Latero-Orbital and Anterior-Temporal Electrodes
"Their Usefulness in Diagnosing Complex Partial Seizures"

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ABSTRACT

Complex partial seizures in adults are of considerable importance, they are the predominant seizure type in approximately 40 per cent of patients with epilepsy. The electroencephalogram (EEG) is a very important tool in the investigation of patients with temporal lobe epilepsy. However, EEG using only standard placed electrodes is often inadequate to reveal any abnormalities. The aim of our work is to investigate the usefulness of latero-orbital (LO) and anterior-temporal (AT) electrodes in detecting interictal epileptiform activity in a previously normal EEG recording of patients with complex partial seizures. Patients and Methods: Forty patients with complex partial seizures have been studied. The analysis consisted of studying the EEG data using the 10-20 international system of electrode placement, and in addition LO and AT electrodes are placed on either side. EEG activity was recorded for 10 to 15 min with a 14-channel, Nihon Kohden conventional EEG machine with a bipolar montage. The recorded epileptiform discharges were identified by visual inspection of the EEG in search of focal spikes and slow waves. Results: All cases had a normal background activity for their ages. Interictal epileptiform activity was present in 12 cases (30%) out of the 40 studied cases at latero-orbital electrodes sites. About 16 cases (40%) cases had interictal epileptiform activity at anterior-temporal (AT) electrode sites. Conclusion: Both AT and LO electrode sites were significantly superior to the 10-20 system of electrode placement in detection of epileptiform activity in patients with complex partial seizures. (Egypt J. Neurol. Psychiat. Neurosurg., 2006, 43(1): 35-40)

INTRODUCTION

The temporal lobe is the most epileptogenic region of the brain. In fact, 90% of patients with temporal interictal epileptiform abnormalities in their EEG have a history of seizures. They are usually classified by clinical history and interictal EEG findings alone.⁴

However, the value of interictal EEG in the identification and lateralization of temporal lobe seizures has received only limited attention.

Temporal lobe seizures usually begin in the deeper portions of the temporal lobe, and the most common location of interictal epileptiform EEG activity in patients with complex partial seizures is the anterior-mesial temporal region.⁵

It has long been claimed that the international 10-20 system of electrode placement does not provide appropriate coverage of the basal aspect of the temporal lobe. Electrodes F7 and F8 are closest to the temporal tips; however, these electrodes are relatively distant from anterior and mesial temporal structures.⁶,⁷

To resolve this weakness, several types of special additional basal electrodes are needed to record from the anterior and mesial temporal
structures. Among these, there are the sphenoidal, nasopharyngeal, zygomatic, anterior temporal (AT), latero-orbital (LO) and other non-invasive surface electrodes.

Sphenoidal electrodes are positioned most closely to the infero-mesial temporal regions, but they are semi-invasive, uncomfortable during insertion, require an experienced physician for their placement and do not necessarily distinguish spikes originating from antero-mesial temporal areas from those originating in antero-lateral temporal areas.

Moreover, the practical usefulness of sphenoidal and other invasive electrodes has been strongly questioned as it appears that anterior temporal scalp electrodes are as effective as sphenoidal electrodes in detecting epileptiform discharges.

Of note, in the last few years there has been increasing evidence that lateral surface placed electrodes mainly AT and LO electrodes are as effective as sphenoidal electrodes in detecting temporal epileptiform activity. Thus according to the solid angle principle, one might argue that electrodes placed everywhere within a small rounded area from the ear to the eye are capable of seeing surface temporal discharges.

Anterior temporal surface interictal spikes are thought to reflect interictal activity from the mesial temporal region.

The use of latero-orbital electrodes is a routine practice in any EEG laboratory for evaluating eye motion, and therefore provides a more accurate and reliable interpretation of scalp EEG activity.

In the present study, we prospectively investigated the usefulness of latero-orbital (LO) and anterior-temporal (AT) electrodes in detecting interictal temporal epileptiform activity in the EEG of patients with complex partial seizures. If so, since LO electrodes are used routinely to register eye motion, they could become an acceptable and practical substitute for other basal temporal electrodes in the day-to-day EEG evaluation of patients with known or suspected complex partial seizures.

MATERIALS AND METHODS

This study included forty consecutive patients (28 males, 12 females; mean ages: 23.4±9.2 years; range 8-43 years) with complex partial seizures with or without secondary generalization. The patients were selected having previous normal EEG examination on applying only the standard 10/20 system of electrode placement.

A) EEG acquisition:

EEG electrodes were placed according to the 10-20 international system recording with a 14-channel Nihon Kohden Equipment, using a bipolar montage. EEG activity was recorded for 10 to 15 min under standard conditions, and with hyperventilation as provocation technique and was digitally filtered below 2 Hz and above 20 Hz.

