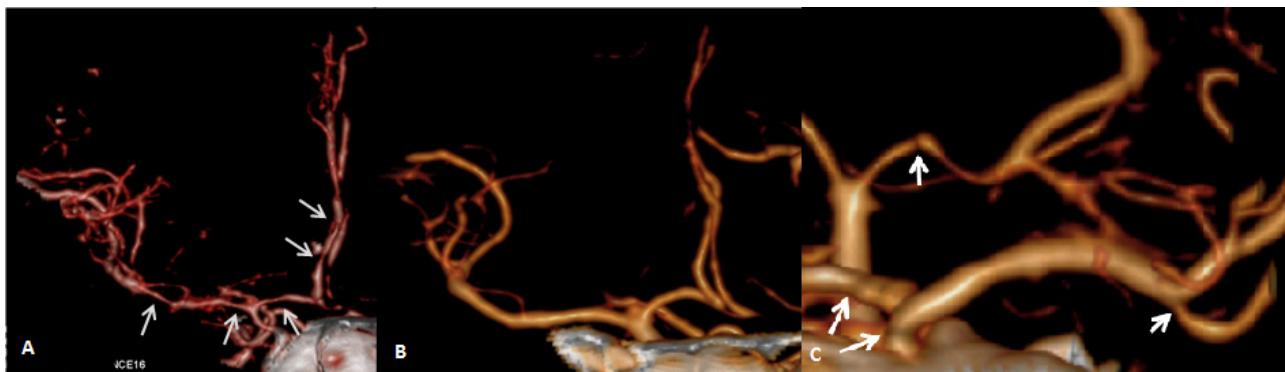
**Figure 1** Brain CT (A–C) on admission: cortico–subcortical frontotemporal oedema on the right side, with effacement of the adjacent sulci (A, B); haematic content fills the sulci over the right frontal convexity (C).

interpreted in the context of hyperaemia. On the 15th day, reflecting her deteriorating clinical status, the  $V_{MCA}$  and LI reached the cut-off value, suggesting vasospasm with a high risk for vascular events ( $V_{MCA} > 120$  cm/s and  $LI > 3$ ).<sup>1</sup> We gave empirical oral nimodipine from day 15 post surgery. However, on day 17, her measurements continued to worsen:  $V_{MCA} 217$  cm/s and LI 4.1.

At this point, we felt that the likely diagnosis was reversible cerebral vasoconstriction syndrome. Neurological examination showed left upper limb monoparesis more pronounced distally (2/5 using Medical Research Council Scale) and left central facial paresis. CT scan of head and CT angiography on day 19 showed recent right frontal infarction and segmental narrowing involving the following segments of the right side: A1 of anterior cerebral artery; M1 and M2 of middle cerebral artery and pre-bifurcation segment of the internal carotid artery (figure 2A). We stopped her paroxetine because of the known relationship between selective serotonin reuptake inhibitors and reversible cerebral vasoconstriction syndrome.<sup>2</sup> Her

condition improved a little with neurorehabilitation, and, having achieved clinical stability, we discharged her to continue rehabilitation as an outpatient. At 1 month post surgery, her  $V_{MCA}$  and LI were normal. CT angiogram 1 year later showed complete resolution of the stenosis (figure 2B) and of her neurological deficits.

One year later, a carotid Doppler ultrasound showed left internal carotid artery stenosis of 70%–75%. Given the slightly worsening in narrowing and the velocities criteria for >80% stenosis (pre-stenosis velocity of 409/181 cm/s vs post-stenosis velocity of 47/21 cm/s), she underwent left carotid endarterectomy, without acute complications. Arterial blood pressure had been carefully monitored during and after surgery. However, on day 5 she developed a left-sided headache. Neurological examination was normal (NIHSS 0). Transcranial Doppler ultrasound scan surveillance of the left middle cerebral artery on days 11 and day 23 showed  $V_{MCA}$  was 141 and 127 cm/s, and LI was 3.2 and 3.3; these values are above the cut-off value



**Figure 2** Brain CT angiography (A, B first episode, C second episode): (A) at day 19 shows segmental narrowing of the right middle cerebral artery (M1 and M2 segments), the A1 segment of the right anterior cerebral artery and terminal portion of internal carotid artery (arrows). (B) Several months after shows reversal of arterial calibre abnormalities. (C) After the second operation, at day 9, CT angiography showed narrowing of the M2 segment of the left middle cerebral artery and the P1 segment of the left posterior cerebral artery (arrows) and terminal portion of left internal carotid artery (not shown).

