SPHENOIDAL ELECTRODES IN THE ELECTROGRAPHIC STUDY OF PATIENTS WITH TEMPORAL LOBE EPILEPSY

AN EVALUATION*

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The principal epileptogenic area in the majority of patients with temporal lobe epilepsy involves the mesiobasal regions of the temporal lobe (uncus, amygdaloid and hippocampal areas). Accordingly, it has been well recognized that some type of recording from the base of the skull is essential for detailed electroencephalographic study of this most common type of focal epilepsy. Standard scalp electrodes are, therefore, supplemented in most electroencephalographic laboratories by the use of either pharyngeal or sphenoidal electrodes. Other techniques such as electrodes placed against the tympanic membranes, etc., have been less popular.

At the Montreal Neurological Institute, nasopharyngeal electrodes have been used routinely in the investigation of all patients suspected of having temporal lobe epilepsy. A single pair of sphenoidal electrodes has been used on rare occasions, usually when the pharyngeal recording was unsuccessful. With multiple recordings and use of various activation techniques, satisfactory localization of the epileptiform abnormality has been possible in most, but not all, patients suspected clinically of suffering from temporal lobe epilepsy. In an effort to improve the accuracy of the electroencephalogram in complicated problems of temporal lobe seizures, a technique has been developed using two sphenoidal electrodes beneath the greater wing of the sphenoid bone on each side to complement the nasopharyngeal electrode and permit recording from six separate points, three on each side, beneath the mesial portions of the temporal lobe.

A detailed description of this technique and a preliminary assessment of its value has been reported elsewhere, so only a brief outline will be presented here.

TECHNIQUE

Under aseptic conditions insulated sphenoidal needle electrodes are inserted into the cheek just below the zygomatic arch and directed mesially to the base of the skull just anterior and lateral to the pterygopalatine fossa (“anterior sphenoidal electrode”), and to the posterior rim of the foramen ovale (“posterior sphenoidal electrode”) as shown in Fig. 1. The landmarks and technique of insertion of the needles are essentially those used for the injection of the 2nd and 3rd divisions of the trigeminal nerve by the lateral approach. Recording is then carried out using electrode linkages that permit comparison and localization of discharges at the anterior or posterior sphenoidal and/or pharyngeal electrodes in relation to the standard scalp and ear electrodes. If Metrazol activation is to be carried out, or if it is desired to repeat the recording on a second or third day, fine (0.008" diameter) insulated piano-wire electrodes are inserted through the needles and the needles are then removed leaving the wire electrodes in situ. The wire electrodes are firmly fixed to the skin with Nylon plugs. The wire electrodes may then be left in place for several days and successive recordings can be made to confirm the existence and localization of an elec-
FIG. 1. Position of sphenoidal electrodes below base of skull. “Anterior sphenoidal electrode” is placed against the lateral pterygopalatine fossa. “Posterior sphenoidal electrode” lies near the posterior rim of the foramen ovale.

trographic abnormality. Spontaneous or induced seizures have failed to dislodge the flexible wire electrodes.

This technique, utilizing multiple basal electrodes, has been performed in over 80 patients suspected of having temporal lobe epilepsy at the Montreal Neurological Institute. No complications have resulted. It is the purpose of the present report to outline the advantages inherent in the use of multiple sphenoidal electrodes in the electroencephalographic diagnosis of patients with temporal lobe epilepsy, and to compare the efficacy of these sphenoidal electrodes with nasopharyngeal electrodes in recording small abnormal electrographic potentials.

ILLUSTRATIVE CASE REPORTS

Case 1. I.C., a 23-year-old female, was becoming increasingly incapacitated by frequent seizures since their onset 6 years previously. The seizures were characterized chiefly by long, complex automatons lasting for as long as 3 to 4 hours. During these attacks her consciousness appeared to wax and wane. Following a few of the attacks, a postictal speech deficit had been elicited. Several major seizures had been observed without any localizing or lateralizing features.