AT electrodes were placed on either side (T1, T2), 1 cm above the anterior one-third of the distance from the external auditory canal to the external canthus of the eye. LO electrodes were placed over the outer canthus of each eye (Lo1, Lo2). Simultaneous comparison of T1-T2 and Lo1-Lo2 electrodes was accomplished by employing the following montages:

Montage (A):

Montage (B):

The visualized EEG data were analyses for:
1- Analysis of the background activity searching for evidence of laterality.
2- Presence of spikes, sharp waves or slow waves at LO and AT electrode placements.
B) Interpretation and analysis:
A sharp-wave or spike was considered epileptiform if it had a sharp contour, a duration of less than 200 ms and was clearly distinct from ongoing background activity by its amplitude and duration. Such discharges were usually asymmetrical in appearance and followed by a slow wave. Localization was based on the site of phase reversal on bipolar montage. When interictal spiking activity occurred over F7, F8, T3, T4, T1, T2, Lo1,Lo2, it was considered to involve the temporal region, and extratemporal when occurring over other electrodes.

RESULTS

I. Clinical data:
This study was carried out for 40 patients aged from 8 years to 43 years old with a mean age of 23.4±9.2 years. 28 (70%) were males and 12 (30%) were females; 32 (80%) cases had history of aura, 2 out of them cases had somatosensory aura, 7 had special sensory, 12 had autonomic and 10 cases had a psychic aura and the remaining 8 cases had no aura. Only 10 cases (25%) had history of secondary generalization and 7 cases (17.5%) had history of oral and manual automatism (Table 1).

II. Visualized Electroencephalographic Data
A. Background activity data:
Background activity was analysed for:
- dominant rhythm
- symmetry

All cases (100.0%) had a normal dominant rhythm for their ages, symmetrical and synchronous over both hemispheres.

Table 1. Clinical results.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Present</th>
<th>Percentage (%)</th>
<th>Absent</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aura</td>
<td>31</td>
<td>77.5</td>
<td>9</td>
<td>22.5</td>
</tr>
<tr>
<td>Type of aura</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a- Somatosensory</td>
<td>2</td>
<td>6.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>b- Special sensory</td>
<td>7</td>
<td>21.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>c- Autonomic</td>
<td>12</td>
<td>37.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>d- Psychic</td>
<td>10</td>
<td>31.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Secondary generalization</td>
<td>10</td>
<td>25</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>Automatism</td>
<td>7</td>
<td>17.5</td>
<td>33</td>
<td>82.5</td>
</tr>
</tbody>
</table>

B. Site of epileptiform discharges:
1. Focal anterior -temporal (AT): 16 cases (40%)
2. Focal latero-orbital (LO): 12 cases (30%).

Table (2) demonstrates the effectiveness of AT and LO electrode sites over the 10-20 system that shows no detection in the studied 40 cases. Sixteen cases (40%) had interictal epileptiform spike foci at AT electrode site, and an additional 12 cases (30%) had interictal epileptiform activity at LO electrode site.

No statistically significant difference was found between the 10-20 electrode system placement and the LO electrode site placement (P>0.05).

A statistically significant difference was found between the 10-20 electrode system placement and the AT site placement (P<0.01) (Table 3).

No statistically significant correlation was found between the type of aura and effectiveness of either the AT or LO electrode site placements (P>0.05) (Table 4).

Case study:
- A Patient aged 24 years with history suggestive of complex partial seizures. He had experienced an autonomic aura, in form of recurrent attacks of an epigastric “rising” sensation, followed by post-ictal confusion. A secondarily generalized tonic-clonic seizure had occurred once. The standard routine EEG examination was not diagnostic, so we tried to use extra-sites at LO and AT sites to reach the diagnosis.
- A sharp wave appeared at the right anterior temporal electrode (T2) (Fig. 1).
Table 2. Site of interictal epileptiform discharges: Anterior temporal vs Latero-orbital electrode placements.

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of cases</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT detection</td>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td>LO detection</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>No detection</td>
<td>12</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 3. Comparison of the effectiveness of AT and LO over the standard 10-20 system for detection of interictal epileptiform activity in patients with complex partial seizures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Interictal foci detection</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT sites</td>
<td>16 cases</td>
<td>0.01</td>
</tr>
<tr>
<td>LO sites</td>
<td>12 cases</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Table 4. Correlation between the type of aura and AT and LO interictal epileptiform activity detection in patients with complex partial seizures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of cases</th>
<th>AT detection</th>
<th>LO detection</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Somatosensory</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td>B- Special sensory</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0.9</td>
</tr>
<tr>
<td>C- Autonomic</td>
<td>12</td>
<td>1</td>
<td>0</td>
<td>0.8</td>
</tr>
<tr>
<td>D- Psychic</td>
<td>10</td>
<td>8</td>
<td>4</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Fig. (1): A sharp wave appeared at the right ant. temporal electrode at T2.
DISCUSSION

Sometimes TLE can be difficult to differentiate from psychiatric diseases, since a temporal epileptic seizure may manifest itself even as psychosis.12

The ictal and interictal EEG and clinical semiology are necessary to define the seizure focus and the patient for proper diagnosis and management.

