ANTERIOR CINGULECTOMY IN MAN

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The first series of bilateral anterior cingulectomies in man was reported in 1949. Since then the operation has met with increasing success in various clinics. It seems worth while to present at this time the therapeutic and psychological results in the first 50 cases in our series. This group does not include 18 "mesial undercuttings."

Just before the War we were studying the aftereffects of the total resection of gliomas of the anterior half of the corpus callosum. The rarity and insignificance of the so-called postoperative frontal syndrome was a first point. A second was the postoperative disappearance of "imperviousness." This apathetic state, then, is probably caused not by callosal interruption, but by bilateral pressure on the mesial frontal surface.

Later, in the treatment of some states of agitated behaviour, it became possible to compare the results of classical lobotomy with those of limited resection of the convexity, or topectomy, introduced by Pool. Topectomy seemed to us definitely less successful when the agitation and violence were apparently not related to anxiety. Perhaps, then, it would be necessary to resect the mesial aspect of the frontal lobe in order to deal with an active psychomotor component, different from the passive element in cases of anxiety and intractable pain.

In physiological experiments (cingular resections in monkeys) Smith and Ward observed a postoperative state of tameness and placidity. That was a further incentive to perform cingulectomy in man, even without Papez's well-known theory of the importance of the temporo-diencephalo-cingular circuit in emotions. At least it was suggestive that the thalamo-cingular fibers came from the anterior nucleus, while the dorso-medial nucleus connected with the granular frontal cortex. Accordingly, when we embarked on a program of systematic study of the clinical and psychological effects of different limited frontal operations, the comparison between granular areas 9 and 10, and agranular area 24, i.e. between topectomy and anterior cingulectomy, was given a high priority. The first cingulectomies were performed in 1948 and the main features relating thereto were described in successive papers from 1949 to 1953: clinical results in agitated behaviour and epilepsy, and in psychoneuroses, especially obsessive; detailed operative technique, description of the special postoperative syndrome, and objective psychological study.

SURGICAL TECHNIQUE AND COMPLICATIONS

The technique has been described previously and need not be repeated here. However, the following main points may be emphasized:
General or local anesthesia is used, according to the cooperation of the patient and the way in which corticography is performed.

A unilateral frontal bone flap (left or right) is made tangential to the longitudinal venous sinus, 2 cm. in front of the coronal suture and 3 cm. above the orbital ridge.

The left frontal lobe is retracted (often involving section of several subdural veins, but still only on one side) until the free edge of the falx is seen. Then the mesial faces of both frontal lobes are separated down to the corpus callosum, whiter than the surrounding convolutions and partly covered by the two pericallosal arteries giving off ascending branches to areas 8, 9 and 10.

When the genu is well freed, minute holes are pierced in the pia mater of the anterior limbic convolution or area 24, and through them the cortex is aspirated with a fine tube, thus respecting the ascending arteries and contributing to the selectivity of the operation. As both cingular gyri are visible under the falx, the cingulectomy is a bilateral operation with a unilateral approach.

Usually the operation is limited to the anterior part of area 24, 3 cm. long and 1.5 cm. high, but can involve area 25 below the genu 2 cm. more ventrally. This is the typical agranular resection. Often it involves some dysgranular cortex of area 32, 2 cm. more in front of the genu, and sometimes area 12 near the orbital level.

Narrow bands of gelfoam, soaked with lipiodol and then partly dried, are put over the resected areas, both for hemostasis and radiological landmarks (Fig. 1), although the genu is a well-defined structure, impossible to miss.

Thus the operation is much more precise anatomically than any other psychosurgical technique. The only obstacle to selectivity is the unilateral section of some subdural veins, but this does not always happen, and even so there is never a complete interruption of the venous drainage. In view of the strict unilaterality of this slight venous drainage, we doubt very much it could leave a permanent significant effect.

The main vital risk in our operation seems to be the need of prolonged
general anesthesia in cases of extreme mental retardation with uncontrollable agitation. The only deaths in the series of 50 cases were in 2 children with such disorder (there was no abnormal hemorrhage). In another similar case tracheal intubation was followed by a laryngeal spasm and recovery followed tracheotomy. In 2 patients a transient hemiparesis was observed for 8–10 days. In another intense anemia developed on the 8th day and was cured with difficulty in 3 weeks. No other patient gave any reason for alarm, and indeed the absence of apparent mental disturbance was the main feature of the immediate postoperative course, as well as the absence of early or late epileptic fits in patients who were not epileptic before the operation.

