CASE REPORT

Bilateral Homonymous Hemianopia with Sparing of the Vertical Meridian

Harpal Panesar,¹ Charles A Romanowski,² Irene M Pepper,³ and Simon J Hickman⁴

¹*School of Medicine, University of Sheffield, Sheffield, UK*

Departments of ²*Radiology*

³*Ophthalmology*

⁴*Neurology, Royal Hallamshire Hospital, Sheffield, UK*

ABSTRACT

A 19-year-old woman, who was 16 weeks post partum, collapsed with loss of consciousness. Following awakening she suffered abrupt loss of vision. Partial recovery occurred, although she has been left with bilateral homonymous hemianopia with sparing of vision just to the left of the vertical meridian. Magnetic resonance imaging demonstrated bilateral occipital infarcts, sparing the lips of the calcarine sulcus on the right. This is compatible with our expectation that the vertical meridian of the retinotopic map is represented at the superior and inferior lips of the calcarine sulcus.

KEYWORDS: bilateral homonymous hemianopia; MRI; occipital infarction; vertical meridian sparing

INTRODUCTION

The acquisition of knowledge about how the visual field is mapped onto the primary visual cortex has principally occurred through study of patients with deficits. Early studies relied on correlating visual field plots against autopsy data or surface reference points in cases of survivors from shrapnel wounds.^{1–5} There have been recent updates of the retinotopic map with data from computerised tomography (CT),⁶ conventional magnetic resonance imaging (MRI)^{7,8} in patients, and functional MRI (fMRI) in normal subjects.^{9,10} The study of additional cases with unusual deficits can help in confirming our understanding of the retinotopic map.

CASE REPORT

A 19-year-old woman presented with bilateral homonymous hemianopia with vertical meridian

sparing following an episode of collapse with loss of consciousness.

She had given birth naturally 16 weeks previously, although suffered a prolonged post partum haemorrhage lasting 10 weeks. She had been commenced on the combined oral contraceptive pill from her first period following the pregnancy and continued onto the next packet without a break. The pregnancy had been uneventful, although she subsequently recalled three episodes of transient distortion of vision, mostly on the right hand side, which had all been followed by headaches. She had no other past medical history or family history of note.

On the day of the collapse, she was home alone. She felt generally unwell but managed to continue her daily activities. She then collapsed with loss of consciousness. On regaining consciousness, she called for an ambulance herself, but following this her vision in both eyes went dark.

On presentation to the accident and emergency department she complained of a moderate headache. She had a Glasgow coma score of 15/15. She had only perception of light vision bilaterally, but her pupils were reactive to light. No other abnormality was detected. A computerised tomographic (CT) scan of her head was reported as normal. By the following

Received 08 September 2010; accepted 23 September 2010

Correspondence: Dr. Simon Hickman, Department of Neurology, Royal Hallamshire Hospital, Glossop Road, Sheffield, S10 2JF, UK. E-mail: simon.hickman@sth.nhs.uk

FIGURE 1 Goldmann visual field examination 17 days after onset of symptoms.

day, her central vision had returned, but only flashes were visible peripherally. She had a visual acuity of 6/7.5–1 OD and 6/6–1 OS, but was unable to read any of the Ishihara plates. She had normal pupillary responses and a normal ocular examination. No clear diagnosis was reached at this stage.

On review, 17 days after her collapse, she could see 6/6 with each eye, but could only read 9/17 of the Ishihara plates OD and 8/17 OS. A Goldmann visual field examination revealed bilateral homonymous hemianopia with sparing of vision just to the left of the vertical meridian (Figure 1). A subsequent MRI, with diffusion weighted imaging, revealed bilateral mature occipital infarcts with sparing of the calcarine lips on the right and an asymptomatic left cerebellar hemisphere infarct (Figure 2). An MRI of her neck did not reveal any evidence for vertebral artery dissection.

Her colour vision (assessed by Ishihara plates) subsequently normalised and her vision remained at 6/6 with each eye. A further Goldmann visual field examination, performed 9 months after the stroke, revealed some improvement, although the pattern remained the same (Figure 3).

