OBSERVATIONS ON SELECTIVE LEUCOTOMY*

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The time is an appropriate one to look back at the development of surgery for the relief of mental illness and to note some of the recent trends, for it is just a quarter of a century since this method of treatment became established. It is true that Burckhardt (1891) had performed some cortical excisions in the frontal and the temporo-parietal regions for mental illness, but this work was not followed up and it was not until 1935 when Moniz and Lima operated on their first patients that leucotomy as now understood began. The effects of frontal lobe injuries in man were known from the reports of the First World War, and Brickner had given a detailed account of frontal ablation in one patient (Brickner, 1934) but Moniz was particularly influenced by the work of Fulton and Jacobsen (1935) on frontal ablation in monkeys. These workers drew especial attention to the change that took place in a neurotic female monkey which after operation became placid and tame. Moniz and Lima operated on their first patient in 1935 and in 10 weeks, 20 such operations had been performed. The monograph describing the immediate results was published the following year (Moniz, 1936). Briefly the claim was that of the 20 patients, seven were cured and eight improved. Following this one can refer to the first phase of leucotomy when for the next 10 years the standard pre-frontal leucotomy was employed for the majority of cases. Some of these early operations were uncritical and were performed mostly on psychotic patients in whom, although the gross effects of the operation could be detected, it was not possible, except in a minority, to decide whether there were any finer changes of personality and intellect. The results obtained were illustrated by the review by the Board of Control of 1,000 cases (1947). The mortality in that series was 6%, and 35.3% of patients were discharged either recovered or improved. Of these 9.3% subsequently relapsed, giving an overall "considerably improved" figure of 26%. This has

remained the average figure of worthwhile benefit to be derived in the psychotic group once stability after the operation, which may take up to two years, has been reached. It was noted then that schizophrenic patients stood only a 23% chance of improvement whereas manic depressive illnesses improved in 50%.

During the latter part of this first period two main factors came to light which damped the early enthusiasm for the operation. One was the occurrence in some patients after leucotomy of uraemic states or a more complex metabolic disorder leading to trophic changes including wasting, decubitus ulceration, and ultimate death. McLardy (1950), who described such a series of patients, noted that these changes were associated with posterior cuts, particularly those involving the corpus striatum. The second factor was that as the operation was extended to psychoneurotic illnesses and later to psychosomatic illnesses, that is to patients with otherwise well-preserved personalities, so the untoward effects of the operation on the intellect and the personality became more apparent. There followed several critical surveys of such effects after the standard leucotomy. Thus Partridge (1950) well summarized them by noting that these patients showed an inability to profit by experience and an inability to plan the future. There was a reduction of activity, lack of spontaneity and persistence. The patients showed a reduction in affect such as worrying less and were emotionally less disturbed with a reduction in restraint and the appearance of such features as greediness, selfishness, and tactlessness. Tow (1955), in a monograph summarizing the work of this first period of leucotomy, concluded that after frontal lobotomy there was a reduction in many functions, although loss in none, and warned against conclusions drawn by meticulous testing of one function to the exclusion of others. In particular he confirmed that pre-frontal leucotomy did reduce the intellect and ability to plan ahead and in general there was a loss of abstract thought and a tendency towards a more concrete life.

The end of this first period closed, therefore, with

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confirmation that leucotomy could benefit a proportion of patients who otherwise were condemned to an inveterate illness but also demonstrated that there were unwanted side-effects to the extent that if surgery was to be applicable outside this small group of patients, a more limited operation would have to be devised which would confer at least the same benefit with far less post-operative complications of all kinds.

The recent years have seen a trial of various limited operations on the frontal lobe, both by open and closed methods, in an attempt to solve this problem. Aside from the immediate practical necessity was the still unanswered neurophysiological question as to whether there was specificity of function within the frontal lobe.

