Temporal Lobectomy in Congenital Porencephaly Associated With Hippocampal Sclerosis

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Background: Clinical and neuroimaging features of patients with epilepsy and coexisting extratemporal porencephaly and hippocampal sclerosis have been previously described.

Objective: To present the clinical characteristics and surgical outcome of 6 patients with intractable epilepsy and coexisting extratemporal porencephaly and hippocampal sclerosis.

Patients and Methods: Twenty-four patients with porencephaly and epilepsy were studied. Of these, 6 had an epileptogenic focus in the temporal region. All patients underwent video electroencephalogram monitoring, magnetic resonance imaging studies, and neuropsychological evaluation. Of the subset of patients with temporal lobe epilepsy, 1 patient underwent intracranial electroencephalogram monitoring. Temporal lobe resection was performed in 5 patients. Outcomes were evaluated using the Engel classification.

Results: Freedom from seizures was achieved in all patients. Pathologic analysis of the resected tissue confirmed the presurgical diagnosis of mesial temporal sclerosis.

Conclusion: Patients with extratemporal porencephaly and intractable seizures should be evaluated early and be considered for temporal lobectomy if clinical, magnetic resonance imaging, and electroencephalogram findings support the diagnosis of temporal lobe onset seizures.

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Dual pathology in temporal lobe epilepsy is an important determining factor of prognosis. Recent studies1,2 have demonstrated the association of congenital extratemporal porencephaly and hippocampal sclerosis. This particular form of dual pathology coexists in numerous patients with porencephaly. Although hippocampal atrophy in most patients is ipsilateral to the porencephalic cyst, it may be bilateral or contralateral to the porencephalic lesion.2

Epilepsy is commonly seen in patients with congenital porencephaly. Seizures often begin in early life and may be of different symptoms and severity. The presence of a large destructive extratemporal porencephalic lesion suggests that seizures may be associated with this pathologic feature. In these patients, the traditional neurosurgical approach has been hemispherectomy.3 However, we previously reported that, based on imaging and electroencephalography (EEG) criteria, some patients with extratemporal porencephaly may have hippocampal sclerosis. In this context, we have postulated that hippocampal atrophy may be epileptogenic and cause intractable seizures in this population. If this hypothesis is correct, temporal resection may be more appropriate in this population. We present herein the clinical characteristics and surgical outcome of patients with extratemporal porencephalic lesions and associated hippocampal atrophy who underwent tailored temporal lobe resections for intractable epilepsy.

METHODS

We studied 24 patients with porencephaly and intractable seizures. Patients with acquired cystic lesions (ie, after trauma, tumor resection, or infection) or developmental malformations (eg, schizencephaly) were excluded from the study. Of the 24 patients with these characteristics,1,2 9 had medically refractory epilepsy, with a subset of 6 patients with an epileptogenic focus in the temporal lobe. Five patients in this group underwent epilepsy surgery. One patient was lost to follow-up.
Clinical evaluation included a detailed neurologic history and examination. All patients underwent routine EEG studies using the International 10-20 System. All patients with medically intractable epilepsy underwent long-term video EEG monitoring with scalp electrodes, with additional anterior temporal electrodes (FT9-FT10) or placement of subdural electrodes if necessary. One patient underwent intracranial EEG monitoring with subdural electrodes.

MAGNETIC RESONANCE IMAGING

All patients underwent scanning on a 1.5-T magnet using a standardized protocol. Sagittal T1-weighted and coronal T2-weighted spin echo, fluid attenuation inversion recovery, and inversion recovery sequences were acquired. Hippocampal volumes were obtained in all patients using previously described techniques. For volumetric studies, a 3-dimensional spoiled gradient-echo (20/6.2/1) sequence was used with a 23-cm field of view, a flip angle of 28°, and a matrix size of 218 × 256 to acquire images in the coronal plane perpendicular to the long axis of the hippocampus and was then formatted to 1.5-mm contiguous coronal sections without gaps. The images were transferred then to a Silicon Graphics Indigo workstation (Silicon Graphics, Mountain View, Calif) for volumetric measurements using a software program developed in a laboratory at the University of Alabama at Birmingham. The regions of interest were outlined by the same interpreter using the manual contouring function, and the section volume was calculated automatically by the computer program. Anatomic guidelines for outlining the amygdala and hippocampal formation were consistent with previous reports. Reliability of volumetric assessment has been previously reported.

