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DISCUSSION ON THE SURGERY OF TEMPORAL LOBE EPILEPSY

Dr. Denis Hill (Department of Clinical Neurophysiology, Institute of Psychiatry): *The Clinical Study and Selection of Patients*

During the last three years five reports have appeared from North America describing operations upon the temporal lobes of man for the ablation of epileptogenic foci and these reports have been encouraging both from the point of view of the control of epilepsy and for the amelioration of the associated personality disorder. Between 1939 and 1949 Penfield and Flanigin (1950) had performed 75 such operations on 68 cases and their early success led them to perform a further 30 in 1950. 51 cases have been followed up, some as long as ten years. They reported a 52·9% success; 27·4% of their cases having had no fits at all since operation, 25·4% one or two fits and then cessation, and a further 25·4% were improved. In only 21·5% was the operation regarded as a failure. These writers give little information about the mental states of their patients, but report that although half the temporal lobe or more was removed there was no evidence for alteration of behaviour, no particular memory loss and no persistent aphasia; nor was there any defect of initiative or capacity for decision.

Bailey and Gibbs (1951) reported on 28 patients. 14 had been committed to a mental hospital; all were serious social and economic liabilities. Following operation 6 were discharged from hospital and 7 became self-supporting. Major seizures were reduced in 15 cases and ceased altogether in 9. Psychomotor seizures, which had occurred in all 28, ceased in 17, were reduced in 8, and remained unchanged in 3. 16 of the patients were psychotic and 8 of these became quiet in behaviour, but only 2 became free from thought disorder. These writers considered that the mental status of their patients was remarkably better in 3, moderately improved in 15, unimproved in 8, and worse in 2. They claimed that the operation had a favourable influence on 64% of their patients. Green, Duisberg and McGrath (1951) followed 23 cases for periods up to thirty months after operation. 12 were free from seizures and in 9 there was a reduction in incidence. Only 3 were unimproved. In 8 of the 23 patients there was an improvement in the mental state. Smaller series have been reported by Morris (1950) and by Obrador (1953) from Spain. The total number of such patients reported in the literature is 132.

In these papers we are to report upon 14 epileptic subjects for whom temporal lobectomies have been performed by Mr. Murray Falconer at the Guy's-Maudsley Neurosurgical Unit. 2 of these patients have been referred by colleagues at Guy's Hospital and the remainder have been in-patients at the Maudsley Hospital. Dr. Desmond Pond has been responsible with me for the pre-operative clinical study of most of these patients and some of them have been under his care. Dr. G. Pampiglione has assisted us with the electroencephalography and has been responsible for the electrocorticography at operation which is now part of the routine procedure. My contribution is to discuss first the identification and selection of patients for whom this operation would appear to offer a hope of amelioration, and secondly to describe some of the results obtained. Mr. Murray Falconer will deal with the surgical aspects and, in the unfortunate absence of Professor Meyer, with some of the pathological findings which have proved most interesting and unexpected.

The necessary investigations which allow the surgeon to open the skull and resect a part of the brain with the confident expectation that he will remove the epileptogenic focus have been developed as the result of the new EEG techniques for the activation and identification of epileptogenic foci. At the same time, thanks to the work particularly of Penfield and Jasper at Montrêal, that of the Gibbses, Earl Walker and others, as well as the more detailed clinical approach made to this subject by many workers, there has been a much greater understanding not only of the main sites of seizure onset in the brain but also of the probable pathways of spread from the focus. Remarkable advances in neurosurgery and anæsthesiology have allowed for greater control of the operative situation and enabled the neurophysiologist to join the surgeon at the operation and for them together to map out the abnormal excitable areas by electrocorticography. Thus the epileptogenic areas crudely identified from the scalp by the usual techniques of indirect electroencephalography can now be precisely located upon the surface of the exposed cortex or followed into the deep structures by means of depth electrodes.

The investigation of the type of patient with which we are dealing naturally falls therefore into the following stages.

(1) The presumptive evidence on clinical grounds that the epilepsy starts in the temporal lobe.

(2) The identification of the focus by electroencephalography and the demonstration of its constancy, as well as the relationship which may exist to structural changes in the brain revealed by pneumoencephalography or arteriography.

(3) An attempt to control the activity of the focus by anticonvulsants, failure of which leads on to the question of whether the total situation will be improved by surgical removal of the focus.

(4) The decision to proceed to operation when it is necessary to demonstrate by electrocorticography that the abnormal discharging area is confined to the anterior parts of a temporal lobe within that area which can be safely removed by surgery.

(5) Finally there is the post-operative treatment and rehabilitation of the patient which in cases of social deterioration is extremely important and may be very difficult.

The Pre-operative Study

Unfortunately the term "psychomotor epilepsy" has come to be used synonymously with temporal lobe epilepsy. The term "psychomotor epilepsy" was introduced by Gibbs *et al.* in 1937 when they made their first classification of the epilepsies based upon frequency and wave form of the EEG. At this time no attention was paid to the locational differences of such patterns. The so-called "square-topped wave" repeating at 4 per second which they observed to be frequently associated with behavioural automatisms was called the "psychomotor pattern". By 1948 it was shown by Gibbs *et al.* as well as by other workers (Jasper and Kershman, 1941; Hill, 1949) that the square-topped wave was not a wave at all, but a long duration spike repeating at 4 per second and that the commonest site for the focus for the discharge was a temporal lobe. However, such spike foci can occur from areas of cortex outside the temporal lobe and in some patients such foci can give rise to behavioural automatisms. The clinical evidence of automatism *alone* is not therefore certain evidence that the site of discharge is temporal. The evidence for this can, we think, be assumed with confidence only when the aura preceding the automatism indicates it. Many such patients with epileptogenic foci either in the temporal lobe or outside it have major seizures as well as behavioural automatisms. The important issue is not therefore the pathways by which the seizure spreads but the evidence showing from where it starts. This cannot be obtained by observing the patient's seizure although this may lateralize the focus to one side of the brain. The final evidence can only be obtained by asking the patient about his warning. As is well known the auras of the temporal cortex or deep temporal structures include a variety of visceral sensory, ideational and perceptual phenomena. Of these, epigastric, substernal and throat sensations are probably the commonest, and objective or subjective vertigo next. Olfactory, gustatory and auditory hallucinations are common and may be associated with *déjà vu* or unreality feeling. There may be an experience of echo of a word or thought or conversation previously experienced, or again a strong sense of being about to remember something but not doing so. The dream state involving visual or auditory hallucinations or both is not uncommon. In many cases intense fear is experienced and the patient may be aware of tachycardia and sweating. In our 14 cases 8 experienced epigastric sensations, 3 intense fear, 2 unreality feeling, 1 familiarity feeling, 3 olfactory or gustatory hallucinations; visual hallucinations with a dream state occurred in 1 and 1 patient experienced a compulsive idea.