Case Material

It is not proposed in this paper to describe in detail the various procedures which have been carried out but to illustrate this second phase of leucotomy by reference to two operations which have been practised in this department during the last 11 years. It seemed reasonable that selective leucotomies should be open operations wherever possible, not only in order to be more certain that the procedures in fact were limited, but also so that their effects could perhaps be more accurately applicable to the problem of frontal lobe function. The two operations have been orbital leucotomy and cinglectomy. In 1948-59, 115 such operations were performed in 113 patients. There was one death related to operation. This was in a patient with involutional melancholia who after cinglectomy developed cerebral infection and died from bronchopneumonia three months after operation. Eight other patients have died within the period of follow-up, six from unrelated causes, and two committed suicide, one in an unrelieved mental illness and one in a relapse after seven years' improvement following cinglectomy (*vide infra*).

Orbital Leucotomy

Evidence of the relation between the orbital cortex and emotional disturbance, and the suggestion that interference with the pathways of the orbital cortex would have a beneficial effect on emotional disturbances, characterized by depression and anxiety, have accumulated over the years. Kleist (1934) reviewed a large series of head injuries and concluded that injury to the supero-lateral aspect led to disturbance of intellect, and lesions of the orbital surface produced emotional changes. These observations were confirmed on a small but more thoroughly studied group of cases by Rylander (1939).

In the experimental field Livingston, Fulton, Delgado, Sachs, Brendler, and Davis (1948) in Fulton's laboratory had shown that orbital ablation in monkeys led to decreased activity, tameness, and freedom from excessive fear. In man, Meyer and Beck (1945) and McLardy and Meyer (1949), from neuroanatomical studies on leucotomized brains, concluded that although clinical recovery was correlated with the greater lesion, there was some evidence to suggest there was a possible advantage in isolating the orbital cortex. Clark, Le Gros, and Boggon (1933) had demonstrated in cats the connexion between the medial portion of the dorsomedial nucleus of the thalamus, the hypothalamus, and the orbital cortex of the frontal lobe, and the studies of Meyer, Beck, and McLardy (1947) on leucotomized brains confirmed this in man, but showed that the projection was confined to the medial half of the orbital region. Spiegel, Wycis, Marks, and Lee (1947) showed that electrocoagulation of the medial nucleus of the thalamus produced good effects in the emotional sphere. This relationship between the dorsomedial nucleus of the thalamus and the orbital cortex could be demonstrated later by Ström-Olsen and Northfield (1955) who reported their findings in a patient who died from a systemic illness some time after a successful orbital leucotomy. The orbital surface had been undercut and there was degeneration of the medial part of the dorsomedial nucleus of the thalamus.

These connexions of the orbital cortex and its posterior part in particular have been associated with the concept of the "visceral brain". Economo (1929) felt that the cingulate gyrus was part of the cortical station for the autonomic system and Papez (1937) presented the hypothalamus, anterior thalamic nuclei, gyrus cinguli, hippocampus, and their connexions as a cerebral mechanism subserving elaboration of emotion and emotional expression. McLean (1949) developed this concept of the visceral brain to include the posterior orbital cortex and the temporal pole with the amygdaloid nucleus and this work has been supported by the experimental work of Fulton.

Results.—Orbital leucotomy was introduced by Scoville (1949). Our earlier results, together with a description of the operative details, have been described elsewhere (Tow and Lewin, 1953). At the beginning of the series the majority of patients were schizophrenics who showed marked tension, anxiety, or agitation. In the last six years or so, however, we have operated far less for schizophrenic illness than for affective disorders characterized by agitated depression, severe anxiety, or depression which have incapacitated the patients and failed to

yield to all other treatment. In these patients the overt illness has lasted at least two years, and in most cases for much longer. All these patients were considered by the psychiatrists under whose care they were to have a prognosis without operation which was virtually hopeless. In this series of 60 patients there were no deaths or operative complications. The results are summarized in Tables I and II. All but four have been followed up for at least two years after operation, and others for periods up to 10 years.

