A 75-Year-Old Woman with a Hemispheric Stroke

Stavros K. Kakkos, George Geroulakos*

DESCRIPTION of CASE

A 75-year-old right-handed woman presented with a two-day history of symptoms suggestive of a right hemispheric stroke (slurred speech and left facial and left arm weakness). She had no previous cerebrovascular symptoms, such as symptoms of a previous transient ischaemic attack or amaurosis fugax (loss of vision in one eye due to a temporary lack of blood flow to the retina). Past medical history included long-standing hypertension and chronic obstructive pulmonary disease. She was on amlodipine, 10 mg once daily, and salbutamol and fluticasone inhalers.

On examination, the patient had a Glasgow Coma Score of 15, she was apyrexial, her pulse rate was regular, at 80 per min, and her blood pressure was 176/99 mm Hg. There was no cardiac murmur or carotid bruits. She had left-sided weakness.

What Investigation Is Indicated at This Stage?

Brain imaging is necessary for two main reasons. The first is to exclude a brain haemorrhage (responsible for 25% of all strokes [1]); against this diagnosis was the absence of headache and a normal Glasgow Coma Score. The second is to rule out a brain tumour.

Computed tomography (CT) brain scanning on admission showed two areas of low density within the right cerebral hemisphere, one in the right parietal lobe and one in the posterior right frontal lobe (Figure 1), most likely ischaemic in nature. Small low-density lesions consistent with lacunar infarcts were also seen in both basal ganglia, the most prominent ones seen within the left basal ganglia. There was also marked frontal atrophy, and atrophy of the brain stem structures. The CT scan showed no evidence of haemorrhagic transformation of the infarct, a condition that is a contraindication for anticoagulation.

Routine blood tests (full blood count, urea and electrolytes, and clotting), an electrocardiogram, and a chest X ray were performed before the CT brain scan. The electrocardiogram showed no arrhythmia or changes suggestive of an old or new myocardial infarction. The normal electrocardiogram raised the possibility of embolisation from a large artery (such as the right carotid artery or the aortic arch), rather than from the heart.

How Did We Identify the Source of Embolisation?

A carotid ultrasound showed a calcified, haemodynamically significant plaque at the right carotid bifurcation. A similar lesion seen at the left carotid bifurcation was not haemodynamically significant. Carotid angiogram showed

Citation: Kakkos SK, Geroulakos G (2005) A 75-year-old woman with a hemispheric stroke. PLoS Med 2(4): e79.

Copyright: © 2005 Kakkos and Geroulakos. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abbreviations: CT, computed tomography; ECST, European Carotid Surgery Trial; NASCET, North American Symptomatic Carotid Endarterectomy Trial

Stavros K. Kakkos is a Clinical Vascular Fellow with a particular interest in carotid artery disease and George Geroulakos is a Consultant Vascular Surgeon and Senior Lecturer, Vascular Unit, Ealing Hospital, London, United Kingdom.

Competing Interests: The authors declare that they have no competing interests.

*To whom correspondence should be addressed. E-mail: George.geroulakos@eh. nhs.uk

DOI: 10.1371/journal.pmed.0020079
The patient’s symptoms gradually improved and she was discharged two days later. A contrast-enhanced CT brain scan performed nine days after the onset of symptoms confirmed the previous findings. The dose of perindopril was gradually increased from 2 mg to 6 mg daily to achieve satisfactory control of the patient’s hypertension.

After a Hemispheric Stroke, How Soon Should Carotid Endarterectomy Be Performed?

Six weeks after the stroke, the patient underwent elective right carotid endarterectomy under general anaesthesia with the use of a shunt. Although some surgeons favour early carotid endarterectomy, most agree that this should not be performed earlier than six weeks, to allow the autoregulative mechanism of the brain to recover [3,4]. Arteriotomy was closed with a Dacron patch. No neurological deficits or cranial nerve palsy were noted postoperatively. The patient’s discharge was postponed until the seventh postoperative day because of a mild urinary tract infection and an episode of syncope. Histology revealed an atheroma producing near total lumen occlusion. Eleven months after the operation no new neurological events have occurred.