Standard Electroencephalograms. Numerous recordings had been made previously at the Montreal Neurological Institute and other institutions. Very little abnormality had ever been seen; surely nothing characteristic of a localized lesion. Some bilateral, irregular, low-voltage 5 to 6 c./sec. waves had been recorded over both temporal regions. These were occasionally slightly sharp in form, but no predominance of one side could be made out, even using pharyngeal electrodes. Activation techniques including hyperventilation, photic stimulation, sleep and Metrazol failed to induce any evidence of a localized epileptogenic lesion.

Sphenoidal Electrode Studies. Two recordings were made using both sphenoidal and pharyngeal electrodes, as well as the standard scalp leads. Surface electrodes over the temporal regions showed only bilateral theta rhythms. Almost continuous spike and sharp-wave activity of low and medium voltage was present at both anterior and posterior sphenoidal electrodes beneath the mesial portion of the left temporal lobe during the first examination; at a time when surface and pharyngeal electrodes recorded normal activity. This examination was repeated and discrete epileptogenic spike activity was seen at both of the left sphenoidal electrodes, and to a lesser extent at the left pharyngeal lead. Again, no diagnostic abnormal potentials were seen from scalp electrodes over the lateral surface of either temporal lobe (Fig. 2).

Operative Findings. When left temporal lobectomy was carried out the left uncinate region was found to be extremely soft and atrophic. The patients had had numerous electroencephalographic studies performed over a period of years prior to the present examination. All previous electroencephalograms, if available, were studied, summarized, and compared with the results obtained using this multiple sphenoidal electrode technique. Special attention was paid to the comparative efficiency of nasopharyngeal electrodes and the separate sphenoidal electrodes in recording small abnormal electrographic potentials.
hippocampus was yellowed and fibrosed. Surface recordings over the convexity of the left temporal lobe revealed only slow activity—usually 5 to 8 c./sec. Spike activity was recorded only from depth electrodes inserted into the hippocampal and amygdaloid regions.

**Comment.** At the time of her several investigations before operation, this patient was felt to have temporal lobe epilepsy without clinical evidence of lateralization. No clear epileptogenic focus was ever revealed by standard electroencephalographic techniques, despite the use of a number of activation procedures. The discharging focus in the left uncinate region initially was uncovered only with sphenoidal electrodes. At a second examination, the left uncinate focus was also seen with the pharyngeal electrodes. These findings were confirmed at operation.

**Case 2.** A.M., a 26-year-old laborer, had experienced major and minor seizures for 2 years. Major seizures were generalized from their onset without any lateralizing features. Minor attacks were characterized by an epigastric aura, an olfactory hallucination, and somewhat purposeless automatic movements. Speech was incoherent during the ictal episodes, but it was uncertain whether this disturbance was related to the patient’s confused state or was primarily dysphasic in nature.

**Electroencephalographic Findings.** Numerous previous recordings had been made during the past and present hospital admissions. These studies were all quite similar. Bitemporal abnormalities had been recorded, occasionally being more pronounced in one hemisphere, and on the next occasion being seen more clearly on the opposite side. Pharyngeal electrode studies confirmed the bitemporal abnormalities seen with scalp electrodes. Hyperventilation induced bilaterally synchronous bursts of slow- and sharp-wave activity over the convexities of both temporal lobes.

**Sphenoidal Electrode Studies.** Two separate sphenoidal examinations revealed the presence of almost continuous high-voltage spike activity emanating from the left posterior sphenoidal electrode. Lesser and not always diagnostic degrees of this abnormality could be elicited from the anterior sphenoidal and pharyngeal electrodes on the left side. It was clearly evident that the bitemporal surface dysrhythmias were reflections of an extremely active focus in the left uncinate region with transmission of attenuated epileptogenic potentials peripherally to both lateral temporal convexities. No independent right-sided epileptogenic abnormality was revealed.

**Operation** was deferred for further trial of medical anticonvulsant therapy.

**Comment.** Although it was evident that this patient was experiencing temporal lobe attacks, there was no clear clinical evidence of the lateralization of the epileptogenic area. Standard scalp and pharyngeal electroen-
cephalograms provided suggestive evidence of independent bitemporal abnormalities without clear predominance of one side. The electroencephalogram with sphenoidal electrodes showed clear evidence of a single active epileptogenic area in the uncinate region of the left side. This focus presumably discharged directly or indirectly outward to both lateral temporal surfaces, producing an apparent bitemporal abnormality. Failure to perform sphenoidal electrode studies would have eliminated this patient as a potential candidate for surgery.