TABLE I

ORBITAL LEUCOTOMY FOR AFFECTIVE DISORDERS AND PSYCHONEUROSIS

Diagnosis	No.	Result		
		Greatly Improved	Some Benefit	No Improvement
Agitated depression	11	5	4	2
Depression	11	6	2	3
Anxiety and "tension" states	7	2	4	1
Obsessional neurosis	4	2	1	1
Anorexia nervosa	3	3	—	—
	36	18	11*	7
		29		

*Eight of these 11 patients are at home.

TABLE II

ORBITAL LEUCOTOMY FOR PSYCHOTIC ILLNESS AND PSYCHOPATHIC STATES

Diagnosis	No.	Result		
		Greatly Improved	Some Benefit	No Improvement
Schizophrenia	19	4	7	8
Psychopathic illness	3	1	1	1
Manic depressive psychosis	2	1	1	—
	24	6	9*	9
		15		

*Six of these nine patients are at home.

Orbital Leucotomy in Psychotic Illness.—Of 24 patients with major psychotic illnesses, schizophrenia in 19, manic depressive psychosis in two and three patients best described as gross psychopaths, six have been considered greatly improved. This term indicates that these patients have left hospital and have returned home and are working. The quality of the improvement is such that four of the schizophrenic patients declare that they are cured and their relatives think so, too, but in such an illness it is wiser to avoid the word "recovered" or "cured". In the second group "some benefit" refers to patients who are undoubtedly much improved after operation; indeed five of the seven schizophrenic patients have returned home and the two who still remain in

hospital are quieter, working, and joining in social activities. But in all these patients there is still a very obvious schizophrenic illness present and it would be wrong to class them as greatly improved, merely because several have been able to leave hospital. Of the other eight schizophrenic patients, although some are quieter and easier to manage, one would not consider this a worthwhile improvement from a surgical point of view and a justification for operation. Indeed three of these patients may be worse, for although relieved considerably of their tension and impulsiveness, they have remained since operation apathetic and unwilling to work within the hospital, and should be classed as failures.

Two points may be made about these results in schizophrenic patients. The first is that with the indications for operation as set out above, the results obtained by orbital undercutting (nine patients discharged from hospital out of 19) are at least comparable to those by standard pre-frontal leucotomy. The second point is that four of these patients obtained such a degree of improvement as to be considered by some to be cured. Attention in the past has been focused on percentage improvement to leaving hospital but it is surely important to study closely the so-called "cures" to discover why it is that they have done so well. It has been suggested that success or failure is unpredictable and in a schizophrenic illness leucotomy will improve a quarter of any selected group. Nevertheless, one should search for trends in the clinical pattern of these patients which might enable a firmer prognosis to be made as to the success or otherwise of a proposed operation. Thus in these four patients it may be significant that before their illness all had been individuals with good affect and there was nothing in these patients' earlier histories or in the family histories to suggest schizophrenic traits. Again, none showed the typical schizophrenic build; in fact, three of the four were rather short and stocky. The onset and duration of illness should also be noted, for in two cases the length of illness had been comparatively short, at about two years, and in the other two, although the illness had lasted seven and nine years respectively, both patients had previously been well adjusted. Other writers have commented before on the importance of basic personality in assessing prognosis and it would appear that in judging the likely response of a schizophrenic illness to operation, the basic personality of the patient, the family history, and the type of affective life before illness, may all be valuable pointers in addition to the accepted symptomatic indications of tension and aggression. The phenotype (Parnell, 1955) may also prove to be another helpful guide in adopting standards for operation.

Orbital Leucotomy for Affective Disorders.—Table II shows the results of 36 operations for affective disorders. No fewer than 18 of the 36 patients were greatly improved and a further 11 benefited, all but three being at home. Indeed in 12 it is pardonable to speak of recovery in that all the symptoms complained of before operation have gone, the patients are well adjusted to life, and their relatives consider them cured. There were seven failures, but in four this possibility was anticipated owing to the patients' poor personality background. Pointers towards a good prognosis after operation were a good personality before the illness, and where the illness was accompanied by some loss of weight (Knight and Tredgold, 1955). On the other hand the results in those patients with an inadequate or immature personality or where there was a strong hysterical element in the illness were less satisfactory.