CLINICAL RESULTS

The results are shown in Table 1. "Good results" mean: complete or nearly complete cure with useful activity in patients with a not too deteriorated preoperative intellectual level, and marked improvement with at least some activity in the cases of pronounced mental retardation.

To sum up, the results of anterior cingulotomy are good in the clinical syndromes of extraversion with irritability and violence, especially perhaps in chronic generalized epilepsy, but not in the excitation of psychopathic personality. They seem bad in the clinical syndromes of introversion with

<p>| TABLE 1 |</p>
<table>
<thead>
<tr>
<th>Clinical results of anterior cingulotomy</th>
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<tr>
<td>Diagnosis</td>
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<tr>
<td>I. Depressive states</td>
</tr>
<tr>
<td>a. with anxiety or pain (including 2 epileptics)</td>
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<tr>
<td>b. with obsessive neurosis (including 1 epileptic)</td>
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<td>II. Excited states</td>
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<tr>
<td>a. with hysteria (including 2 epileptics)</td>
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<td>b. with psychopathic disorders (including 1 epileptic)</td>
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<tr>
<td>III. Psychoses with violence</td>
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<tr>
<td>a. dementia epileptica</td>
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<td>b. schizophrenic syndrome</td>
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<tr>
<td>IV. Epilepsy</td>
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<tr>
<td>a. subnormal mental state</td>
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<tr>
<td>b. irritability and violence</td>
</tr>
<tr>
<td>V. Mental retardation and agitation</td>
</tr>
<tr>
<td>a. with epilepsy</td>
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<td>b. without epilepsy</td>
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chronic anxiety and pain. They are good in the obsessive compulsive neurosis in which it seems there is an active component added to the classical anxiety.

Thus schematically presented the results stand in sharp contrast to those of topectomy of the dorsal granular cortex of areas 9 and 10. The latter operation in our experience\(^5,11\) is mostly effective in cases of intractable pain, anxiety neurosis, and depressive states, in which it is generally justified to describe a clinical introversion syndrome; but it often fails in states of
excitation, agitation and violence, in which clinical extraversion seems predominant.

The mesial undercutting, of which we have had 18 cases since 1950, is in a way an intermediary operation, excluding part of the granular cortex of areas 9 and 10, and areas 32 and 24 as well. We found it especially effective in obsessive compulsive neurosis (as much as cingulectomy and more than dorsal topectomy), and we would try it first in confirmed schizophreniacs with agitation and violence, rather than cingulectomy.

We feel entitled to conclude that the clinical results suggest an opposition between the effects of ablation of mesial agranular and dorsal granular frontal cortex.

ANALYSIS OF POSTOPERATIVE SYNDROME

Four years ago our experience with anterior cingulectomy was sufficient to allow us to write that, in marked contrast to the "convexity" patients, the classical euphoric and careless behaviour was not present after cingulectomy. During the first postoperative days, the patients are often quieter, and seldom slightly agitated. But there is no mental confusion—they are very well aware of the surroundings and events with the proper amount of attention; there is no euphoria, no irritability, no sphincteric incontinence. We could conclude on the weight of such clear-cut differences that behaviour was modified in perhaps specific ways by those two types of limited frontal resection.\textsuperscript{13,14}

A study of the immediate postoperative course of the not too mentally retarded patients yielded the following figures: out of 80 convexity operations, a clinical postoperative syndrome was present in 53 (63 per cent); while out of 40 cingulectomies it was found in only 6 patients (15 per cent), and then nearly always when the resection went as far down as the region of area 12. The figures for orbital operations and mesial undercuttings have been reported previously, together with details of both the convexity operation and cingulectomy.\textsuperscript{9,11} The larger numbers presented now further support our first observations and conclusions.