Case 3. J.A., a 28-year-old right-handed housewife, was admitted for investigation of numerous relatively stereotyped seizures which she had been experiencing for about 12 years. Her seizure pattern was characteristic of temporal lobe epilepsy, consisting of a rising epigastric aura, smacking movements of the lips and a prolonged ictus characterized by complex automatisms. Jargon aphasia had been observed at the onset of her attacks. A clinical diagnosis of left temporal lobe epilepsy had been strongly entertained.

Standard Electroencephalograms. Recordings were made at the Montreal Neurological Institute and compared with those made previously at other institutions. All showed clear evidence of a focus involving the mesiobasal and lateral aspect of the left temporal lobe. Spikes and sharp waves were elicited from these areas on all examinations. Pharyngeal electrodes confirmed this left temporal focus. No abnormality had ever been recorded from the right hemisphere.

Sphenoidal Electrode Studies. Findings with the sphenoidal electrode confirmed the presence of an active epileptogenic focus involving the basal and lateral surfaces of the left temporal lobe. An additional independent focus was also picked up in the uncinate region on the right side. This latter focus was seen clearly at both sphenoidal electrodes on the right, but was not transmitted into any of the scalp or pharyngeal electrodes (Fig. 3).

Comment. On clinical and standard electroencephalographic examinations, this patient would have been diagnosed as a case of temporal lobe epilepsy with a clear focus in the left uncinate region. Only after sphenoidal electrode studies had been performed was it apparent that another independent epileptogenic focus was present in the uncinate region on the right side. In view of the independent bitemporal abnormalities, surgery was deferred.

Case 4. H.C., a 26-year-old laborer, had experienced major and minor seizures following a severe closed head injury at age 18. His seizures were initiated by a sensation of constriction in his throat followed by a visual hallucination. Fumbling automatic movements followed, often terminating in a generalized convulsion. Postictally the patient was clearly dysphasic.

**Fig. 3. Case 3.** Bilateral epileptogenic foci are seen clearly at right and left anterior sphenoidal electrodes. There are random high-voltage spikes and sharp waves on the right side, and frequent low-voltage but independent spikes and sharp waves on the left. Note minimal reflection of the spikes in the pharyngeal recording.
Fig. 4. Case 4. Well localized spike and sharp-wave epileptogenic activity is present at the left anterior sphenoidal electrode with little or no spread to the left posterior sphenoidal electrode. No epileptiform activity was recorded from the right side.

**Standard Electroencephalograms.** Several studies had been carried out over the period of years since the initiation of his attacks. All showed slight irregularities in rhythm over the left temporal lobe. Although the surface dysrhythmia was clearly abnormal, no focal spike activity had ever been recorded from scalp or pharyngeal electrodes.

**Sphenoidal Electrode Studies.** An active discrete epileptiform abnormality, characterized by extremely high-voltage spikes, was found sharply limited to the left anterior sphenoidal electrode and often the spikes were not transmitted even to the posterior sphenoidal electrode on that side (Fig. 4). No potentials diagnostic of a focal epileptogenic lesion were seen at the standard scalp and pharyngeal electrodes.

**Operative Findings.** Left temporal lobectomy revealed the characteristic gross findings of insusural sclerosis of marked severity. High-voltage spike activity was recorded from depth electrodes in the hippocampal region.

**Comment.** Numerous electroencephalograms in the past had failed to outline a discrete epileptogenic area in this patient. Sphenoidal electrode studies revealed a surprisingly discrete epileptic abnormality confined to the left anterior sphenoidal electrode without evidence of transmission to adjacent basal or more distant scalp leads.

**SUMMARY OF RESULTS**

The first 50 patients with both clinical and electroencephalographic evidence of temporal lobe epilepsy who were examined using scalp, nasopharyngeal and multiple sphenoidal electrodes were surveyed for this report. The first 27 were consecutive patients with a clinical diagnosis of temporal lobe epilepsy who were being studied for possible surgical therapy. The remaining 23 patients were selected for sphenoidal electrode studies because standard scalp and pharyngeal recordings did not show a clear-cut unilateral temporal epileptic activity, although their attacks were clinically temporal in origin.