These results, therefore, in depressive and anxiety states appear satisfactory, and improvement has been maintained now for periods up to 10 years and compare not only favourably with standard leucotomy but immeasurably better in that in none has there been any gross personality change or metabolic disorder associated with the more destructive operation. Older patients did well with orbital leucotomy and this series included three patients of 70 years.

The general pattern of recovery after operation was usually one of immediate change and in most patients it was possible to gauge within the first few weeks whether there was likely to be a good result or not. This differed from the immediate effects of cingulectomy to which reference will be made later. It was important, however, to arrange a rehabilitation programme for some patients who showed limited early improvement, for it was found that they could go on improving slowly for periods up to two or three years.

Complications.—Although clinical recovery has been mentioned it has been avoided in tabulating the results, for there is little doubt that although personality changes are mild after orbital undercutting and certainly much less than after the standard cut, yet they are present in practically every case. In the early post-operative period there may be definite disinhibition and euphoria, although in only one patient was it ever marked and this later settled down. As regards the long-term effects some of these patients when questioned said that they tired more easily, a few remarked that they were unable to plan ahead as well as they used to in the past, and some of the housewives noticed that whereas they used to be able to calculate their house-keeping expenses very easily before the illness,

calculation took them longer although it was still accurate. We were particular to ask these patients whether they had lost anything they valued by operation and usually received a negative answer. It should be added that some of these patients were not highly endowed, but on the other hand within this group there were teachers, journalists, social workers, and the like who were able to return to their work, including university education. In particular no patient noticed any difference in his religious appreciation or experience. A number of these patients had undergone intellectual tests before and after operation and no significant intellectual impairment was found (Mittler, 1957).

Prolonged incontinence following this operation was not present, and indeed in only eight of the 60 patients did it ever occur post-operatively at all. In only one patient did it persist for a few weeks and interestingly enough that patient ultimately made an excellent recovery.

Some *increase in weight* after operation was by no means uncommon but in only three patients was it considerable. One patient increased in weight from 9 to 15 stone in the six years after operation. It should be noted that the three cases of anorexia nervosa responded well and showed considerable weight gains. Knight and Tredgold (1955) noted that the operative results were favourable where the illness was accompanied by a considerable loss of weight.

There was no example of metabolic or trophic disturbance. Ström-Olsen and Northfield (1955), however, described one case where the cut went more posteriorly than usual and involved the internal capsule and the caudate nucleus on both sides. In the post-operative period this patient exhibited the classical syndrome to die ultimately with extensive ulceration. This gives further proof of the evidence for the site of lesion which produces this disturbance and also emphasizes the care that has to be taken in estimating the depth of the lesion at operation. It is true that in the great majority of cases, this, when compared with the length of the orbital roof, is usually fairly constant. But as in Ström-Olsen and Northfield's case and it may well be in others, particularly where the skull is small or there is some other disparity, this may not be so, and at operation it is important to note the individual landmarks.

Epilepsy occurred post-operatively in a few patients (five out of 60), although in two there was but a single attack and three of the five patients had either had a fit before operation or the pre-operative E.E.G. had shown a frankly epileptic record. No patient went on to have frequent attacks.

Orbital leucotomy would therefore appear to be a satisfactory operation for some of the effective disorders and to have a low incidence of complications. Scoville (1954) has reported similar results, and in this country Knight and Tredgold (1955) found that of 52 patients 23 were markedly better, the best effects being on depression and anxiety, and Ström-Olsen and Northfield (1955) found that of 13 patients with tension and anxiety or depression, seven could be classed as recovered and three improved.

