SHORT REPORT

Can diffusion weighted magnetic resonance imaging help differentiate stroke from stroke-like events in MELAS?

C Oppenheim*, D Galanaud*, Y Samson, M Sahel, D Dormont, B Wechsler, C Marsault

Abstract
The precise mechanism of neurological symptoms in patients with mitochondrial myopathy, encephalopathy, lactic acidosis, and stroke-like episodes (MELAS) is still controversial. The diffusion weighted MR findings at the acute phase of a neurological event in MELAS are described and the pathophysiology of stroke-like lesion in the light of diffusion changes is discussed. Brain MRI was performed 2 days after the sudden onset of cortical blindness in a 25 year old patient with MELAS. Fluid attenuated inversion recovery (FLAIR) images showed multifocal cortical and subcortical hyperintensities located bilaterally in the frontobasal and the temporopolar lobes. Diffusion weighted images showed normal to increased apparent diffusion coefficient values in the acute left temporooccipital lesion and increased values in the older stroke-like lesions. These diffusion weighted findings support the metabolic rather than the ischaemic pathophysiological hypothesis for stroke-like episodes occurring in MELAS. Normal or increased apparent diffusion coefficient values within 48 hours of a neurological deficit of abrupt onset should raise the possibility of MELAS, especially if conventional MR images show infarct-like lesions.

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Keywords: degenerative disease; diffusion weighted image; mitochondrial encephalopathy

*These authors contributed equally to this work

Department of Neuroradiology, Groupe Hospitalier Pitié-Salpêtrière, Paris VI University, 47 Boulevard de l’Hôpital, 75651 Paris, Cedex 13, France
C Oppenheim
D Galanaud
M Sahel
D Dormont
C Marsault

Urgences cérébro-vasculaires
Y Samson

Department of Internal Medicine
B Wechsler

Correspondence to:
Dr Catherine Oppenheim
catherine.oppenheim@piti-hop-paris.fr

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Case report
A 25 year old patient of short stature (1.59 m) with a history of bilateral deafness and insulin dependent diabetes mellitus was admitted to hospital for a left sided hemianopia of rapid onset with partial seizures. Conventional MRI performed at the acute phase of this first neurological event showed a large area of hypersignal on T2 weighted pulse sequences with associated brain swelling in the right temporo-occipital lobe. Cerebral angiography showed normal intracranial and extracranial vessels. A lumbar puncture showed increased lactates (5.6 mmol/l (normal<3 mmol/l)) in the CSF. The presence of ragged-red fibres on muscle biopsy raised the possibility of MELAS, which was confirmed by the presence of mutation at position 3243 in the mitochondrial genome. A treatment with carnitine, coenzyme Q, and riboflavine was then initiated.

One year later, a second MRI was performed 48 hours (figure) after the onset of rapidly progressive aphasia and sudden cortical blindness. The following sequences were used: spin echo T1 weighted sagittal acquisition, fast spin echo T2 weighted axial acquisition, and fast fluid attenuation inversion recovery (FLAIR) acquisition. Diffusion weighted imaging with an echo planar spin echo pulse sequence was used with 6 mm slice thickness, 1.5 mm gap, 96×96 matrix, 28×21 cm field of view, 4000/120 (repetition time (ms)/effective echo time (ms)). Five sets of images were successively acquired with five values of b, starting from b=0 s/mm² and rising to 800 s/mm², with diffusion gradients applied in three orthogonal spatial directions. Dedicated software (Functool, General Electric) allowed calculation of the apparent diffusion coefficient (ADC). Regions of interest (ROIs) were positioned on diffusion images and the apparent diffusion coefficient values were calculated in the acute lesion.

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weighted images in cortical, subcortical, and white matter areas alternatively in normal and abnormal appearing areas. An MR angiography of the circle of Willis and its major branches was also obtained and displayed normal vessels.

FLAIR sequences showed multifocal areas of high signal in the right frontobasal lobe and in the temporoparietal lobes bilaterally. When compared with the MRI performed a year earlier (not shown), an additional lesion was seen in the left temporoparietal lobe, matching the acute clinical presentation. On FLAIR images, this acute left temporoparietal lesion showed striking hypersignal with swelling gyri and mass effect. In this region, diffusion weighted images showed a heterogeneous signal with areas of isosignal and hypersignal. The ADC values calculated in the left temporoparietal region were normal or increased when compared with the normal appearing left frontocortical/subcortical region. Diffusion weighted images showed no signal changes in the right sequellar temporoparietal lesion and ADC values were increased. Detailed mean ADC values are listed on the table.