When the final diagnosis had been established, we attempted to assess from the electroencephalographic recordings the comparative value of the various scalp and basal electrodes in providing a complete and accurate picture of the location and extent of the epileptic disorder. The results of this analysis are tabulated in Table 1. It is evident that the standard scalp electrodes were adequate in only one-fourth of these patients with temporal lobe epilepsy. The addition of the nasopharyngeal electrode recordings...
TABLE 1
Comparative value of scalp and basal electrodes in patients with temporal lobe epilepsy

<table>
<thead>
<tr>
<th></th>
<th>Scalp Electrodes Alone Adequate</th>
<th>Localization Established with Pharyngeal Electrodes</th>
<th>Sphenoidal Electrodes Necessary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Unilateral cases</td>
<td>30</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>18</td>
<td>19</td>
</tr>
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provided accurate definition of the epileptic lesion in two-thirds of the unilateral group and half of the bitemporal group. The use of sphenoidal electrodes was deemed necessary or highly desirable for complete evaluation of the patients' seizure problem in the remainder (38 per cent of the total group).

Following the sphenoidal electrode studies, the patients were divided into two groups on the basis of the electroencephalographic data:

*Group 1.* Those with a unilateral temporal epileptogenic lesion (30 patients).
*Group 2.* Those with bilateral independent temporal epileptogenic lesions (20 patients).

All available electroencephalograms of each patient were studied and the area of maximal epileptogenic activity was ascertained in each individual case. These results are summarized in Table 2. In 84 per cent of the total group (90 per cent of the unilateral temporal, and 75 per cent of the independent bitemporal cases), the maximal area of epileptogenic activity was clearly in the uncinate region rather than the lateral convexity of the temporal lobe. This is almost identical with results of a similar analysis of the first 27 consecutive unselected cases of this series (88 per cent). This marked predominance of epileptiform activity in the mesiobasal regions of the temporal lobe, therefore, is not ascribable to the selection of more complicated problems of temporal lobe seizures in the latter half of the series, but rather is characteristic of temporal lobe epilepsy in general. This predominant involvement of the medial and basal regions of the temporal lobe emphasized the importance of electroencephalographic techniques for recording from the basal aspect of the middle fossa in the study of patients with temporal lobe epilepsy.

### DISCUSSION

The clinical manifestations of seizures arising from the temporal lobe have been discussed in several recent publications. With an adequate detailed description of the pattern of the attack, the identification of these attacks as arising in a temporal lobe usually is not difficult. In some patients, the presence of ictal or postictal aphasia points to involvement of the temporal lobe of the dominant hemisphere. In others, spread of the discharge to the neighboring sensorimotor areas gives evidence of the lateralization of the seizure discharge. In most patients with temporal lobe seizures, however, it is necessary to rely on the electroencephalogram for a decision as to whether the seizures are arising in the right or the left or both temporal lobes. It is, therefore, unwise to rely on a single electroencephalographic examination when evaluating the possibility of surgical therapy. Repeated examinations and use of various forms of activation increase the accuracy of interpretation of the record.

With multiple examinations and various activation procedures, sufficient evidence of abnormal activity was found in the recording of the scalp electrodes to corroborate a clinical
diagnosis of temporal lobe epilepsy in many of the patients in this series. Precise localization of the epileptiform discharges, adequate to serve as a basis for decision regarding possible surgical therapy, however, was provided by the standard scalp electrodes in only one-fourth of the patients in this series. In the remaining three-fourths, some form of basal electrode recording, pharyngeal or sphenoideal, was necessary, and in over one-half of these the sphenoidal electrodes gave valuable or essential information.