Many workers (Gibbs *et al.*, 1948; Mulder and Daly, 1952) have recently emphasized the association between temporal lobe lesions with or without epilepsy and psychiatric disorder. Our own experience is entirely in agreement with this. Gibbs reported that 50% of such patients show severe personality disorder and in 25% of them psychoses occur at some time. Owing to the pre-selection of psychiatric cases at the Maudsley Hospital our figures for this are much higher and we find that there is a greater incidence of personality disorders in those patients in whom the focus is placed posteriorly in the temporal lobe rather than towards the temporal pole; a finding which is unfortunate from the point of view of surgery. Dr. D. W. Liddell, who has recently surveyed the epileptic in-patient population at Runwell Hospital has kindly allowed me to quote his findings which are to be published. A temporal lobe EEG focus was found in 50% of his epileptic patients which comprise 4·3% of the hospital population at Runwell. In 78% of those with temporal foci behavioural automatisms occurred. These figures are much higher than those given by Jasper for the general epileptic population, one in five of whom are believed to have a temporal lobe origin for their fits. There can be little doubt that temporal lobe epilepsy carries a serious risk of personality disorder and of psychosis. We have ourselves observed 13 cases of epilepsy with psychosis and in 11 of these demonstrated a temporal lobe origin for the seizures. In the 14 patients of this series 9 had automatisms and 11 major seizures. All but 2 had severe personality disorder showing excessive irritability and a liability to aggressive behaviour. 8 had been dangerously violent, 5 were paranoid, 7 had shown severe short-lived depressive episodes and 4 had fairly constant psychotic symptoms. The histories were characterized by multiple admissions to mental hospitals, casualty wards and prisons and attendance at public assistance offices. 4 of the 8 male adults had been unemployed for over a year prior to operation.

The EEG Investigation

In many patients the EEG is normal until the patient is put to sleep and basal electrodes used (Figs. 1, 2, 3). The focus may then be single or multiple, unilateral or bilateral, on the cortex of the convexity, buried in the sylvian fissure, or only seen beneath the anterior part from the sphenoidal electrode—in which case it may arise in the uncus or hippocampus. It is important to find the extent to which the activity spreads to the opposite side and whether another independent focus is to be found on that side. The best results of surgery are to be obtained, as Jasper *et al.* (1951) emphasize, in those with strictly unilateral, single foci. Whereas 12 out of 18 of their cases with definite unilateral foci had no recurrence of seizures at all, only 3 out of 14 had no recurrence when bilateral

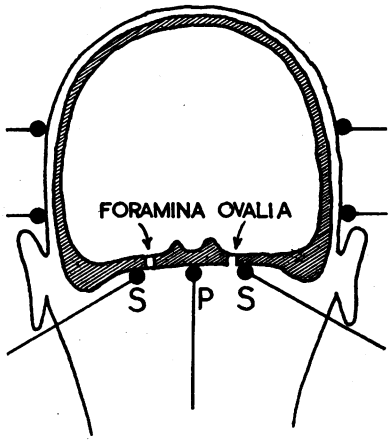

FIG. 1.—Sphenoidal electrodes. Schema of electrode arrangements using single pharyngeal (P) and bilateral sphenoidal (S) electrodes, the latter being connected in series with scalp electrodes on and above the temporal areas. The pharyngeal electrode is passed through an anæsthetized nasal passage and rests against the roof of the nasopharynx. Each sphenoidal electrode is inserted below the zygoma at a point 1 in. in front of the middle of the external auditory meatus, on a line drawn between the ala nasi and the incisura notch of the lobule of the ear. Passed upwards and inwards above the coronoid notch of the mandible the tip of the needle, which is the electrode, comes to lie just lateral to the foramen ovale.