DISCUSSION

Causes of Hemispheric Ischaemic Stroke

Mohr et al. classified the causes of ischaemic stroke into three broad categories: embolism to the brain of cardiac or aortic origin, cerebral ischaemia due to perfusion failure and artery-to-artery embolism, and cerebral artery thrombosis [5]. Embolism to the brain of cardiac or aortic origin includes myocardial infarction, atrial fibrillation, valvular disease in native, prosthetic, or repaired cardiac valves (including mitral valve prolapse), embolism of aortic arch origin, and myxoma of the heart and from venous thrombi via a patent foramen ovale. Cerebral ischaemia due to perfusion failure and artery-to-artery embolism includes large artery atherosclerotic plaque, vasculitis, and other arterial disease and small artery occlusion. Thrombosis is caused by prothrombotic states.

Carotid stenosis accounts for about 20% of all cases of ischaemic stroke [6], and is considered as the single most preventable cause of stroke. Like all atherosclerotic diseases, the most common risk factors for carotid stenosis are smoking, hypertension, hyperlipidaemia, and diabetes mellitus.

Investigation of Carotid Artery Bifurcation Stenosis

Carotid ultrasound duplex is the imaging method of choice for the initial investigation of a patient with suspected carotid artery stenosis [7]. It is non-invasive and low-cost, and can be easily repeated if necessary.

Anatomical criteria at the point of stenosis (cross-sectional area reduction or diameter reduction) should always be applied to ensure that stenosis is present and that flow velocity is not increased secondary to a vessel curve. A limitation of using anatomical criteria to estimate the degree of carotid stenosis is that in the presence of heavy acoustic shadowing (due to calcification) interrupting flow visualisation, no intraluminal diameter reduction can be calculated (Figure 3).

Because of these problems, intrastenotic velocity measurements are widely used; in cases of acoustic shadowing due to calcification, these measurements should be performed just distally to the acoustic shadowing, at the point of the flow jet. Long acoustic shadowing, known also as the Gibraltar sign [8], can result in falsely reduced velocity measurements and downgrade the stenosis. It has been found that velocity measurements are affected by different ultrasound scanners, physiological changes, and the presence of contralateral occlusion or “tandem” lesions [9]. To overcome this problem, intrastenotic flow velocities are “normalised” using the common carotid or distal internal carotid flow velocities as a reference point, and the resulting ratio is used. There are potential problems related to the sampling point and to patients with heart failure with falsely low end-diastolic velocity of the common carotid artery [10]. In order to overcome potential limitations of individual
criteria, the use of combined criteria has been suggested (Figure 4) [11,12].

Selective arteriogram is nowadays rarely indicated, because the procedure itself can cause stroke, and non-invasive alternative methods (magnetic resonance angiography) are available. There is no consensus on the optimum method to grade carotid stenosis (Figure 5) [13,14].

The Role of Carotid Endarterectomy in Preventing a Recurrent Event

Carotid reconstruction was first performed by Eastcott et al. at St. Mary’s Hospital, London, in 1954 [15]. However, it took nearly four decades until trial evidence became available to show that carotid endarterectomy was better than best medical treatment in patients with amaurosis fugax or hemispheric symptoms, transient ischaemic attacks, or stroke who had made a good recovery and whose symptoms were caused by severe carotid bifurcation stenosis (>70% with the North American Symptomatic Carotid Endarterectomy Trial [NASCET] method or >80% with the European Carotid Surgery Trial [ECST] method) [13,14]. The two-year risk of stroke in the medical arm of NASCET was 26% compared with 9% in those who underwent endarterectomy [13]. Subsequently, the NASCET trialists reported that endarterectomy reduces the five-year risk of stroke in moderate stenosis (50%–69%) from 22.2% to 15.7% [16]. Longer follow-up also showed that the long-term risk of stroke after carotid endarterectomy is about 1% per year. A recent meta-analysis of the NASCET and ECST trials showed that benefit from surgery was greatest in men, patients aged 75 years or older, and those randomised within two weeks after their last ischaemic event, and fell rapidly with increasing delay [17].