Transthoracic echocardiography following bubble contrast injection revealed a patent foramen ovale with right-to-left shunt. An aneurysmal inter-atrial septum was seen on trans-oesophageal echocardiography. She has chosen not to take warfarin and remains on dual anti-platelet therapy. She is being considered for closure of the patent foramen ovale.

DISCUSSION

Our patient probably suffered a paradoxical embolic event across the patent foramen ovale with the

embolus initially lodging in the basilar artery to cause the loss of consciousness. It then broke up, embolising to the left posterior inferior cerebellar artery and both calcarine arteries. The pattern of the visual field defect with sparing of vision just to the left of the vertical meridian corresponds with the sparing on MRI of the calcarine lips on the right. The non-congruous sparing in both infero-temporal fields probably reflects some sparing more rostrally, within the area of the calcarine cortex subserving the monocular temporal crescents, although this is not clearly demonstrated on the images. Her initial inability to read any of the Ishihara plates despite having good central acuity is probably due to her initial extremely narrow field of vision that permitted single letter reading at a distance but did not enable her to read the more complex form of the numbers closer to.

The occipital lobe was discovered to be the brain's vision area by Munk in 1881.¹¹ He removed the occipital lobe from one side of a monkey's brain and rendered the animal hemianopic. By correlating visual field defects with autopsy findings, Henschen localised the primary visual cortex in humans to the area surrounding the calcarine fissure and he proposed that the lower visual field was represented on the upper bank of the calcarine cortex, and vice versa for the upper visual field.¹ His observations were based on study of cases of tumours, haemorrhages and 'cerebral softening' and therefore he was unable to deduce the fine detail of the retinotopic map. For example, he incorrectly localised the representation of foveal vision to the anterior calcarine cortex rather than the occipital pole.

Developments in weapons technology around the turn of the 20th Century led to rifles that could fire hard, stable bullets at high muzzle velocities. During the Russo-Japanese War of 1904–5 and the

First World War, a number of soldiers survived with bullet wounds that entered the skull at one point and left at another leaving a straight track of brain lesion between the entry and exit wounds. Pivotal studies by Inouye and Holmes on these soldiers correctly identified central vision as being represented at the occipital pole with the upper and lower visual fields being represented by the lower and upper banks of calcarine sulcus, respectively.²⁻⁴ Inouye was the first to demonstrate that the horizontal meridian was represented at the base of the calcarine sulcus and the vertical meridia along the calcarine lips.² The importance of Inouye's work was largely ignored in the Western literature until recently,¹² although the recent translation of his paper has made his findings

more accessible and cemented his place alongside Holmes in this area.²

In the 1990s, the Holmes map was revised by using MRI to correlate the region of primary visual cortex undergoing infarction with the respective visual field defects.^{6,7} The basic findings in these studies demonstrated that, although largely accurate, the Holmes map had underestimated cortical magnification of central vision. Due to the nature of the striate cortex, with the majority of the visual field being represented on the hidden area within the calcarine sulcus, the revised maps depict the calcarine sulcus as if it had been flattened out. The lower and upper vertical meridia are represented along the dorsal and ventral borders of the calcarine cortex, but in reality,

FIGURE 2 (a) Axial T2-weighted MRI demonstrating bilateral occipital infarction (black arrows) with sparing of the calcarine lip on the right (white arrowhead). (b) Coronal T2-weighted MRI demonstrating bilateral occipital infarction (black arrows) and a left cerebellar hemisphere infarction (white arrow). (c) Sagittal T2-weighted MRI in the region of the medial right occipital lobe demonstrating sparing of both the superior and inferior calcarine lips (black arrowheads). (d) Sagittal T2-weighted MRI in the region of the medial left occipital lobe demonstrating infarction within the calcarine cortex with no sparing of the calcarine lips (black arrow).