The proximity of the sphenoidal electrodes to the mesiobasal temporal region doubtless accounts for their pronounced superiority in recording discharges from this region. When epileptiform discharges remain localized in the mesiotemporal region, they may be recorded with fairly high amplitude in the sphenoidal electrodes, and yet be seen poorly in the pharyngeal electrodes and not seen at all in the scalp electrodes over the temporal region. The counterpart of this is often seen at operation, when epileptiform discharges of high amplitude recorded through depth electrodes inserted into the amygdaloid nucleus or hippocampus are not seen at all in electrodes placed on the cortex of the convexity of the temporal lobe.

The presence of independent bitemporal epileptiform electroencephalographic abnormality reduces the likelihood of successful surgical therapy. For example, unilateral temporal lobectomy results in complete or nearly complete relief of seizures in 2 out of 3 patients with strictly unilateral epileptiform activity of the temporal lobe. When there is a minor but independent discharging lesion in the contralateral temporal lobe, a similarly successful result occurs in 1 out of 3 patients after operation. When the electroencephalographic activity is about equal in the two temporal lobes and operation is carried out on the basis of lateralization by the pattern of the attack and roentgen-ray evidence of unilateral atrophy of the temporal lobe, the rate of success drops to 1 out of 10. A multiple basal electrode technique is of particular value in assessing the presence and degree or absence of bilaterality of epileptiform activity of the temporal lobe, and thus improves the pre-operative prediction of the possible beneficial effects of temporal lobectomy for temporal lobe seizures.

The second group of cases, in which the sphenoidal leads have been of especial value, includes the occasional patient with definite clinical evidence of temporal lobe epilepsy, but with little or no electroencephalographic abnormality in the standard scalp and pharyngeal recordings. At operation these patients have shown the typical gross changes of incisural sclerosis similar in extent and severity to other patients in whom the epileptiform electroencephalographic discharges were distributed more widely. It seems obvious that other, as yet obscure, factors are important in the spread and distribution of epileptiform discharges apparently arising in the medial temporal regions.

**SUMMARY**

The results of electroencephalographic studies using both standard surface and multiple basal electrodes have been analyzed in 50 patients with temporal lobe epilepsy. These basal electrodes, one pair of anterior sphenoidal, one pair of posterior sphenoidal, and one pair of pharyngeal electrodes, provided more nearly accurate localization of the epileptiform discharges than was possible with routine scalp and ear electrodes and a single basal electrode, pharyngeal or sphenoidal.

Scalp electrodes alone provided accurate definition of the complete electroencephalographic abnormality in 13 (26 per cent) of the 50 patients. Some form of basal electrode, pharyngeal or sphenoidal, was required in the remaining 37 patients. Sphenoidal electrodes were necessary or highly desirable in half of this latter group, or 38 per cent of the total series.

A strictly unilateral temporal epileptogenic electroencephalographic abnormality was found in 30 patients (60 per cent), while in the remaining 20 (40 per cent) a bilateral independent temporal electroencephalographic abnormality was demonstrated.

The uncinate or mesiobasal region of the
temporal lobe was the site of the maximal epileptiform discharge in 84 per cent of all the patients in this series.

Sphenoidal electrodes were of particular value in this series in the study of the presence and degree of independent bilateral temporal epileptiform abnormality, which has an important influence on the results of surgical therapy.

In a few patients, active spiking in the sphenoidal electrode recording was not reflected at all in the recording from the scalp electrodes, and was seen poorly or not at all in the pharyngeal recording.

REFERENCES


DISCUSSION

Dr. Harry F. Steelman: I should like to congratulate the authors on the use of a very fine technique for recording. Someone has noted that one of the marks of a scientific mind is the ability to become astonished at the proper time. I am sure that the authors, in their initial wonderment at the simplicity of this technique of recording from the basal part of the brain, have then found it not necessary to use implanted electrodes, which are much more complicated. They have used this technique for the specific purpose of localization of abnormal activity and selection of patients for operation. They have verified the validity of their recordings by several levels of analysis: (1) correlation of the seizure pattern (there was not time, I am sure, to discuss this in the paper); (2) operative recordings by direct and implanted electrodes; (3) by the relief of seizures in a fair percentage of the patients; and (4) alteration of the postoperative recordings. They have by this method proceeded in a scientific manner to prove certain clinical points.

Furthermore, Dr. Rovit should be an expert at injecting branches of the trigeminal nerve.