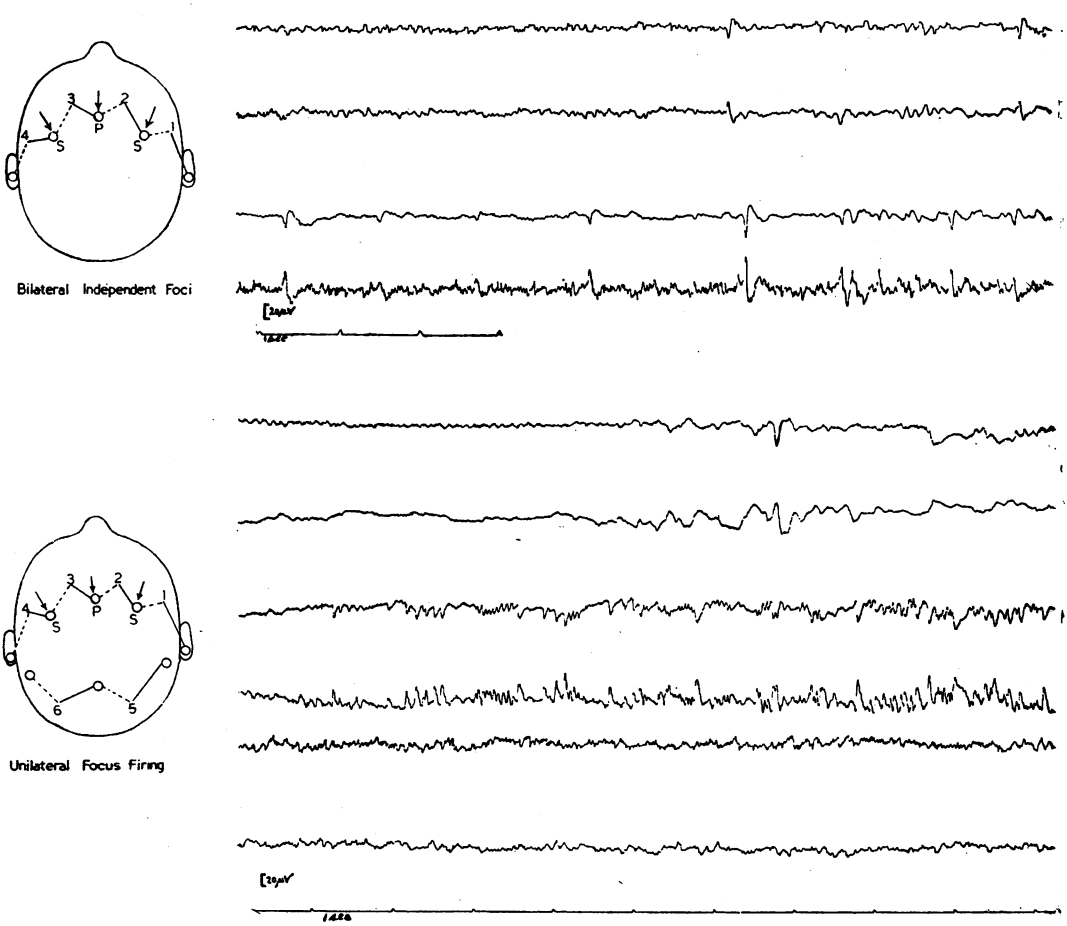

FIG. 2.—Shows two patients' EEGs. In the upper trace bilateral independently firing foci of spikes are seen at the two sphenoidal electrodes. The focus on the left side is the most active. In the lower trace a focus of spikes at the left sphenoidal electrode is firing very frequently. This initiates a slow wave disturbance on the right side at the right sphenoidal electrode. (S = sphenoidal electrode; P = pharyngeal electrode.)

or shifting foci were found. There is increasing evidence that in the course of time the unilateral focus is followed by another focus on the opposite side. I have observed this in a few cases studied over periods of years and Merlis (1953) recently reported that indeed, if studied long enough, 75% of cases become bilateral. The activation of foci at a distance and particularly on the cortex of the opposite hemisphere is frequently seen in cases of infantile hemiplegia with epilepsy, but it is gratifying that those who have followed cases of hemispherectomy where such foci have been found on the good side of the brain, find that they disappear after hemispherectomy. As Earl Walker once said, the epileptic focus is like a rotten apple in a basket of apples: leave it long enough and the other apples become rotten.

Our 14 patients were selected for operation upon the evidence, first clinical, then electroencephalographic, that a single dominant focus existed in the anterior part of a temporal lobe; secondly that the seizures had not been controlled by adequate anticonvulsant therapy. We were gratified when other evidence based on pneumoencephalographic or arteriographic studies pointed to structural change associated with the EEG focus, but were not discouraged by normal appearances. Some of these patients had been studied for years before operation. The 14 patients have had 82 separate EEG investigations made upon them spaced over intervals of weeks to years. Since operation 48 further EEG investigations have been made on the group to watch the effects on the epileptic activity. The first operation was performed two years ago, the last only a few weeks ago. Insufficient time to assess the lasting effects has therefore elapsed and the present study is in the nature of a report on the short-term results.

Results (Table I)

One patient, a woman of 41 with epilepsy since the age of 15, and a severe chronic paranoid hallucinatory psychosis, did not recover consciousness after operation and died after a few days. She was the first patient. Of the other 13, 10 have remained free from seizures, the follow-up period ranging from two years to a few weeks. However, 3 of these patients have experienced occasional premonitions of their fits. These 10 patients include all the patients of the series, 6 in all, in whom the EEG focus could be regarded as strictly unilateral, that is, showing no spread to the opposite temporal lobe. The 3 remaining patients have shown a reduction, in some degree, of their previous seizure frequency. These 3 patients had independent epileptogenic foci in the other temporal

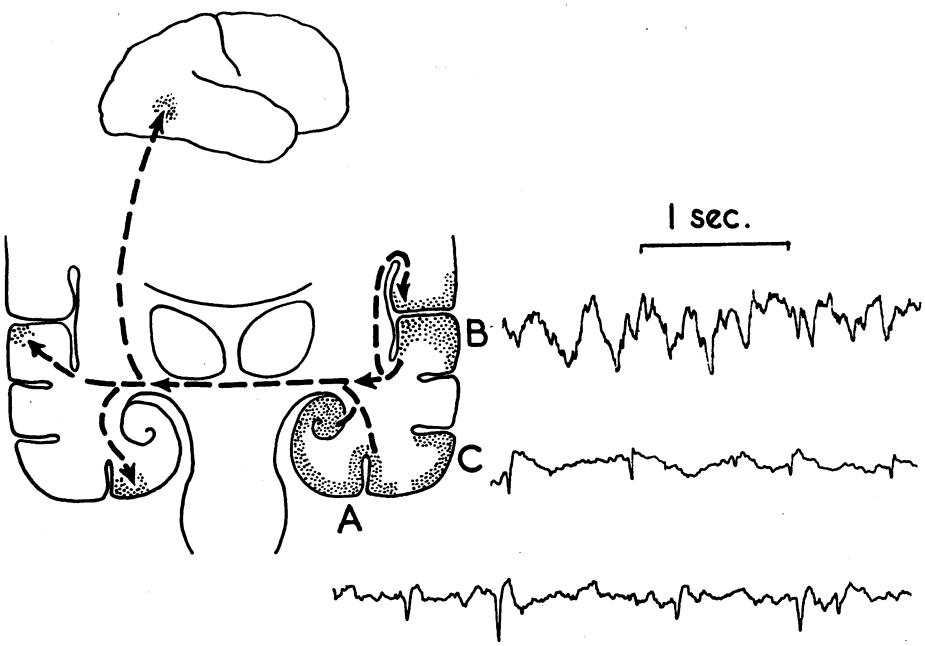

FIG. 3.—A schema illustrating the three main sites in the temporal cortex from which spike activity has been observed in patients with temporal lobe epilepsy; (A) from the anterior inferior surface at the sphenoidal electrode; (B) from the walls of the sylvian fissure and from the lateral surface of the superior temporal gyrus; (C) from the lateral surface and lower part of the temporal convexity. In (A) and (C) the spikes tend to be of short duration but when they are recorded from the scalp from buried cortex such as the sylvian fissure (B) the spikes tend to be of long duration, i.e. sharp waves. The diagram illustrates the possible effects of such foci in initiating secondary foci on the opposite hemisphere, either in the sylvian region, on the inferior surface or in the posterior temporal areas of the convexity.

lobe, which were observed pre-operatively, but regarded as secondary, or at least less active than the side upon which the operation was performed. A clear relationship between recovery from the seizures and improvement in the post-operative EEG state, has been observed. In the post-operative EEGs of the 10 patients who have been seizure-free, all were free from spikes or sharp waves except in 2. In a third a spike focus appeared on one occasion but disappeared later. On the other hand the 3 patients with recurrence of fits post-operatively showed EEGs with persistent firing of spikes, in 2 more frequently on the side contralateral to the lobectomy. We are therefore able to confirm the finding of previous workers that, at least as far as the short-term follow-up is concerned, the patients with strictly unilateral foci benefit most from surgery. In the others, the operation is followed either by a great increase in the epileptic activity in the remaining temporal lobe or by a reduction of such pre-existing activity. It would be important to be able to anticipate which of these courses is likely to ensue. It would appear that shifting or multiple contralateral foci and those which show a clear independence of that on the major side are of ill-omen, but more work on this is required.