The majority of patients with complex partial seizures have a mesial temporal focus (Hippocampal seizure onset. Anterior temporal surface and sphenoidal interictal spikes are thought to reflect interictal activity from this region, and spikes limited to sphenoidal electrodes are sometimes said to be specific for a mesial temporal focus.4,13

In the present study we investigated whether non-invasive electrodes placed over the skin are effective and comparable to invasive ones in detecting and localizing interictal discharges in patients with complex partial seizures.

We found that recordings from latero-orbital and anterior temporal electrodes are reliable in detecting interictal epileptiform discharges in patients with complex partial seizures and both can improve the diagnostic capability in patients with complex partial seizures.

Both electrodes are superior to the standard 10-20 system of electrode placement, they could detect an additional 16 cases and 12 cases at the anterior temporal and latero-orbital electrodes placements respectively, in patients with normal EEG on applying only the standard 10-20 system.

Our findings are in agreement with the results of previous studies reported by Sperling and Engel6. However, several studies have reported that sphenoidal electrodes are more sensitive to paroxysmal activity from the mesial temporal region than routine surface temporal electrodes, these studies concluded that the proximity of the sphenoidal electrodes to the basal temporal region was responsible for their increased sensitivity.6,14

It is conceivable that such widespread volume-conducted epileptogenic potential propagating from mesial to lateral temporal region, may also be depicted by other relatively more distant scalp electrodes, which are simply optimally located for visualization of such synchronized temporal epileptiform discharges.15

This explanation was also supported by Smith et al.16, who suggested that volume conduction was responsible for potentials recorded from the surface, and they demonstrated that scalp potentials could be recorded from a deep generator which they artificially produced by passing a current source between 2 adjacent hippocampal depth electrodes.

We also found no statistically significant correlation between the type of aura and effectiveness of applying either the LO or AT electrode. Even the invasive sphenoidal electrodes do not necessarily distinguish spikes originating from antero-mesial temporal areas from those originating in antero-lateral temporal areas.6

Thus anterior temporal and latero-orbital electrodes may be very useful and become an acceptable and practical substitute for other basal invasive temporal electrodes in the day-to-day working of the EEG laboratory, and both electrodes can improve diagnostic capability in patients with complex partial seizures.

REFERENCES


الملخص العربي

أهمية استخدام القطب بجانب العين في تقنيات تشخيص الصرع الجزئي

يعتبر مرض الصرع الجزئي في البالغين ذو أهمية بالغة حيث أنه يمثل 40% من أنواع الصرع الأخرى. كما يعتبر التخطيط الكهربائي لمناخ من أهم الفحوصات التشخيصية لهذا المرض. وعند استخدام التوزيع الروتيني لتقنية رسم المخ طبقاً لنظام 10 إلى 20 العالمي، يصعب أحياناً تشخيص هذا المرض عن طريق إظهار الظاهرة السرعت في المنطقة المصاب بها. لذلك كان من الأهمية البحث في استخدام أمكنة غير تقليدية وإضافية للنظام المنبع وهذا التخطيط ساحة أكبر من المخ خاصة في الفص الصدغي المفصول عن هذا المرض. وذاه في محاولة لانتقاء أي أوجه صرعية قد تنشأ وقعاً في هذا الفص من المخ من أهم هذه الأمكنة. يعتبر القطب الموضوع بجانب العين والقطب الموضوع في تقنيات الفص الصدغي ذات حساسية ودالة تشخيصية في إظهار الظاهرة المفصولة التي قد لا تظهر باستخدام التوزيع الروتيني النابع لنظام 10 إلى 20.

وقد جاء نتيجة هذا البحث واستخدام هذه الأمكنة الإضافية أنها ذات حساسية تشخيصية أكثر من الأمكنة الروتينية حيث أن الظاهرة المفصولة خرجت في 12 حالة من بين 40 حالة عينة هذا البحث عند المكان الأول بجانب العين. وفي 16 حالة عند المكان الآخر في مقدمة الفص الصدغي.

نتسلخ من هذه الدراسة أن الأمكنة الإضافية للأقطاب ذات أهمية تشخيصية في تشخيص مرض الصرع الجزئي خاصة في حالة عدم تشخيصه باستخدام التوزيع الروتيني لتقنية رسم المخ طبقاً لنظام 10 إلى 20.

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