<table>
<thead>
<tr>
<th>ROI</th>
<th>Mean ADC value (10^{-3} mm^2/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal appearing grey matter (left frontal lobe)</td>
<td>0.91</td>
</tr>
<tr>
<td>Normal appearing white matter (left frontal lobe)</td>
<td>0.97</td>
</tr>
<tr>
<td>Lesion at the chronic stage (right temporoparietal cortex)</td>
<td>1.01</td>
</tr>
<tr>
<td>Cortico/subcortical acute lesion (left temporoparietal lesion)</td>
<td>0.83</td>
</tr>
<tr>
<td>Abnormal deep white matter (adjacent to the left atrium)</td>
<td>1.01</td>
</tr>
</tbody>
</table>

A statistical analysis using an unpaired two tailed Student’s t test showed a significant difference (p<0.03) between ADC values in ROIs positioned in normal appearing brain regions (mean 0.93 (SD 0.08) mm^2/s) and those located in acute lesions (mean 1.26 (SD 0.24) mm^2/s).

The condition of the patient rapidly deteriorated and he died the following month. Permission for necropsy was not granted.

**Discussion**

The focal neurological deficits of abrupt onset landmarking the evolution of MELAS are clinically indistinguishable from stroke events. Brain MRI of patients with MELAS classically shows signal changes involving both grey and white matter predominantly in the occipital and parietal lobes that strongly mimic stroke lesions. However, distribution of these infarct-like lesions on MRI does not usually follow vascular territories and pathological studies do not find lesions of the major cerebral blood vessels. Thus, the physiopathology of this disease remains unclear. Two main hypotheses have been raised to explain these cerebral lesions.

1. **The vascular hypothesis:** metabolic damage of the endothelium leads to small vessel occlusion and secondary neuronal death. It is supported by the clinical course of the disease similar to that of stroke and the CT and MRI appearance of the lesions and some pathological reports of endothelium alterations in the brain of patients with MELAS.

2. **The defect in neuronal metabolism hypothesis:** mitochondrial dysfunction results in anaerobic metabolism and neuronal death from acidosis. It relies on PET and SPECT studies showing hyperperfusion and dissociation between glucose and oxygen consumption in the affected areas of the brain.

Diffusion weighted imaging is a new technique in which images display local movement possibilities of water molecules that can help distinguish between cellular and extracellular oedema. Indeed, experimental results and human studies suggest that decreased ADC values reflects cellular oedema, whereas in-
creased ADC values correspond to increased of the extracellular space—that is, extracellular oedema.10 11 It has been well documented that cellular oedema during acute infarction is characterised by markedly decreased diffusion. It has been shown that ADC starts diminishing very early in the course of acute human stroke, reaches a minimum 2 or 3 days after onset,12 and remains under normal values for about 144 hours.13 It is thus now recognised that the finding of normal or increased ADC values within a few days after a neurological deficit of sudden onset virtually rules out acute ischaemic stroke.14 Although the duration of insult remains unknown in MELAS, the neurological symptoms of this patient were of sudden onset. Brain MRI was obtained 48 hours after this sudden onset and displayed normal or increased ADC values in brain areas undergoing acute dysfunction. Although a very short lasting ADC decrease immediately followed by an increase of ADC values cannot be excluded, such a rapid time course has not yet been reported in large acute arterial stroke in humans.12 13 The ADC pattern we found 48 hours after onset strongly differs from the marked ADC decrease that should be seen at this time point in pure acute arterial stroke and thus does not favour ischaemic damage as the main mechanism explaining focal neurological deficit in MELAS. This confirms the recent finding of increased ADC values at the acute phase of a small stroke-like lesion in a case of childhood onset MELAS15 and extends this result to a large stroke-like lesion in MELAS of adult onset.

Conclusion
Unlike routine MR imaging, diffusion weighted imaging can discriminate between cellular and extracellular oedema. By showing increased ADC values consistent with predominant extracellular oedema in an acute lesion in MELAS, diffusion weighted imaging adds further evidence against an ischaemic mechanism for stroke-like events in MELAS. The finding of normal to increased ADC values within 48 hours of a neurological deficit of abrupt onset should raise the possibility of MELAS, especially if conventional MR shows infarct-like lesions.

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