TABLE I.—RESULTS OF LOBECTOMY IN 14 CASES OF TEMPORAL LOBE EPILEPSY

Case	Age	Onset ep. at age	Site of focus	Personality disorder	Post-operative		
					Fits	Personality	EEG
Ke	41	15	L	+++ (P)	Died		
S	5	1	L > R	+	F	I +	I ++
Pa	24	18	R > L	+++	I	I	NI
R	31	2	L	+++	F	I +	I
Ki	14	9	R	+++	F	I +++	I ++
Mac	45	2	R > L	+++ (P)	I	NI	I
F	45	18	R > L	+++ (P)	I++	NI	NI
W	22	12	R > L	+++	F	NI	I
V	23	21	L	—	F	—	I +
C	47	42	L > R	+	F	I ++	I +
Lew	43	35	L > R	++	F	I +	I ++
Le	38	5	L	++	F	I +	I ++
P	12	2	L + LF	+++	F	I +	NI
St	21	2	L	+++	F	?	?

F = fit-free. I = improved. NI = not improved. P = psychosis.
LF = left frontal lobe.

(Fits occurring in the post-operative period of four weeks have not been included in the results.)

Changes in Mental Status

These patients have been studied pre-operatively and after operation, not only by clinicians, occupational therapists and the nursing staff, but accounts from relatives have been taken by P.S.W.s and formal testing has been carried out by Miss S. Cox, Mr. V. W. Meyer and Mr. A. J. Yates of the Department of Psychology at the Institute of Psychiatry. There is general agreement among all observers that in the immediate post-operative period of hospitalization up to two months there is an improvement in personality in the form of greater warmth in interpersonal relationships, the patient being more co-operative and friendly. It is difficult to decide how much of this is due to the optimism and the relief of having passed through a major surgical procedure. No significant change was observed in formal intelligence and no change could be found in the Rorschach responses, except an improvement in verbalization which was noticeably more direct and simple in 4 patients. The greatest changes were in behaviour which were usually strikingly shown in personal contact with the tester and in the attitude to the tests. All but one of the 10 patients who have become fit-free have shown some degree of improvement in personality. A girl of 14 who had been deemed beyond control, broken out of remand homes, smashed windows in hospitals and could only be nursed in the refractory wards of a mental hospital, has returned to live with her parents where she has been now for nine months, to their great satisfaction. A man of 31, whose fits began at the age of 2, has since operation spent two months in prison for smashing a window in a public assistance office but thereafter was able to work for some months. He had been unemployed and unemployable for four years previously, but social deterioration is extreme and he is again on the verge of institutional care. He has not, however, suffered a fit since operation thirteen months ago. The best informants of the personality change are certainly the marital partners when these happen to be intelligent and one case, in which this was so, is worth quoting.

A married woman of 43 with temporal lobe automatisms in which she would undress herself, occurring every two to three days, either at home, in the street or wherever she happened to be, was paranoid, irritable, mildly hypochondriacal and coldly hostile to her husband and family. Interviewed some months after the operation since when she has been fit-free her husband said: "Although the results of this operation from a physical point of view are a miracle in that she has not had any seizures and her memory for current events is much better than it was and she speaks more fluently, yet from the temperamental point of view I think her condition is poor. Whereas before (operation) she had explosive periods, they were succeeded by periods of comparative calm and amiability, but now I am afraid her condition is evened out at a constant level of sullenness, depression, quarrelsomeness and abusiveness. She abuses her son on the slightest thing."

Of the 3 patients whose mental status is regarded as not improved 2 had been regarded as chronic psychotic with paranoid ideas; both had bilateral foci, neither is fit-free since operation and both have shown a deterioration in mental state. Although the seizures have been fewer and milder in both cases, both have been readmitted to hospital because of aggressive impulsive behaviour and in one case certification appears inevitable. In one patient the increasing tension, depressive mood and irritable restless behaviour led us to think that he would be better if he had a recurrence of seizures. E.C.T. was administered and after 3 convulsions he showed great improvement and became calm and amenable, but only to relapse again a few weeks later despite a continuation of electroshock.

The third patient, a single man of 22 whose seizures started at the age of 12, was grossly alcoholic, aggressively psychopathic, abusive, insincere, homeless and unemployed. After his operation his seizures ceased despite bilateral foci, but his personality remained unchanged. He alone of the series showed an *increase* of libido, resembling the descriptions of Klüver's monkeys with bilateral temporal lobe ablations. In clear consciousness he began to expose himself and to masturbate in front of other patients and nursing staff, as frequently as twenty times a day. This behaviour was completely controlled by the administration of stilbœstrol and after a month this behaviour did not recur when the drug was withdrawn.

With the exception of the 3 patients who must be described as worse or at least unimproved by the operation, the procedure has been followed by an improvement in general health, seen in increase of weight and improvement of appetite. The effects on libido have been varied, most patients describing a reduction.

We must not ignore the fact that the majority of these patients have local structural lesions. However, the interesting fact is that the epileptic temporal cortex appears to have the effect, on occasion, of *fixing* or engramming the memory of previously traumatic events in such a way that when a seizure occurs these events may be relived with all their original affective intensity. Moreover the continued existence in the brain of such epileptic cortex would appear to exercise a disturbing influence not only on the patient's attitudes to the events which are engrammed but also in his total psychological adaptation. Following operation voluntary or induced recall of the traumatic experience is no longer disturbing and if all the epileptic tissue is removed, and probably only then, total psychological adaptation is improved: while of course it is only in a proportion that experiences engrammed and linked to epilepsy occur, our acquaintance with a larger population of temporal lobe epileptics suggests that the phenomenon is not at all uncommon. But it must be emphasized that personality deterioration occurs in patients in whom no engrammed experiences are demonstrable and therefore personality deterioration cannot be related directly to their existence. However, in many of these the epilepsy has started in infancy or childhood and it is now a common observation of ours that after years of temporal lobe epilepsy, not only do elements of the aura disappear but the patient cannot even recall the fact that on a previous occasion, perhaps years before, he has described them to his doctor. Since epilepsy of the temporal lobes appears to carry such serious risks for the personality, we cannot afford to neglect any evidence suggesting how the disturbed physiology may affect psychological functions. Penfield's remarkable studies in which he has shown that it is possible by electrical stimulation of the exposed epileptic temporal cortex to cause the conscious patient to relive previous experiences have aroused the greatest interest and enthusiasm. They will remain the model and the stimulus to all those who, like ourselves, hope to work in this interesting field.