Volumes of the hippocampal formation were obtained for each patient and compared with values obtained from healthy control subjects according to age criteria. The patient group consisted of 13 male and 11 female patients. The control group consisted of 12 male and 6 female subjects. The hippocampal volumes in the patients were normalized using data from control subjects of similar ages to minimize variability in volumes due to different ages and sizes of the patients. We used a previously validated method for normalization of hippocampal volumes. In addition, magnetic resonance images (MRIs) were evaluated qualitatively for the presence of signal alterations indicative of mesial temporal sclerosis according to previously validated diagnostic criteria. At the same time, MRI results were analyzed for the presence of porencephalic changes, including cavitation (well-circumscribed cystic appearance), cephaloelastic changes (poorly circumscribed areas of parenchymal destruction associated with cystic components), and ventricular enlargement.

SURGERY

Five of 6 patients with temporal lobe epilepsy underwent temporal lobe surgery for medically refractory epilepsy. Surgical resections were performed by the subpial aspiration technique, with removal of the uncus, amygdala, and anterior 2.5 cm of the hippocampus. The neocortical resection included the anterior basal-temporal neocortex with sparing of the middle and posterior segments of the middle and superior temporal gyri, as previously described. Seizure outcome was analyzed using the Engel classification.

PATHOLOGIC CHARACTERISTICS

Representative tissue samples of the hippocampus were routinely obtained for analysis. Specimens were fixed in formalin and embedded in paraffin. Histologic sections of the hippocampus and temporal lobe were stained with hematoxylin-eosin and with glial fibrillary acidic protein. Pathologic classification using previous diagnostic criteria for mesial temporal sclerosis was used. Adequate hippocampal tissue was available for the diagnosis of hippocampal sclerosis in all patients.

RESULTS

Of the 9 patients with medically intractable epilepsy, 3 had an extratemporal epileptogenic onset (left orbitofrontal region, right occipital region, and right frontoparietal region). Six patients with a temporal lobe epileptogenic onset (3 men), with a mean age of 31.3 years (range, 15-42 years), were studied. The time between the onset of epilepsy and the age of evaluation was 27 years (range, 14.5-41.5 years). Three patients (1, 3, and 6) had clinical symptoms consistent with typical temporal lobe epilepsy. In patients 2 and 5, symptoms suggested temporal lobe onset, although typical temporal lobe auras were not elicited on patient history review. One patient reported tingling sensation in the body, whereas the other had a cooling sensation in all limbs. The symptoms in patient 4 were compatible with temporal lobe epilepsy of neocortical origin. The clinical features, presurgical data, and other details are listed in the Table. One patient had childhood febrile convulsions, and another had a history of ventriculoperitoneal shunt placement. One patient reported mild head injury. Mean seizure onset was 4.3 years (range, 6 months to 10 years). In the 3 extratemporal cases, symptoms and positron emission tomographic studies corroborated extratemporal localization of the epileptogenic foci. Studies with intracranially placed electrodes were necessary to adequately map the epileptogenic region.

MRI FINDINGS

All patients had evidence of extratemporal porencephaly. This condition occupied almost a complete hemisphere in 2 patients, more than 1 lobe in 2 patients, and 1 lobe in 2 patients. In all patients, hippocampal atrophy and signal changes were present. Hippocampal atrophy was unilateral to the porencephalic lesion in 5 patients (Figure 1) and contralateral to it in 1 patient (Figure 2). In 1 patient, there was bifrontal porencephaly, with left hippocampal sclerosis. Volumetry detected hippocampal atrophy in all 6 patients. Porencephalic cyst volume ranged from 1% to 32% of total intracranial volume (mean, 11%).

SURGICAL OUTCOME

Five patients underwent exclusively temporal lobe resections. One of them required recording with subdural intracranial electrodes, covering the inferior and lateral aspects of the left temporal lobe due to discordant presurgical information. Parietal coverage, even though planned, was not performed due to the unfavorable region for resection, its size, and the technical difficulties of the procedure. Freedom from seizures was achieved in all 5 patients (Engel class I). Mean follow-up was 47
months (range, 22-67 months). No symptomatic neurologic complications followed surgery. All patients continue to take antiepileptic medication but at lower doses or as monotherapy. Hippocampal sclerosis was histopathologically confirmed in all patients.