Surgery is usually performed at six weeks if there is good recovery, but there is a tendency to perform it earlier in patients with transient ischaemic attacks or strokes with good recovery when CT brain scan shows no infarct. Surgery reduces the risk of stroke by 50% even if the event occurred more than six months previously, as shown by the Medical Research Council Asymptomatic Carotid Surgery Trial [18], but because of the low incidence of stroke at five years and the relatively small number of patients in the trial, benefit was only marginally significant [18].

Best Medical Treatment

While recovering from stroke and awaiting carotid endarterectomy, aspirin even at a low dose of 75 mg daily reduces the risk of recurrence. This is improved with dipyramadole [19], but not clopidogrel [20]. The Heart Protection Study has recently shown that regardless of pretreatment lipid levels, lipid-lowering agents are beneficial in secondary prevention of stroke [21]. In our patient’s case, total cholesterol levels after treatment were 3.6 mmol/l.

Carotid Endarterectomy under Local Anaesthesia, or Carotid Angioplasty and Stenting?

Minimally invasive treatment is considered nowadays a preferable mode of delivering health care, and carotid disease is no exception. Meta-analysis of previous studies has shown that carotid endarterectomy under local anaesthesia has less surgical hazards than under general anaesthesia. This was the basis for the GALA trial—a multicentre randomised trial assessing the relative risks of stroke, cardiac events, and death with these two different treatments (http://www.galatrial.com/). The results are not yet available.

Carotid angioplasty and stenting with the aid of distal protection devices has recently emerged as a good alternative to endarterectomy, being equivalent or slightly better, when periprocedural complications are considered [22,23]. In the

Key Learning Points

- Although carotid stenosis accounts for about 20% of all cases of ischaemic stroke, it has been considered as the single most preventable cause of stroke.
- Carotid ultrasound is the method of choice for the initial investigation of a patient with suspected carotid artery stenosis.
- Carotid endarterectomy has been proven to reduce the incidence of recurrent stroke, mainly in severe stenosis.
- Carotid stenting has recently emerged as an alternative procedure.
- Early intervention as soon as possible is desirable to reduce the risk of recurrent stroke.
SAPPHIRE trial, performed in selected high-risk patients, those allocated to the stenting group had fewer cardiovascular events than those undergoing surgery [23].