One further issue, of some importance to the problems of epilepsy, must be mentioned. Many hold that the epileptic seizure is cathartic or to use a physiological term, homeostatic. Many have treated the psychotic epileptic, whose seizures have become infrequent, by E.C.T. and noted temporary improvement. The tension and irritability which may precede the fit in some patients is relieved by its advent. One of our 3 patients whose personalities showed deterioration after operation was treated with temporary benefit by E.C.T. Although reassured by the results of the American work I was concerned that these operations might not be followed by an increase in psychosis. This certainly occurred in one and possibly two patients who were psychotic pre-operatively, but both had active epileptic foci remaining and both had occasional seizures after operation. There has been no patient in whom the seizures have ceased, and the EEG firing areas ablated, whose personality has not benefited from the operation. The best results have indeed occurred when these two conditions have followed operation and a structural lesion been found in the excised tissue. This is in agreement with the observations of Green, Duisberg and McGrath (1951).

At the present time our limited experience would suggest the following tentative conclusions regarding the results of surgery in these 14 cases.

(1) Patients with seizures of temporal lobe onset in which the focus of onset is strictly unilateral can expect to benefit from the point of view of seizures, all 6 cases of this type being fit-free. Of 7 cases with evidence of firing in the contralateral temporal cortex, 4 became fit-free. With a longer follow-up this good result may have to be modified.

These results are in general agreement with those of previous workers.

(2) Improvement in personality occurred in some degree in all but 3 patients. 2 of these were

psychotic patients whose fits recurred after operation. The other was grossly psychopathic, alcoholic and homeless prior to operation. All 3 patients had bilateral EEG foci. The combination of bilateral EEG foci with psychosis or severe personality disorder would appear to be a contra-indication to surgery.

(3) The decision of whether any given patient is likely to benefit from temporal lobectomy, can only be made on EEG evidence demonstrating the constancy of the site of the focus, its location in a site available to surgical ablation and the absence of other foci in neighbouring parts of the cortex beyond the reach of surgery. Routine direct electroencephalography can only give approximate answers to these questions. Once the decision to proceed to operation has been made, it is obvious that direct electrocorticography can give the surgeon more precise answers to these questions, and will inevitably take its place, we believe, as an essential part of the procedure.

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Mr. Murray A. Falconer: *Surgical and Pathological Aspec s.*

Epilepsy arising in the temporal lobe can result from a wide range of lesions. Some of these, such as neoplasms, vascular malformations, porencephaly and scars from penetrating injuries, can be readily recognized by neuroradiological studies, and lend themselves to surgical intervention with, usually, a favourable result. However, they account for only a minority of cases. Mostly in temporal lobe epilepsy the clinical and radiological investigations prove negative, and even the surface of the brain when exposed at operation shows little or no abnormality. It is with such obscure cases that we propose to deal.

Considering that electroencephalography will frequently disclose a focus of epileptic activity in the anterior part of one or both temporal lobes, it is not surprising that several neurosurgical centres have attempted to treat cases by operation, particularly when the focus is unilateral. Morris (1950), Bailey and Gibbs (1951), Green, Duisberg, and McGrath (1951), and Obrador (1953), for instance, have each recorded their experiences with a few cases. Various operative measures have been tried, including section of the white matter of the lobe (lobotomy), and ablation of the superficial temporal convolutions (gyrectomy), but so far the most encouraging results have followed upon removal of the temporal lobe itself (lobectomy). The extent of the lobectomies, however, has varied, in some instances being limited largely to the temporal pole, and in most instances the hippocampus and uncus have been left in situ. Consequently little opportunity has been afforded for studying the histological changes which affect these deeper parts of the temporal lobe, although in several cases atrophic changes have been noted naked eye.

Penfield and his associates (Penfield and Baldwin, 1952; Earle, Baldwin, and Penfield, 1953) have recorded the largest experience. In 100 out of 157 patients with temporal lobe epilepsy submitted to operation, Penfield observed macroscopically areas of sclerosis and atrophy, which usually affected the uncus, hippocampal gyrus, and the anterior part of the first temporal gyrus. These changes were ascribed to birth trauma, and it was postulated that they resulted from transient interference to the blood supply of the temporal lobe during parturition, when because of head moulding the uncinate regions were temporarily herniated through the tentorial opening. The remaining 57 cases were accounted for by post-natal injury, intracranial infection or neoplasm. These views relating to "incisional sclerosis" represent a distinct change in observation and interpretation from those of Penfield's earlier paper (Penfield and Flanigin, 1950). Penfield has yet to report in detail the symptomatology of his various patients, but it would seem that few of them had pronounced psychiatric features. He has also to indicate what are the results of surgery in his recent material. However, in an earlier paper (Penfield and Flanigin, 1950) he claimed a 52·9% success (i.e. cure) rate with a further 25·4% of patients appreciably improved. In his cases the uncus and hippocampus and other deeper parts of the temporal lobe were removed by suction, thus precluding their detailed histological study.

Personal Experiences

During the past two years, at the Guy's-Maudsley Neurosurgical Unit, we have operated on 14 patients with intractable temporal lobe epilepsy in whom careful clinical and neuroradiological

studies had been negative from the viewpoint of tumour, vascular malformation, or similar gross abnormality. Although we made the diagnosis of temporal lobe epilepsy from the clinical features, it was generally on the EEG evidence alone that we determined on which temporal lobe we would operate. Indeed, in 5 cases air encephalography disclosed a perfectly normal ventricular system, while in the remaining cases the temporal horn on the side of the EEG focus was either slightly larger or slightly smaller than on the presumed normal side. The most significant finding, however, was when one-half of the cranial cavity was slightly smaller than the other. The EEG focus was always on the smaller side.

Operative Technique

At first we did not have electrocorticography available to delineate the irritable area, and so at the outset we adopted the policy of removing as much of the affected temporal lobe as possible without crippling the patient. In this way we hoped not only to remove the epileptogenic area, but also to secure the affected tissue for histological study. In our first 3 patients we spared the uncus and hippocampus, not realizing that these structures could be removed without danger. However, as one of these patients (Case Pa in Dr. Hill's Table I) continued to have fits and also still showed a local EEG focus in the temporal lobe, we operated for a second time and removed these structures, with some benefit.