The convexity postoperative syndrome is mostly one of uninhibited behaviour, often similar to slight drunkenness. It deserves the clinical name of extraversion. On the contrary, after cingulectomy, the patients seem quieter and more restrained. Perhaps it can be said that their behaviour is one of clinical introversion. Thus there is a suggestive analogy between the behaviour during the immediate postoperative period and the long-term therapeutic results, as seen above. But it should be emphasized again that there is no correlation between the final result and the apparent intensity of the immediate syndrome.\textsuperscript{9}

PSYCHOLOGICAL RESULTS

In 1950, thanks to Professor Alfred Meyer, we became acquainted with the psychological method of objective behaviour tests developed at the Maudsley Hospital in London by Eysenck and his collaborators, notably
Mrs. Petrie. There was at last the possibility of making quantitative psychological studies of the noncognitive dimensions of personality. We decided then to submit our patients in Paris before and after the operation to a series of objective tests strictly following Eysenck's technique. This long and difficult work would not have been possible without the constant help of Mrs. Petrie, who trained our psychologists and worked out all the statistical results.

The personality measures used in these studies are related to the following dimensions of personality: intelligence, extraversion, neuroticism, psychoticism. Let us remark at once that those terms have a defined operative meaning and should not be confused with the vague clinical meaning. In practice, the groups of tests objectively differentiate between the neurotic and the non-neurotic, the psychotic and the nonpsychotic, the extravert and the introvert.

The main results have been published before and more recently at the International Neurological Congress in Lisbon:

1. The convexity operations are followed by changes in the direction of decreased neuroticism and increased extraversion, confirming the studies of Mrs. Petrie on lobotomies. There is no indication of decreased psychoticism. There is no lowering of intelligence.

2. The cingulectomies are followed by changes in the direction of slightly decreased neuroticism, but there is no indication of increased extraversion. Psychoticism has decreased. There is no lowering of intelligence.

The psychological studies afford striking confirmation of the clinical inferences. After selective surgery there are definite indications of specific effects, at least when cingulectomy (mostly agranular) and convexity resection (granular) are compared. Furthermore, cingulectomy is on the average less extensive than convexity resection, but nevertheless it is followed by more pronounced changes in decreased psychoticism than any other operation, including standard lobotomy. Finally the significance of these findings is enhanced by the nature of our material: mostly patients with intractable pain for the convexity operation and mostly chronic epileptics for cingulectomy; in other words the observed changes are in all likelihood related to the resection of the frontal cortex and not to the cure of an evolutional mental disease.

Needless to say these conclusions in favor of the specific or qualitative theory of frontal lobe mental functions, are in no way a negation of the possibility of quantitative action as well. But such an abstract discussion is irrelevant. The only scientifically satisfying attitude is to find an objective method of estimating the relative importance of the qualitative and quantitative factors. The psychological techniques advocated here appear to be a definite advance in combination with selective frontal surgery.

ELECTROENCEPHALOGRAPHIC STUDIES OF CINGUELECTOMIES

The largest group in our series of cingulectomies are the epileptics, with pronounced disorders of character, chiefly irritability and violence. Thirty-
four cingulectomies were performed in cases of chronic generalized medically irreducible epilepsy. The results in the main confirm those previously published.}\(^4\)--\(^7\),\(^10\),\(^13\),\(^14\) Cingulectomy is nearly always effective against the irritability, anger, aggressiveness, violence, permanent or intermittent, of chronic epilepsy, and this is often enough for gratifying social rehabilitations. Epilepsy itself was never made worse; usually it was somewhat improved, sometimes it was completely cured. This for the clinical side.

On the electric side, corticography never disclosed focal activity in the cingular or precingular areas, and for this reason we do not perform it any more as a routine, in order to shorten the operation.

A detailed study of the EEG was carried out and in spite of the many well-known causes of errors in the estimation of the results in such a disease as chronic epilepsy,\(^10\) it is interesting to give here the main findings, a detailed account of which is in press.\(^12\)

In chronic clinically generalized epilepsy, some focalized unilateral predominance was observed in a few instances, but in only 2 cases is it perhaps legitimate to discuss a surgically localized epilepsy. There was no indication for a focal operation in any of the others.

The first postoperative EEG (less than 1 month) shows transitory alterations, more often temporal than purely frontal, contrasting again with the convexity operations. Later, after more than 1 year, about 45 per cent of the patients are much improved and 3 have a normal EEG. About 30 per cent have a comparable EEG, and 30 per cent seem worse. This, again, refers to the EEG findings and not necessarily to the clinical evolution.