References
1. Kunitz SC, Gross CR, Heyman A, Kase CS, Mohr JP, et al. (1984) The pilot Stroke Data Bank: Definition, design, and data. Stroke 15: 740–746.
2. Poldermans D, Boersma E, Bax JJ, Thomson IR, van de Ven LL, et al. (1999) The effect of bisoprolol on perioperative mortality and myocardial infarction in high-risk patients undergoing vascular surgery. N Engl J Med 341: 1789–1794.
3. Bond R, Rerkasem K, Rothwell PM (2003) Systematic review of the risks of carotid endarterectomy in relation to the clinical indication for and timing of surgery. Stroke 34: 2290–2301.
4. Wollé KD, Pfaddenhäuer K, Bruijnen H, Becker T, Engelhardt M, et al. (2004) Early carotid endarterectomy in patients with a nondisabling ischemic stroke: Results of a retrospective analysis. Vasa 33: 30–35.
5. Mohr JP, Albers GW, Amarenco P, Babikian VL, Biller J, et al. (1997) Etiology of stroke. Stroke 28: 1501–1506.
6. Bond R, Rerkasem K, Rothwell PM (2003) Systematic review of the risks of carotid endarterectomy in relation to the clinical indication for and timing of surgery. Stroke 34: 2290–2301.
7. Bernstein EF (1993) Current noninvasive evaluation of extracranial arterial disease. In: Bernstein EF, Callow AD, Nicolaides AN, Shifrin EG, editors. Cerebral revascularisation. London: Med-Orion Publishing. pp. 73–83.
8. Wilson CL, Devine JJ, Mills JL (2001) The Gibraltar sign. J Am Coll Surg 192: 537.
9. Ray SA, Lockhart SJ, Dourado R, Irvine AT, Burnand KG (2000) Effect of contralateral disease on duplex measurements of internal carotid artery stenosis. Br J Surg 87: 1057–1062.
10. Lee VS, Hertzberg BS, Workman MJ, Smith TP, Kliewer MA, et al. (2000) Variability of Doppler US measurements along the common carotid artery: Effects on estimates of internal carotid arterial stenosis in patients with angiographically proved disease. Radiology 214: 387–392.
11. Nicolaides AN, Shifrin EG, Bradbury A, Dhanji S, Griffin M (1996) Angiographic and duplex grading of internal carotid stenosis: Can we overcome the confusion? J Endovasc Surg 3: 158–165.
12. Carpenter JP, Lexa FJ, Davis JT (1996) Determination of duplex Doppler ultrasound criteria appropriate to the North American Symptomatic Carotid Endarterectomy Trial. Stroke 27: 695–699.
13. North American Symptomatic Carotid Endarterectomy Trial Collaborators (1991) Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. N Engl J Med 325: 445–453.
14. European Carotid Surgery Trialists’ Collaborative Group (1991) MRC European carotid surgery trial: Interim results for symptomatic patients with severe (70–99%) or with mild (0–29%) carotid stenosis. Lancet 335: 1235–1243.
15. Eastcott HHG, Pickering GW, Rob CG (1954) Reconstruction of internal carotid artery in a patient with intermittent attacks of hemiplegia. Lancet 2: 994–996.
16. European Carotid Surgery Trialists’ Collaborative Group (1998) Randomised trial of endarterectomy for recently symptomatic carotid stenosis: Final results of the MRC European Carotid Surgery Trial. Lancet 351: 1379–1387.
17. Rothwell PM, Eliazy M, Gutnikov SA, Varlow CP, Barnett HJM, et al. (2004) Endarterectomy for symptomatic carotid stenosis in relation to clinical subgroups and timing of surgery. Lancet 363: 915–924.
18. MRC Asymptomatic Carotid Surgery Trialists’ Collaborative Group (1998) Randomised trial of endarterectomy for recently symptomatic carotid stenosis: Final results of the MRC European Carotid Surgery Trial. Lancet 351: 1379–1387.
19. Rothwell PM, Eliazy M, Gutnikov SA, Varlow CP, Barnett HJM, et al. (2004) Endarterectomy for symptomatic carotid stenosis in relation to clinical subgroups and timing of surgery. Lancet 363: 915–924.
20. Diener HC, Bogousslavsky J, Brass LM, Gimmiacci C, Costa A, et al. (2004) Aspirin and clopidogrel compared with clopidogrel alone after recent ischaemic stroke or transient ischaemic attack in high-risk patients (MATCH): Randomised, double-blind, placebo-controlled trial. Lancet 364: 331–337.
21. Heart Protection Study Collaborative Group (2004) Effects of cholesterol-lowering with simvastatin on stroke and other major vascular events in 20,536 people with cerebrovascular disease or other high-risk conditions. Lancet 363: 757–767.
22. CAVATAS investigators (2001) Endovascular versus surgical treatment in patients with carotid stenosis in the Carotid and Vertebral Artery Transluminal Angioplasty Study (CAVATAS): A randomised trial. Lancet 357: 1729–1737.
23. Yadav JS, Wholey MH, Kuntz RE, Fayad P, Katzen BT, et al. (2004) Protected carotid-artery stenting versus endarterectomy in high-risk patients. N Engl J Med 351: 1493–1501.