Cingulectomy

Experimental ablation of the cingulate gyri in monkeys (Smith, 1944, 1945; Ward, 1948; Gleeves, Cole, Whitty, and Cairns, 1950) resulted in marked alteration in emotional behaviour with lessening of aggression and increased tameness. Fulton in 1947, at a meeting in Glasgow of the Society of British Neurological Surgeons, mentioned in discussion that were it feasible, cingulectomy in man would seem an appropriate place for limited leucotomy. Accordingly the late Sir Hugh Cairns in 1948 began the operation of anterior cingulectomy, the evidence at that time being that it was the anterior part of area 24 which was more concerned than its posterior part, area 23. The technique has been described previously (Whitty, Duffield, Tow, and Cairns, 1952). Through a formal right frontal osteoplastic flap the cingulate region is approached alongside the falx cerebri and the anterior 4 cm. of the cingulate gyrus on each side is removed by suction, the blood supply and the rest of the frontal lobes being left intact.

Early Results.—At first 18 chronic deteriorated patients, mainly schizophrenics with tension and aggression, who were candidates for leucotomy, had the more limited operation of cingulectomy performed. The early results allowed three conclusions: that the operation was technically possible but could be difficult and was not free from risk, mainly due to the proximity of the anterior cerebral arteries; that a truly limited procedure could be carried out; that although it became apparent that cingulectomy was not an adequate operation for schizophrenia, the immediate lessening of tension in these patients, and particularly the improvement in any obsessional features which took place, together with the absence of any added gross personality or intellectual change, suggested that such a limited operation might be applicable to psychoneurotic illnesses and to obsessional neurosis in particular.

Recent Results.—Since that time 34 patients have undergone cingulectomy. Table III* shows the

*One of these patients operated on for schizophrenia with aggression is not included in Tables III and IV.

TABLE III
CINGULECTOMY FOR PSYCHONEUROTIC ILLNESS

Diagnosis	No.	Result		
		Greatly Improved	Some Benefit	No. Improvement
Obsessional neurosis	15	7	6*	2
Anxiety/obsessional	6	3	2	1
Depression/obsessional	5	1	2	2†
	26	11	10	5
		21		

*Of whom three were operated on less than two years, and are still improving. All at home.
†One patient relapsed after seven years during which time she was greatly improved.

results in 26 patients with psychoneurotic illnesses who have been followed up so far for at least a year and some up to 11 years. Of 15 patients with obsessional neurosis, 13 improved significantly, seven markedly so. The two failures in this group were due probably in one to the fact that the operation was incomplete for technical reasons, and in the other because there were also associated hysterical features, always a bad prognostic sign for any form of leucotomy. It was interesting to note, however, that in the first of these failures, a patient with a lifelong obsessional illness, there was no improvement three years after operation, but in the fourth year she made an excellent recovery following further psychotherapy.

The pattern of recovery of these patients after cingulectomy should be noted, for although in the immediate post-operative period there is an obvious lessening of tension, together with a transient Korsakoff confusion in some patients (Whitty and Lewin, 1957, 1960), other dramatic changes are not seen. The obsessional thoughts retreat gradually but progressively into the background and the drive behind them lessens.

The following case record is typical.

Illustrative Case Record (No. R.I. 207229).—This young woman, aged 29 years, had had an unhappy family background. Mild obsessive features appeared when she was about 8 years old. She was easily upset at school, and shortly after leaving had an illness attended by fear of eating and a good deal of loss of weight which sounded very like anorexia nervosa. The patient was married when she was 19 years of age but the marriage was never a success physically. The patient had increasing difficulty in coping with her mounting obsessions until eight years before operation when she suddenly informed her husband that she could carry on no longer and from that date until operation there was increasing incapacity with her obsessional illness needing intensive psychiatric treatment, mainly psychotherapy. The situation was reached where the patient was unable to do any housework. A complicated ritual accompanied getting up and

dressing in the morning, which took nearly eight hours, and at night it would apparently take nearly four hours to get to bed. She also had a considerable fear of eating, although she still looked well nourished. The patient also feared that she might develop an undesirable sexual attachment, although this never actually occurred. In the period before operation there was a steadily mounting tension.