FIGURE 3 Goldmann visual field examination 9 months after onset of symptoms.

these would be located outside the calcarine fissure on the medial aspect of the occipital lobe, along the calcarine lips. A recent fMRI study in primates and humans also shows mapping of the vertical meridia on the calcarine lips.¹⁰ Because the vertical meridian is represented as an upper and a lower portion on respectively the lower and upper lips of the calcarine gyri and the horizontal meridian is represented at the apex of the calcarine fissure, it has been suggested that the retinotopic map may constrain the pattern of cortical folding during development.¹⁰ Careful inspection of the sagittal MR images from our case reveals sparing of the calcarine lips in the right hemisphere, but infarction of the calcarine lips on the left. This explains the sparing of vision in the left visual field abutting the vertical meridian (Figure 2d).

The occipital lobe is the most commonly infarcted area in posterior cerebral artery (PCA) strokes.¹³ This does not always lead to a complete homonymous hemianopia, as sparing of areas within the affected visual field can occur, the most common pattern of which is macular sparing.^{6–8,13,14} There have been previous theories as to the reason for this, with bilateral representation of vision in both occipital lobes or artefacts of fixation proposed.¹⁵ It seems likely, however, that sparing occurs due to incomplete damage to the calcarine cortex due to variations in the distribution of arterial supply to the calcarine cortex.^{15–17} The calcarine artery, which is a terminal branch of the PCA, supplies the floor, dorsal, and ventral banks of the calcarine sulcus.¹⁶ Additional branches of the PCA that may supply the calcarine cortex are the lingual gyrus artery, posterior temporal artery, common temporal artery and the parieto-occipital artery. The caudal part of the cortex, towards the occipital pole, is often supplied by the posterior temporal artery or by occipital branches from the middle cerebral artery.^{16,17} This will explain how both macular sparing and small macular-involving

scotomatous defects can occur.¹⁶ There is variation in the amount of the rest of the calcarine cortex supplied by the different arteries.¹⁶ Vertical meridian sparing can therefore occur if the calcarine lips have a different arterial supply from the rest of the calcarine cortex. There have been three previous reports of vertical meridian sparing following occipital infarction. Gray *et al.* reported a case of unilateral calcarine artery infarction with calcarine lip sparing, resulting in a left homonymous hemianopia with inferior vertical meridian sparing.¹⁸ Harrington demonstrated one case of partial inferior vertical meridian sparing in bilateral inferior quadrantanopias (see figure 15–22 in Harrington¹⁹) and one case of inferior vertical meridian sparing with more extensive bilateral homonymous hemianopias (see figure 15–23 in the same volume). In our case and in the two cases described by Harrington,¹⁹ the territory of supply of the calcarine arteries must have been asymmetrical to explain the sparing of vision to one side of the vertical meridian with, otherwise, bilateral vision loss.

In other previous cases of bilateral homonymous hemianopia, various degrees of macular sparing^{6,7,20–23} or quadrant sparing,²³ which could be asymmetrical, have been described. This is the first report of complete unilateral sparing of the vertical meridian in a case of bilateral homonymous hemianopia. The imaging correlation confirms the lips of the calcarine fissure as being where the upper and lower halves of the vertical meridian map onto the primary visual cortex.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Note: Figures 1 and 3 of this article are available in colour online at www.informahealthcare.com/oph.