### Clinical and Demographic Details of Study Patients

<table>
<thead>
<tr>
<th>Patient No./Sex/ Age at Evaluation, y</th>
<th>Age at Onset</th>
<th>Handedness</th>
<th>Risk Factors</th>
<th>Seizure Symptoms</th>
<th>Video EEG Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/15</td>
<td>9 mo</td>
<td>Right</td>
<td>None</td>
<td>Aura, epigastric “sensation,” oral automatism, hallucinations, talk tingling of the whole body, staring, hand automatisms, rocking of body</td>
<td>Interictal: right and temporal (FT10); ictal: right and temporal (FT10)</td>
</tr>
<tr>
<td>2/F/29</td>
<td>8.5 y</td>
<td>Left</td>
<td>Febrile seizures</td>
<td>Staring, oral and hand automatisms</td>
<td>Interictal: left temporal (SP1); ictal: muscle artifact</td>
</tr>
<tr>
<td>3/M/31</td>
<td>10 y</td>
<td>Left</td>
<td>None</td>
<td>“Buzzing” in the head, auditory distortion, flushed</td>
<td>Interictal: left anterior temporal; ictal: left anterior temporal (FT9)</td>
</tr>
<tr>
<td>4/F/38</td>
<td>5 y</td>
<td>Left</td>
<td>Shunt</td>
<td>Cool sensation in limbs, staring, dystonic posture of right hand</td>
<td>Interictal: right anterior temporal (FT10); ictal: right anterior temporal (FT10)</td>
</tr>
<tr>
<td>5/F/42</td>
<td>6 mo</td>
<td>Left</td>
<td>None</td>
<td>Fear, oral and hand automatisms, dystonic posture of right arm</td>
<td>Interictal: left anterior temporal (SP1); ictal: left anterior temporal (SP1)</td>
</tr>
<tr>
<td>6/M/33</td>
<td>1 y</td>
<td>Right</td>
<td>None</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### MRI Results

<table>
<thead>
<tr>
<th>Condition</th>
<th>HS Volumes</th>
<th>Neuropsychological Test Results</th>
<th>Intracranial Studies</th>
<th>Surgery Resection</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right hemispheric porencephaly, right HS, and right brainstem atrophy</td>
<td>Rh 1.69</td>
<td>Right hemisphere: FSIQ: 73, VIQ: 82, PIQ: 68</td>
<td>No</td>
<td>Right temporal</td>
<td>HS</td>
</tr>
<tr>
<td>Left parietal porencephaly, left HS, and temporal atrophy</td>
<td>Rh 4.44</td>
<td>Left parietal: FSIQ: 95, VIQ: 101, PIQ: 89</td>
<td>Left subtemporal and lateral strips</td>
<td>Left temporal</td>
<td>HS</td>
</tr>
<tr>
<td>Left hemispheric porencephaly, left HS, and temporal atrophy</td>
<td>Rh 3.82</td>
<td>Left hemisphere: FSIQ: 76, VIQ: 85, PIQ: 70</td>
<td>No</td>
<td>Left temporal</td>
<td>HS</td>
</tr>
<tr>
<td>Bilateral frontal porencephaly and left HS</td>
<td>NA</td>
<td>Left hemisphere: FSIQ: 89, VIQ: 97, PIQ: 80</td>
<td>No</td>
<td>Left temporal</td>
<td>HS</td>
</tr>
<tr>
<td>Left centroparietal porencephaly, right HS, and atrophic corpus callosum</td>
<td>Rh 2.88</td>
<td>Right temporal: FSIQ: 90, PIQ: 74</td>
<td>No</td>
<td>Right temporal</td>
<td>HS</td>
</tr>
<tr>
<td>Right occipital porencephaly and right HS</td>
<td>Rh 2.27</td>
<td>Nonlocalizing: FSIQ: 66, VIQ: 71, PIQ: 65</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

### Abbreviations

- EEG, electroencephalography
- FSIQ, full-scale IQ
- HS, hippocampal sclerosis
- Lh, left hippocampus
- MRI, magnetic resonance imaging
- NA, not applicable
- PIQ, performance IQ
- Rh, right hippocampus
- VIQ, visual IQ

**Figure 1.** T1-weighted coronal image of the brain of a 15-year-old boy with right hemisphere porencephaly and ipsilateral hippocampal sclerosis.

**Figure 2.** T1-weighted coronal image of the brain of a 42-year-old woman with left hemispheric porencephaly and contralateral hippocampal sclerosis.

**COMMENT**

The coexistence of mesial temporal sclerosis with extra-hippocampal lesions in some patients with epilepsy has been previously reported and has been called “dual
The extrahippocampal lesions may include malformations of cortical development, porencephalic cysts, low-grade tumors, arteriovenous malformations, posttraumatic areas of encephalomalacia, and reactive gliosis. Cendes et al\(^1\) published the most extensive series of cases of dual pathology; these authors found that malformations of cortical development were by far the most common extrahippocampal lesion associated with medial temporal sclerosis. They also mentioned the presence of hippocampal atrophy in 31% of patients with porencephaly, which is lower than the figure reported by our group.\(^1\)

Seizures are an important cause of morbidity in patients with congenital porencephaly. Correlation of the structural lesion with electroclinical findings may enable effective surgical treatment in patients with seizures refractory to medical treatment. Previous studies\(^1\) have found a high prevalence of coexisting amygdala and hippocampal atrophy in patients with congenital porencephaly. It is likely that hippocampal sclerosis is the cause of epilepsy in these patients, but proof could only be established by surgical removal of the putative site.