In some patients we performed the whole operation under general anæsthesia, but in 7 we commenced the procedure under local anæsthesia so that we could stimulate the exposed brain, and plot the lower part of the motor cortex so obtaining a useful landmark. In 6 patients we were faced with amputating the dominant temporal lobe, and by stimulating along the line of the proposed excision while the patient was reciting nursery rhymes we were able to show that there was no arrest of speech from these regions, and hence that no permanent speech disturbance would follow operation. In 2 patients we succeeded in provoking a seizure. In all patients, however, elevation of the temporal lobe from the skull base caused pain, and consequently the later stages were completed under intravenous Pentothal anæsthesia.

The steps of the operation practised in most of our cases are outlined in Figs. 1 to 4. Starting at the sylvian point the incision ran backwards through the upper part of the superior temporal convolution to the foot of the rolandic fissure, and then it curved downwards to reach the inferior border of the temporal lobe a little in front of Labbé's anastomotic vein (Fig. 1). Then the incision was steadily deepened to expose above and anteriorly the insula and the upper bank of the sylvian fissure still covered by the pial mantle of the temporal operculum, and posteriorly to open the hinder part of the temporal horn (Fig. 2). Next the white matter was divided between the lower boundary of the insula and the temporal horn, thus laying open the temporal horn with the hippocampus in its floor and the choroid plexus above this (Fig. 3). The removal of the lobe was then completed by continuing the incision across the hinder end of the hippocampus on to its medial border, as well as along the medial border of the uncus (Fig. 4). The actual sectioning of the cerebral substance was made with a fine metal sucker, and most of the hippocampus and uncus was subsequently found to be preserved on the amputated specimen. Finely controlled diathermy was used for hæmostasis. Our operative removals involved between 5 cm. and 9 cm. of the length of the temporal lobe, an extent similar to that of the removals described by Penfield and Baldwin (1952). Recently we have been controlling our excisions by electrocorticography.

Results

Surprisingly little disturbance results from such a large excision. Each patient except one (a 5 cm. removal) has developed an upper-quadrantic homonymous hemianopia, but without being aware of it. 8 patients had the left temporal lobe removed, and 1 of these showed some aphasic manifestations, which, however, disappeared. Several patients have shown a transient oculomotor imbalance suggesting a partial III nerve lesion, and one actually showed a fairly complete palsy which fortunately also disappeared. Psychological testing has shown no constant disturbance of intellectual functions.

The therapeutic results have been encouraging, apart from our first case which died after remaining in coma for eight days. The craniotomy had been reopened on the second day, but no clot formation had been found. At post-mortem the uncus, which had not been removed, was found to be prolapsed into the tentorial opening. Judging from a recent temporal lobectomy for tumour in which a similar prolapse of the uncus occurred, we could have saved this patient's life had we been aware of this complication, by reopening the craniotomy and dividing the tentorium.

The remaining 13 patients have now been followed up for periods ranging from one month to two years. Two main generalizations can be made:

(1) Operation usually will either stop or diminish the epileptic attacks. In possibly 10 patients the attacks have ceased, and in the remaining 3 their frequency has lessened considerably. All 3 had bilateral foci although pre-operatively the focus in the operative side appeared to be dominant.

(2) The personality often shares in this improvement, but not always. In some of our patients a striking improvement occurred, but in at least 2 it was worse.

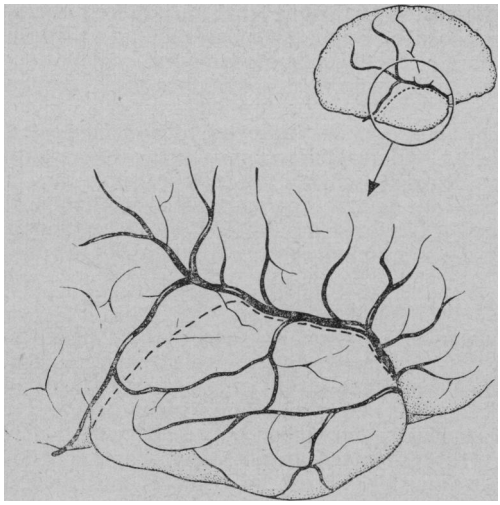

FIG. 1.—First stage of temporal lobectomy: The line of the incision in relation to the sylvian vessels and to Labbé's vein.

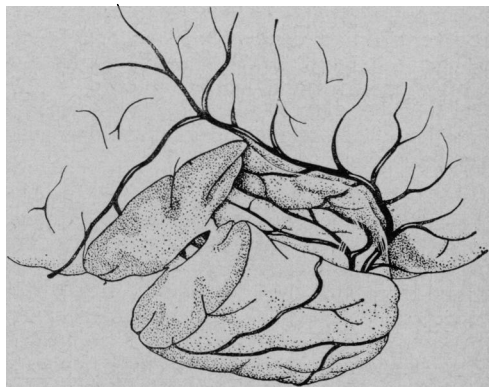

FIG. 2.—Second stage: The insula has been uncovered and the temporal horn opened.

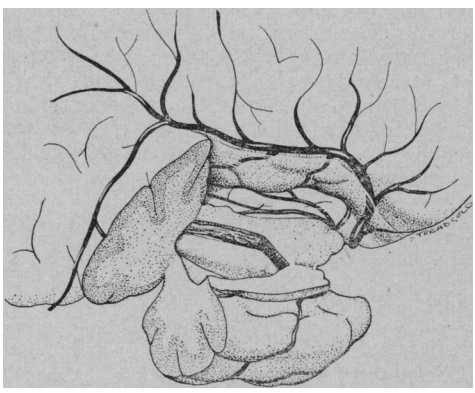

FIG. 3.—Third stage: The temporal horn has been opened exposing the hippocampus in its floor with the choroid plexus lying above it.

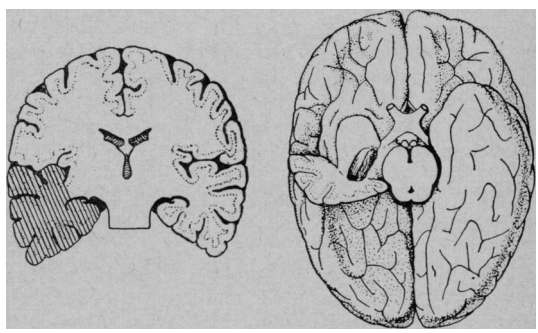

FIG. 4.—Representation of extent of temporal lobe removal at completion of operation. Note in the basal view that the roof of the third ventricle still remains as well as the choroid plexus.