REFERENCES

- [1] Henschen SE. *Klinische und anatomische Beiträge zur Pathologie des Gehirns* (Pt 1). Almqvist and Wiksell; Stockholm, Sweden, 1890.
- [2] Inouye, T. Visual disturbances following gunshot wounds of the cortical visual area. Based on observations of the wounded in the recent Japanese wars: 1900, 1904–05. Tr. M Glickstein & M.Fahle. *Brain* 2000;123 (Special Suppl i–ix):1–101. Originally published as: Inouye T. Die Sehstörungen bei Schussverletzungen der kortikalen Sehsphäre nach Beobachtungen an Verwundeten der letzten Japanischen Kriege. Leipzig: W Engelmann; 1909.
- [3] Holmes G, Lister WT. Disturbances of vision from cerebral lesions with special reference to the cortical representation of the macula. *Brain* 1916;39:34–73.
- [4] Holmes G. Disturbances of vision by cerebral lesions. *Br J Ophthalmol* 1918;2:353–384.
- [5] Spalding JMD. Wounds of the visual pathway, II: The striate cortex. *J Neurol Neurosurg Psychiatry* 1952;15:169–183.
- [6] McAuley DL, Ross Russell RW. Correlation of CAT scan and visual field defects in vascular lesions of the posterior visual pathways. *J Neurol Neurosurg Psychiatry* 1979;42:298–311.
- [7] Horton JC, Hoyt WF. The representation of the visual field in human striate cortex: a revision of the classic Holmes map. *Arch Ophthalmol* 1991;109:816–824.
- [8] Wong AMF, Sharpe JA. Representation of the visual field in the human occipital cortex: a magnetic resonance imaging and perimetric correlation. *Arch Ophthalmol* 1999;117:208–217.
- [9] Dougherty RF, Koch VM, Brewer AA, Fischer B, Modersitzki J, Wandell BA. Visual field representations and locations of visual areas V1/2/3 in human visual cortex. *J Vis* 2003;3:586–598.
- [10] Rajimehr R, Tootell RBH. Does retinotopy influence cortical folding in primate visual cortex? *J Neurosci* 2009;29:11149–11152.
- [11] Munk H. *Über die Funktionen der Grosshirnrinde*. A., Hirschwald; Berlin, Germany, 1881 (English translation in Yon Bonin G, ed. *The Cerebral Cortex*. Springfield, IL: Thomas; 1960:97–117).
- [12] Jokl DHK, Hiyama F. Tatsuji Inouye—topographer of the visual cortex. Exemplar of the Germany–Japan ophthalmic legacy of the Meiji era. *Neuro-Ophthalmology* 2007;31:33–43.
- [13] Kumral E, Bayulkem G, Ataç C, Alper Y. Spectrum of superficial posterior cerebral artery territory infarcts. *Eur J Neurol* 2004;11:237–246.
- [14] Zhang X, Kedar S, Lynn MJ, Newman NJ, Bioussé V. Homonymous hemianopias: clinical-anatomic correlations in 904 cases. *Neurology* 2006;66:906–910.
- [15] Leff A. A historical review of the representation of the visual field in primary visual cortex with special reference to the neural mechanisms underlying macular sparing. *Brain Lang* 2004;88:268–278.
- [16] Marinković SV, Milisavljević MM, Lolić-Draganić V, Kovačević MS. Distribution of the occipital branches of the posterior cerebral artery: correlation with occipital lobe infarcts. *Stroke* 1987;18:728–732.
- [17] Smith CG, Richardson WFG. The course and distribution of the arteries supplying the visual (striate) cortex. *Am J Ophthalmol* 1966;61:1391–1396.
- [18] Gray LG, Galetta SL, Schatz, NJ. Vertical and horizontal meridian sparing in occipital lobe homonymous hemianopias. *Neurology* 1998;50:1170–1173.
- [19] Harrington DO. *The Visual Fields: A Textbook and Atlas of Clinical Perimetry*. St. Louis, MO: C.V. Mosby; 1971;324–325.
- [20] Steiner AA. Homonymous hemianopia, bilateral with macular sparing, of vascular origin. *Am J Ophthalmol* 1951;34:1170–1173.
- [21] Tanaka R, Miyasaka Y, Yada K, Mukuno K. Bilateral homonymous hemianopsia due to tentorial herniation, with sparing of central vision: case report. *Neurosurgery* 1992;31:787–790.
- [22] Kamyar R, Trobe JD. Bilateral mesial occipital lobe infarction after cardiogenic hypotension induced by electrical shock. *J Neuroophthalmol* 2009;29:107–110.
- [23] Nepple EW, Appen RE, Sackett JF. Bilateral homonymous hemianopia. *Am J Ophthalmol* 1978;86:536–543.