to suspect a vasospasm/vasoconstriction. CT angiography on day 9 showed narrowing of the M2 segment of the left middle cerebral artery, the P1 segment of the left posterior cerebral artery and terminal portion of left internal carotid artery (figure 2-C). MR scan of brain at day 12 showed left-sided cortico-subcortical parietal oedema, with effacement of the adjacent sulci, without haemorrhage. We diagnosed recurrent reversible cerebral vasoconstriction syndrome. She made a good clinical recovery and by day 25 the transcranial Doppler scan was normal. MR scan of brain 1 month later showed that most of the hyperintensity in left middle cerebral artery territory had resolved.

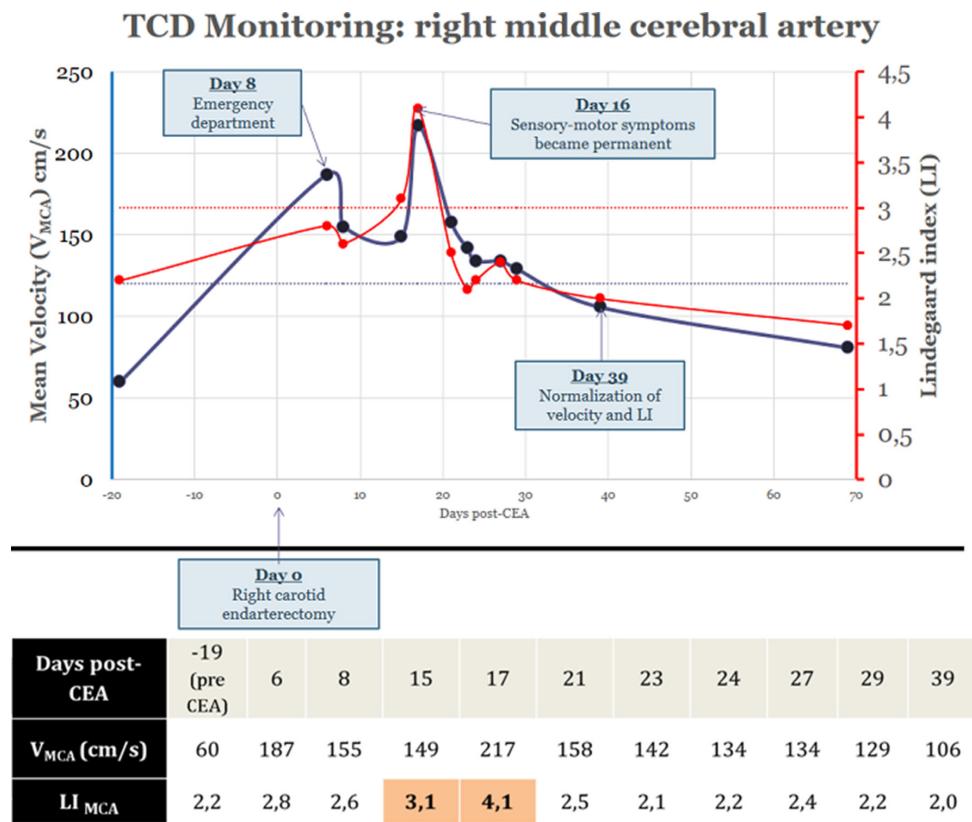
## DISCUSSION

Carotid endarterectomy remains the gold standard treatment for high-grade carotid stenosis. The most common complications are early (stroke, hyperperfusion syndrome, cerebral haemorrhage, cranial nerve injury and cardiac events) and late (recurrent stenosis and false aneurysm).<sup>3</sup>

This patient's presenting symptoms (headaches and somnolence) initially resembled either migraine aura (she had a history) or cerebral hyperperfusion syndrome. When her transient sensorimotor deficits

began, the likely diagnoses appeared to be seizures and vascular complications (such as transient ischaemic attack or stroke). Other endarterectomy complications listed above seemed less likely.