Pathological Changes

Professor Alfred Meyer (who unfortunately is absent) has been studying the resected temporal lobes. In several cases we have observed sclerosis of Ammon's horn. The frequent presence of such sclerosis in cases of chronic epilepsy which come to autopsy is an old observation, and Professor Meyer several years ago reported on it (Meyer, 1939). The classical view has been that such sclerosis is the result of vasomotor and ischæmic changes which occur during the cyanotic stages of major seizures. In support of this view that such changes are secondary to the epileptic seizures and are not the cause of them, can be marshalled evidence that the cells of Ammon's horn are particularly vulnerable to a wide range of toxic processes. However, the long acceptance of this view should not blind us to the possibility of interpretations such as Penfield's, that sclerosis in this region may be primary to the epilepsy. Professor Meyer tells me that the brains of many chronic epileptics do not show these changes, even after a long history of severe attacks of *grand mal.* Ammon's horn sclerosis, therefore, is not an invariable sequel of cyanotic seizures.

Professor Meyer has also observed gliotic and sclerotic changes in other parts of the temporal lobe, and has been collecting a series of control sections from healthy temporal lobes for comparison. This comparison will require much time, and he does not yet feel justified in giving a pronouncement.

However, we as surgeons gaining experience of the consistency of various temporal lobes at operation have noted in several cases sclerotic changes as evidenced by undue toughness and yellowish discoloration of the white matter which have the distribution in the superior temporal convolution, uncus, and hippocampal gyrus described by Penfield. If Penfield's view is correct, then these changes precede the epilepsy and are the cause of it.

Other lesions found include two instances of a focal collection of astrocytes, oligodendrocytes, calcospherites, and capillaries, which might be termed a hamartoma or congenital abnormality (Falconer and Pond, 1953); a small meningo-cortical cicatrix involving the temporal pole; and a case of localized chronic leptomeningitis. In fact in each of our first 8 cases, in which pathological studies have been completed, some histological abnormality has been found in the resected temporal lobe, although the significance of these changes (particularly those concerning Ammon's horn) may be open to question.

Further Comments

These communications are merely preliminary, for we are still in the early stages of our experience, and cannot do more than generalize widely. The fact that we are encountering definite pathological changes in a surprisingly high proportion of cases and that subsequently our patients are being benefited as regards their fits, indicates that the type of epilepsy we are dealing with can no longer be regarded as idiopathic. It is really focal epilepsy anatomically determined because of pathological changes which happen to involve the temporal lobe. There is, moreover, no reason why the histological changes could not affect both temporal lobes, thus giving rise to bilateral independent epileptic foci. We have, however, not yet performed a bilateral temporal lobectomy.

So far we have operated on cases which have been crippled by the epilepsy, and which have in most instances been also crippled by a superimposed personality change. If, as we think, our operative intervention carries little risk to life or limb, then we are probably justified in accepting for operation cases with milder seizures and disturbances and without personality changes, but whose lot could be improved none the less. In the long run it may prove wiser to operate early and prevent the personality change, rather than to wait until the symptoms become flagrant.

Temporal lobe epilepsy is common, and causes much disablement in any community. Its frequency has been placed at between a fifth (Lennox, 1951) and a third (Bailey and Gibbs, 1951) of all epilepsy. The exact incidence of all epilepsy is not known, but an approximate figure is possibly 0·5%. Translated into terms of the population of the United Kingdom this means a quarter of a million epileptics and at least 50,000 sufferers from temporal lobe seizures. Many of these may be only slightly disabled, but any approach which promises to improve our knowledge of the subject and to increase our therapeutic effectiveness merits serious consideration.

I wish to thank Miss Sylvia Treadgold of the Department of Medical Illustration, Guy's Hospital, for the illustrations.

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Dr. G. Pampiglione: *Electrocorticographic Approach*

The detection of the abnormalities of cerebral function considered to be related to the initiation and spread of an epileptic seizure is the aim of a combined effort of the clinician, the surgeon and the electrophysiologist. At present applied electrophysiology is an expanding subject with many unknown aspects. The information given by this method of investigation may be, however, of decisive value in the localization of an area of abnormal function in the brain. Dr. Denis Hill and Mr. Murray Falconer have summarized the work done on this series of 14 epileptics with mental disturbances and seizures related to functional abnormalities in the temporal lobe. I shall briefly mention the studies done during operation (electrocorticography).

Electroencephalography, or recording from without the skull, gives a good deal of information about some abnormalities of cerebral function and may indicate the lobe mostly involved. Electrocorticography, or recording in direct contact with the surface of the brain, gives much more detailed information about small areas within a convolution or a sulcus which may be involved in the epileptogenic process. The relevant abnormalities are often recorded from areas appearing quite normal to the eyes of an experienced neurosurgeon.

In man, the pioneering work of Foerster, Grey Walter, Schwartz, Scarff, Jasper, Walker and their collaborators, has given us a good deal of valuable information both about the technical difficulties and the interpretation of electrocorticography. In the future with increasing knowledge, electrocorticography will help the surgeon to assess more precisely the extent of the area of abnormal function, and will help the patient by restricting the removal of healthy brain.

In this series of cases the programme was to excise the anterior part of the temporal lobe irrespective of the corticographic findings. This approach, justifiable in the present state of limited knowledge, will result in the accumulation of a good deal of data. This will give a lead in assessing some of the reasons for success and failure of surgical treatment in individual cases after they have been followed up for several years. As an example of the problems we are dealing with I shall describe 2 of the 4 cases studied by electrocorticography in the present series.

A boy of 12, under the care of Dr. D. A. Pond, had a complex clinical and social history. He was admitted because of frequent fits and outbursts of uncontrollable behaviour in spite of medication. Multiple pre-operative EEGs showed an area with abnormal electrical discharges in his left temporal region. At operation no macroscopic lesions were seen in the temporal cortex but the lobe was small. Electrocorticography showed abnormal discharges over most of the convexity of the temporal lobe, particularly in its anterior half, and from the pole and from the hippocampal convolution. In addition, frequent discharges were recorded from an area of the frontal lobe in a region about 1 cm. above the sylvian point. Intravenous Pentothal increased the amount of abnormal discharges as well as the complexity of the picture and also appeared to synchronize the firing of all areas. No clinical changes were noticed apart from the patient going to sleep. The white matter of the excised temporal lobe appeared rather hard and was brownish in colour towards the pole. Recordings taken from the inferior frontal area following the excision revealed that some electrocorticographic abnormalities still remained. Post-operative scalp recordings showed that the inferior frontal region remained abnormally active several weeks after operation, though the abnormality was not so severe as before operation. This boy is fit-free on medication. (Case P in Dr. Hill's Table I.)

