Comparison of Independent Aura, Ictal and Interictal Cerebral Perfusion

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Technetium-HMPAO cerebral SPECT was performed interictally, immediately after an independent aura and ictally in a patient with complex partial seizures. Interictally there was a left inferior frontoparietal region of decreased perfusion. Ictally there were a number of foci of increased perfusion. The aura study showed focal hyperperfusion in the left frontal region and decreased perfusion in the adjacent cortex posteriorly, suggesting a zone of suppression. This may be the cause or effect of the nonprogression of the aura. The case raises the possibility that cerebral perfusion studies performed immediately after independent auras may localize seizure foci if ictal studies are nonfocal.

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The relationship between changes in cerebral perfusion, metabolism, epileptic seizure onset and propagation is currently being clarified with single-photon emission computed tomography (SPECT) and positron emission tomography (PET). In some respects SPECT studies of cerebral perfusion with technetium-hexamethylpropyleneamine oxime (Tc-HMPAO) have advantages over currently available PET methodologies because Tc-HMPAO is taken up rapidly by the brain and washes out very slowly (*1–5*). Hence an injection can be given during a seizure and perfusion at that time can be determined by performing SPECT acquisition at a later time when seizure activity has abated and the patient is more cooperative (*6–9*).

This method also has the potential to assist in determining the temporal sequence of perfusion changes during seizures. In particular, it allows the performance of serial studies on single patients during different stages of their epileptic events. This paper presents the case of a patient who was scanned interictally, immediately after an independent aura and immediately postictally.

CASE REPORT

Mrs. E.T. was a 42-yr old female with intractable complex partial seizures since childhood. She experienced up to six fits a day which usually consisted of an aura of thoracoabdominal "flushing" followed by the impression of a bad smell and then loss of awareness during which observers described cessation of activities, staring forward, right hand shaking and lip smacking lasting for 2–3 min. After recovering awareness, she frequently experienced gustatory hallucinations which could last for some hours. On some occasions her typical aura would occur without progression to a complex partial seizure, an event usually termed an independent aura, or simple partial seizure.

Surface EEG performed during typical seizures showed generalized slowing starting 15 sec after clinical seizure onset, but no lateralizing features. MRI of the brain was normal.

Because of the frequency and disabling nature of her seizures, she had presented as a potential candidate for surgical treatment. Under the current assessment protocol at this institution, patients have two cerebral perfusion studies: an interictal study and an ictal or early post-ictal study. These are performed after injection of 750 MBq of Tc-HMPAO (Ceretec, Amersham), using a Philips rotating head gamma camera interfaced to a PDP 11/32 computer (Digital) with a 30-degree slant-hole collimator to minimize the distance of the patient's head from the detector (*10*). Studies are acquired in a 64 × 64 matrix over 64 angles at 20 sec per angle and reconstructed using standard NPS software (Philips) incorporating a Metz prefilter and an interactive program that corrects for rotation in the antero-posterior direction between studies.

This patient underwent three scanning procedures. The standard interictal study was performed 3 wk after any previous aura or seizure. Second, a Tc-HMPAO injection was given immediately after the onset of an aura. However, a typical complex partial seizure did not occur, raising concern as to whether this represented a true ictal study. Hence, a further study was acquired after an injection was administered during a characteristic seizure.

Sample transaxial slices from the three studies are shown in Figure 1. The interictal study shows a small left inferior frontoparietal region of decreased perfusion. The aura study shows a similarly positioned but more extensive focus of relatively decreased perfusion, and hyperperfusion in the adjacent left frontal cortex anteriorly and two minor left sided "intercortical" foci. The ictal study shows increased perfusion in both frontal regions, asymmetry in the temporal lobes and a relatively normal appearance of that part of the left frontoparietal region seen to be hypoperfused on the aura study.

DISCUSSION

Studies with PET and SPECT in epilepsy have indicated that epileptic foci can be associated with regional hypoperfusion and hypometabolism interictally, although this appears more common for temproal foci than for foci at

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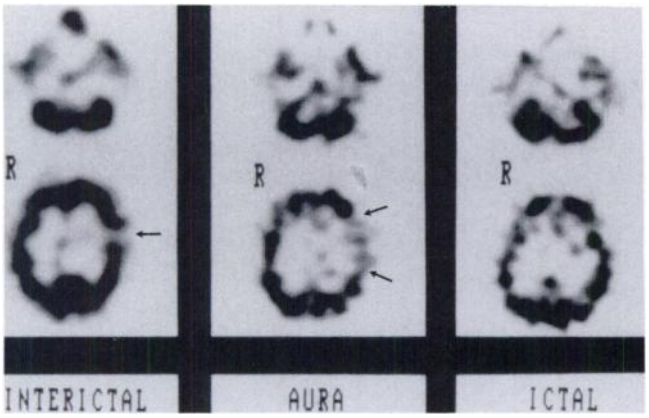

FIGURE 1. Sample transaxial slices from the interictal study, the aura study and the ictal study. The region of hypoperfusion on the interictal study and the greater extent of the similarly positioned hypoperfused region on the aura study are arrowed.

other locations (*6–9, 11–23*). In smaller numbers, it has been shown that the initiation and propagation of electrical seizure activity within the brain is coupled to a local increase in cerebral perfusion (*19–22*) and this has been used to assist focus localization.

Many epileptic patients experience an aura prior to the onset of their seizure and it is usually assumed that this represents the response produced by the onset of abnormal focal electrical activity (*24,25*). However, not all auras progress to typical seizures, and the pathophysiology of why some progress and why some occur independently is not clearly defined. It has been postulated that in the normal situation electrical impulses do not spread in an epileptic fashion because a zone of suppression is developed around the focus (surround inhibition). Seizure propagation may result in part from the failure of this mechanism (*26*).

In the current study, the interictal scan shows a relatively hypoperfused area in the left inferior frontoparietal region, suggesting that this is the site of seizure onset. The immediate postictal study, however, does not absolutely confirm this because it shows increases in flow remotely as well as in the region of the interictal defect. This presumably represents the pattern of cerebral perfusion generated by the subsequent spread of seizure activity.

The focus of relatively increased perfusion seen in the left frontal region on the aura study supports the localization of seizure onset in the inferior frontoparietal region as indicated by the interictal scan. In addition, there is a large region of relatively decreased perfusion posterior to this focus. This suggests that, analogous to electrical surround inhibition, there is relative suppression of perfusion, and therefore probably metabolism, in this region. However, the current study cannot determine whether this finding is the cause or the effect of the pathophysiological events which led to the onset of the aura and its failure to progress. The indistinct "intercortical" foci may represent a small degree of spread of abnormal electrical activity to remote regions unilaterally, but these are minor compared to those on the ictal scan.

This case demonstrates how SPECT can be used to study the changes in cerebral perfusion that accompany the different stages of an epileptic event as well as demonstrating the difficulties of tying these events to changes in pathophysiology at the electrical or cellular level. In addition, it suggests that cerebral perfusion studies performed immediately after independent auras may provide extra information about seizure focus localization in patients with non-focal ictal studies. Whether this extra information carries prognostic significance needs to be investigated.

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