Among the non-epileptic patients, in 1 case only were permanent postoperative alterations disclosed, probably because there was an operative injury of the convexity. In practice we feel the risk of permanent epilepsy after cingulectomy is much less than after lobotomy or even topectomy of the convexity.

**DISCUSSION**

(1) **Clinical and Psychological.** Before our first publication, very few similar operations had been performed: one by Pool, and two limited cingular undercuttings by Ward, all in cases of severe schizophrenia, with no appreciable result. But later other reports appeared in print. Only one concerns cingulectomy properly, from Cairns’ clinic in 1952;\(^20\) the technique, the postoperative observations and the main results are nearly the same as ours. However, in this series more schizophrenics are found (with no lasting successes) and there were no operations in epileptics with irritability and violence. Personality changes in a more recent study\(^27\) (of only 8 patients) were said to consist of a reduction of inhibition, perseveration and self-concern; it is of course always difficult to evaluate nonsurgically defined concepts, but we consider that these findings do not agree well with our own conclusions, which suggest clinically augmented introversion and restraint. They agree better with the diminution of neuroticism and psychoticism. The reduction of anxiety, which seems important to the Oxford workers, is not a specific result of cingulectomy.\(^10\)
Other so-called mesial operations are from time to time implicitly discussed as cingulectomies. All of them are undercuttings of both granular and agranular cortex and do not seem to give the same results as the cortical resection of the cingular region. Scoville's technique and our own mesial undercutting are included here; even Livingston's operation, though more limited, cannot be considered as a selective cingular undercutting; and the limited coagulation recommended by Grantham is very likely to interrupt the thalamo-frontal bundle, therefore not deserving the name of a selective mesial section.

(2) Physiological. Stimulation of the anterior cingular region both in animal and in man yields autonomic effects. Furthermore, it has a generalized regulatory action on the cerebral cortex. We never observed any significant autonomic change after cingular resections, which is not surprising if one considers the other important cortical components (uncus, posterior orbital...). But the effects of cingulectomy on clinical epilepsy and on the EEG have perhaps a deep physiological significance. In that respect it is interesting to note that the neurosurgical inferences in man were published even before the first experimental results, which thus afford objective confirmation. Nevertheless one should remember there is no disease in which the action of any new procedure is more difficult to estimate than epilepsy, because it is in practice impossible to follow the patient for a significant length of time under exactly comparable conditions.

Whether the effect of cingulectomy upon epilepsy depends upon the improvement in character or vice versa is open to question; both possibly depend on a common factor and, generally speaking, the mental changes following cingulectomy are more constant than the beneficial action on epilepsy itself. A recent important experimental work in cats gives suggestive indirect confirmation of the different functions of the cingular and granular cortex: after destruction of the anterior nuclear thalamic complex—connected with the cingular areas—the cats are nicer, more gentle, and the threshold for rage is raised; after destruction of the dorsomedial nucleus—connected with the granular frontal cortex—the cats are more irritable with less motor activity, and the threshold for rage is lowered. Here again it would be gratifying if neurosurgery were to lead the way to experimental physiology.

SUMMARY

1. After an account of its introduction and development, the technique of anterior cingulectomy is described.

2. A series of 50 cases is reported. The best clinical results are found in cases of intractable irritability, aggressiveness, violence, and agitation, especially when associated with chronic epilepsy. Patients with obsessive-compulsive neurosis also react very favorably to cingulectomy. The follow-up period extends from 5½ years to 6 months.

3. Cingulectomy is seldom followed by a significant postoperative clinical
syndrome during the first weeks, in contrast with the “frontal” postoperative syndrome often observed after topectomy of the convexity.

4. A psychological study, with objective behaviour tests, discloses after cingulectomy no lowering at all of intelligence, no indication of augmented extraversion, a decrease in neuroticism, and a marked decrease in psychot- icism.

5. The main EEG findings after cingulectomy are given. Chronic epilepsy is often improved by the operation.

6. The main physiological interest of anterior cingulectomy seems to be the now well-substantiated suggestion of a difference in function between dorsal granular cortex (areas 9 and 10) and mesial agranular cortex (area 24).

REFERENCES