A girl of 21, a patient of Dr. Denis Hill, with a marked educational handicap had rather complex seizures. Her EEGs showed a clear spike focus in her left mid-temporal region. This focus appeared constant without much spread both in the scalp and "sphenoidal" recordings during sleep or the waking state. Corticography, however, showed multiple and apparently independent firing areas maximal over the II and III temporal convolution. There was little abnormality at the temporal pole or towards the hippocampal convolution. Several focal spikes and some slow waves were seen from an area behind Labbé's vein and also from an area in the central region about 1 cm. above the sylvian vessels. Intravenous Pentothal in her case depressed and abolished these cortical discharges. In the immediate post-operative period there has been only one fit on the pre-operative medication, but the patient has experienced her old abdominal aura on a few occasions. (Case St in Dr. Hill's Table I.)

These 2 cases, though rather dissimilar, are of great interest and present to my mind similar problems. In the boy abnormal electrical discharges remain in the inferior frontal region and can be picked up by scalp recording. In the girl the remaining abnormal activity is in the posterior temporal and in the inferior central region, but recent scalp recording suggests that this is diminishing. In the boy Pentothal increased the abnormal firing and in the girl Pentothal diminished it. Both patients are at present free from fits.

These cases illustrate the difficulty in correlating clinical and electrical studies from the scalp, and the electrocorticographic findings. Will the electrical abnormality persist in these cases or will it subside? Will the seizures reappear in one, in both, or in neither of these patients? Or will the attacks be modified? These are the problems we shall be able to solve only in a few years' time after careful clinical and EEG follow-up. Perhaps then new problems will arise: will the patients' mental or personality disorders be changed and if so whether in relationship to or independently of the course of their attacks?

In addition the removal of a relatively large mass of brain—for instance, over one-half of a temporal lobe that includes at least some of the epileptogenic areas—may influence other potentially epileptogenic foci either way: it may make them independently active or may help in their disappearance, with or without the possible influence of medication.

From this small group of cases and from a few other cases not included in this series I have learned how difficult it is to compare one's own findings with other workers' experience in a relatively new field. This seems particularly relevant in the present series of temporal lobectomy cases which is from the clinical, electrical and pathological aspects far more complex than was at first thought.

I am indebted to Messrs. R. Cooper, P. St. J. Loe, and J. Theobald for their technical collaboration. To Dr. J. A. V. Bates and Dr. W. Grey Walter for their kind advice.

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Dr. D. W. Liddell: Temporal lobe epilepsy accounts for 50% of all epilepsies of varied ætiology at Runwell, and in 78% of these cases behavioural automatism occurred.

The total incidence of epilepsy in mental hospitals seems to have varied little in the past seventy-five years, in spite of great advances in treatment. For in 1875 Jackson quoted the figures of Bucknill and Tuke, who estimated that 6% of patients in the asylums of that time were there owing to epilepsy. In a recent review of 1,100 patients at Runwell (Liddell, 1953) I found that epilepsy was the cause for admission in 47 patients—25 male and 22 female—or 4·3% of the total number. The probable reason for this is that temporal lobe epilepsy is poorly controlled by anti-epileptic drugs.

In the present series automatism was commoner among the male patients—13 males (52%) of the total male epileptics had automatism as opposed to 5 females (23%) of the total female epileptics.

The aura is of interest, for with the advent of automatism it appears to cease in a number of cases. This is only partially true, for if an attack is witnessed, the patient, immediately after an attack, will describe an aura, but a few hours later will completely forget it; then will, if reminded of it, rather shamefacedly agree that he can recollect such a feeling or idea. In this way a description of different auras may be obtained after various attacks. Normally the aura is thought to be constant for most patients. This is the rule when it precedes major fits.

In a certain number of cases of automatism the aura may last for some time, up to a minute or more, and enable the patient to warn those near him that an attack is pending. In such cases the aura is always remembered. It would thus seem that a minimum time of exposure is essential for recollection, for the longer an aura is experienced prior to an attack, the more likely is it that it will subsequently be remembered.

Not infrequently the aura or dreamy state occurs at times quite independently of any subsequent fit. This may well not be linked by the patient to his epilepsy.

A male patient, aged 38, following head injury developed epilepsy, preceded by an aura of unreality. After a year or so automatism developed following a transitory fit in place of the major epilepsy. About this time, when alone or reading, he became assailed by the thought that "I have robbed my father's safe" and this belief or thought lingered for a short while and it was associated with a feeling of great distress. It was in no way connected by him with his fits, but his wife had observed that he sometimes cried this aloud before his turn. She had investigated this incident with negative results.

Here a false memory forms the content of the dreamy state. The vocalization of a thought or feeling has been observed in a number of cases before a fit but does not happen if the dreamy state only occurs. It appears that when the discharge spreads sufficiently to cause a fit, vocalization might happen, but there is afterwards complete amnesia for this. Of interest is the fact that stimulation of this limbic area in animals causes vocalization.

Maclean (1952) and Maclean and Delgado (1953) have experimentally investigated the functions of the limbic formation in animals. They have shown that it is intimately concerned with behaviour, related to feeding in all its forms. In humans temporal epilepsy occurs most frequently at the meal table and the prodromata, often of a day or more duration, assume the form of aggression or hostility, noted by the nurses to be related to food.

Lastly, automatism may occur after major epilepsy, adversive fits, or after a transitory minor turn of such short duration that it may well be missed. This latter onset may be associated with the classical jaw champing. The frequency of the preceding fit is minor, adversive and major. The more severe the preceding fit the more violent and purposeless is the subsequent automatic behaviour, so that following the major fit the full-blown epileptic furor reaching homicidal intensity may occur. Following the minor fit, the behaviour approaches that of normal and on superficial observation may be missed by those around him, and is only noticed afterwards by the sufferer by some odd thing that he has done, such as adding up a column of figures and putting something very unusual as the total.

These patients, whatever their individual outlook on life, depending, of course, on their various personality traits, have in common a restless aggressiveness. They never fully settle to any task, often wanting to start something new before they have completed the job on hand. They work hard but fitfully, are quick to take offence over trivial incidents, and at times are openly hostile for no adequate reason. Following lobectomy they become friendly, concentrate on the job in hand and are able to sit and enjoy life. As one patient remarks "I feel satisfied and content now".

It is tempting to make a visceral comparison. Before operation they are hungry, restless, asocial, and have their fits, and afterwards they are replete, friendly, and cease to be explosive. In fact, they are changed from carnivora into herbivora.

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