However, the initial findings on CT scan (cortico-subcortical oedema) and on transcranial Doppler (increased blood flow velocities) suggested that hyperperfusion syndrome was more likely. When the sensorimotor symptoms began, a normal EEG made seizure attacks unlikely. The duration of her symptoms and the non-specific quality of her headaches argued against migraine aura. When her symptoms became permanent, and CT angiography showing multiple vascular narrowings and frontal infarction, it seemed much more likely that this was reversible cerebral vasoconstriction syndrome complicated by stroke. Hyperperfusion syndrome following carotid endarterectomy tends to occur early, within the first 30 days.<sup>3</sup> After the surgery there is usually an increase in blood flow in the ipsilateral internal carotid artery. This syndrome is defined by having a >100% increase in cerebral blood flow compared with the preoperative baseline.<sup>4,5</sup> However, some patients develop symptoms with only a slight increase in cerebral blood flow.<sup>4</sup> This syndrome manifests with acute neurological



**Figure 3** Distribution of mean flow velocities and Lindegaard Index (LI) in the middle cerebral artery (MCA). Red discontinuous line indicates Lindegaard cut-off for vasospasm; blue discontinuous line indicates  $V_{MCA}$  cut-off for vasospasm. When she was admitted to our emergency department,  $V_{MCA}$  was high and LI was normal, probably in the context of hyperaemia. By the 16th day post surgery, when sensorimotor symptoms became irreversible, both  $V_{MCA}$  and LI exceeded the cut-off value for vasospasm ( $V_{MCA} > 120$  cm/s and LI > 3). So, there was a good correlation between clinical and TCD monitoring, which was very important in the suspicion of the correct diagnosis. CEA, carotid endarterectomy; TCD, transcranial doppler.

deficits associated with ipsilateral headache, seizures and intracerebral haemorrhage occurring several days after a carotid procedure. Risk factors include hypertension, tight stenosis, long duration of hypoperfusion and impaired cerebral auto-regulation in the early postoperative period.<sup>4,5</sup>

Reversible cerebral vasoconstriction syndrome is very rare after endarterectomy. It is characterised by (a) an acute and severe (often thunderclap) headache, (b) uniphasic course without new symptoms after 1 month of clinical onset, (c) segmental vasoconstriction of cerebral arteries, (d) no evidence of aneurysmal subarachnoid haemorrhage, (e) normal or near-normal CSF and (f) normalisation within 12 weeks of clinical onset.<sup>6,7</sup> Their most frequent precipitants are pregnancy/puerperium, vasoactive medications, catecholamine-secreting tumours, immunosuppressants or blood products and other miscellaneous factors (head trauma, neurosurgery, endarterectomy).<sup>6,7</sup> In a review of six cases with reversible cerebral vasoconstriction syndrome following carotid endarterectomy, the symptoms appeared 2–8 days post surgery. The presumed mechanism for vasospasm was hyperperfusion with further triggering of vasoconstrictive response in susceptible people.<sup>8</sup> Other vascular risk factors, namely arterial hypertension, migraine, smoking and selective serotonin reuptake inhibitors, were also possible triggers in this patient.

Transcranial Doppler scanning has a well-established role in monitoring cerebral haemodynamics and vasospasm,<sup>1</sup> although with no strong evidence that therapy guided by this imaging after ischaemic stroke or subarachnoid haemorrhage gives better outcomes. By day 15 post endarterectomy, the velocities fulfilled the criteria for mild vasospasm. Only about 13% of reversible cerebral vasoconstriction syndrome cases present with higher values ( $V_{MCA} > 120 \text{ cm/s}$  and LI  $> 3$ ), because those surrogate criteria were created for subarachnoid haemorrhage.<sup>1</sup> However, we used them as risk markers for ischaemic complications in reversible cerebral vasoconstriction syndrome. After the patient received nimodipine the flow velocities in the middle cerebral artery and LI gradually fell (figure 3), but we cannot establish a clear relationship with the treatment, as this is also the natural history of reversible cerebral vasoconstriction syndrome. However, even after the headache had resolved, the changes in transcranial Doppler imaging remained, probably because segmental vasoconstriction usually persists, even after symptoms resolve. This clinico-radiological paradox shows the importance of ultrasonographic follow-up. Some literature suggests the value of routine surveillance at least beyond 1 month until the patient's clinical state has normalised.<sup>9</sup>

In conclusion, reversible cerebral vasoconstriction syndrome is a rare but serious complication of carotid endarterectomy, and may follow a reperfusion

syndrome. It is important to suspect this diagnosis in patients with headache and neurological signs developing a few days after carotid surgery.

### Key points

- Reversible cerebral vasoconstriction syndrome is a rare complication of carotid endarterectomy, but important to consider when patients develop severe headache and neurological signs several days after surgery.
- Patients with reversible cerebral vasoconstriction syndrome after carotid endarterectomy are at risk of recurrence if they undergo contralateral surgery.

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