Previous studies\(^13,14\) indicate seizure-free outcome of 58% to 90% of patients with temporal lobe epilepsy. The high proportion of seizure-free patients in our group may reflect a selection bias toward those with temporal lobe epilepsy and hippocampal sclerosis. Even though the surgical outcome of patients with this dual pathologic condition is less successful compared with those with isolated mesial temporal lobe sclerosis,\(^14\) the results of our study suggest that this particular group behaves differently.

Our study shows that the most common origin of epileptic discharges was the temporal lobe, and in all the cases presented there was concordance between hippocampal atrophy and electroclinical localization to the ipsilateral and contralateral temporal region. A common ischemic pathogenesis for the 2 lesions is possible in these patients. Perinatal occlusion of the posterior cerebral artery could result in tissue necrosis and cavitation, resulting in porencephaly with concurrent ischemia of the hippocampus.\(^1,17,18\) In 1 patient, the hippocampal atrophy was contralateral to the porencephaly. This patient, like the others, had confirmation of mesial temporal sclerosis by pathologic examination and has been seizure free since temporal lobe surgery (case 5, Table). In this patient, the mechanism of diaschisis can potentially explain the presence of a dual but contralateral pathologic condition. The term diaschisis was used by von Monakow to describe remote effects after central nervous system injury, such as cerebral infarction.\(^19,20\) Since then, different types of diaschisis have been recognized, including effects on the contralateral cerebral hemisphere or transhemispheric diaschisis.\(^20\) These changes may involve interruption of hemispheric connections by the infarct, causing deafferentation and transneural metabolic depression, impaired resting blood flow, or alteration in evoked electrophysiologic activity in the remote ipsilateral or contralateral hemisphere.\(^19,20\) Cerebral blood flow has been reported to be decreased contralateral to the infarction 1 to 2 weeks after onset of the lesion.\(^21\) Thus, either diaschisis following prenatal or perinatal cerebral vascu-

lar occlusion or watershed ischemia in the mesial temporal regions may lead to damage to the ipsilateral or contralateral amygdala-hippocampal formation.\(^1\)

A previous study by Li et al\(^22\) described 38 patients with this dual pathologic condition who were treated surgically for intractable partial seizures and found that the outcome was better if the lesion and the mesial temporal lobe structure were removed than if resection were limited to one or the other. The study was a sequel of a previous report from the same group and from the Mayo Clinic in which patients who underwent resection of both the lesion and the atrophic hippocampus became seizure free.\(^23,24\) Although porencephaly was not present in any patients in their series, the rule would apply for any patient with epilepsy with an atrophic hippocampus and an extratemporal lesion.

In all our patients, the findings conclusively indicated that the epileptogenic area was located in the anterior temporal lobe, and they were associated with an excellent outcome. In 1 case, invasive recordings were needed to provide further clarification about which component was the most epileptogenic—the atrophic hippocampus or the area surrounding the porencephalic lesion. This approach refined the surgical strategy and improved the outcome.

The traditional surgical approach to these patients has been to perform hemispherectomy or its variants. This approach was conceived before the introduction of high-resolution MRI into the practice of epilepsyology. Patients with porencephaly may have different possible epileptogenic loci. It is thus expected that given the difficulties of EEG localization, hemispherectomy would be a logical approach. Hemispherectomy has a high yield for seizure-free outcome, albeit with higher morbidity than temporal lobectomy.\(^25\) It is likely that many patients with extratemporal porencephaly and hippocampal sclerosis received hemispherectomy in the past. However, given our results, it would seem appropriate to consider a much more aggressive surgical strategy in selected patients. Although a randomized trial of hemispherectomy vs temporal lobe resection would be the only venue to scientifically answer this question, it may not be practical or ethical to perform.

The excellent results of surgery have great implications for the clinical treatment of this group of patients. Patients, especially children, with congenital porencephaly and intractable epilepsy should be evaluated early and be considered for temporal lobe surgery if clinical, MRI, and EEG findings support a diagnosis of temporal lobe onset seizures.

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Martin, and Bebin); study supervision (Drs Knowlton and Morawetz).

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REFERENCES