A bilateral cingulectomy was performed. In the immediate post-operative period the obsessive thought content remained unchanged but there were three differences. First the patient was quite content to remain in hospital, whereas before it was doubtful whether she would remain in hospital even for the short period before operation. Secondly she immediately began to eat better than she had done for the previous two years. The third change was some immediate lessening of tension and mild disinhibition, but this was no more than the difference between inclining to laugh rather than to grumble at minor upsets in her daily routine. The patient returned home a fortnight after operation and remained under psychiatric care as an out-patient and was seen at regular intervals thereafter.

Three months after operation the patient said that she felt she was now going up the ladder instead of down. The obsessional features were still present but were less, and she could do things which were quite beyond her before operation. She was able to eat well and she could now get herself dressed within an hour, which compared very favourably with the situation beforehand. Six months after the operation the patient was still improving and she was now doing all her housework; help in the house which had been provided for five days a week immediately post-operatively had now been reduced to one day a week. Moreover, she was able to do her shopping, and, previously having had to avoid all shops which had any mirrors, she was now able to go into one or two of them. She realized that she did still wash and change her clothes more than was normal, but it was within reasonable limits. One year after the operation the patient said she could not have believed that she would feel as well as she felt then. She realized that she was still obsessional but she was running her house entirely on her own. Moreover, she had taken a part-time job in a store in order to widen her interests, this suggestion having followed on the post-operative rehabilitation programme. Two years after operation, the patient felt she was entirely back to normal, she was leading a full life and she volunteered the information that such ritual as remained was more a habit than anything else. The patient looked well, and there were no obvious neurological abnormalities.

This improvement was maintained and when seen on the fourth anniversary of the operation, the patient had given up her job as now in addition to her housework she had taken up social work. A family bereavement had been felt appropriately. An increase of weight of nearly 3 stone at two years after operation had now been reduced to 1½ stone over the pre-operative weight.

The results in this particular group are worth emphasizing for the therapeutic effect is striking

when one considers an operation in which only a small amount of brain tissue is removed. Moreover, the results appear superior to other limited procedures. Thus in Knight and Tredgold's series of orbital leucotomy only five of the 12 obsessional patients were benefited; Pippard (1955), when reporting on rostral leucotomy, found less than half improved (12 of 26), and Busch, Halmsted, Lund, Nevin, and Thelle (1955) gave similar results for orbito-medial undercut. Obsessional neurosis is notoriously refractory to most treatment and indeed the only other procedure which gives results superior to cingulectomy is the standard leucotomy, which in one series (Partridge, 1950) gave 20 of 24 patients improved. But this is at the risk of considerable personality change and as many patients in this group are highly intelligent, standard leucotomy is too high a risk to run, certainly as a first procedure.

In general the patients likely to respond best to cingulectomy are, as with orbital leucotomy, those who have had a full emotional life before their illness, and in whom the illness is of acute onset and particularly if related to some external stimulus. By the same token the prognosis has to be more guarded where obsessional symptoms have been lifelong, where the basic personality is immature and in particular where depressive symptoms are also prominent. Excessive ritualistic behaviour is another indication for a cautious approach, although by itself it does not necessarily mitigate against a good result as indeed the case recorded above illustrates. Indeed the obsessional illness which is so severe as to demand operation is the one not infrequently associated with ritualistic tendencies deeply ingrained.

In addition to the 15 patients with obsessional neurosis there were 11 other patients, who although showing obsessional symptoms, had marked anxiety and/or depressive symptoms as well. It would appear in this group that the prognosis is good where anxiety is dominant but, as can be seen from Table III, if depression is a feature the results are not so good and where this factor is marked it would incline one to recommend an orbital leucotomy rather than cingulectomy. Indeed, there was one patient in this series who, after cingulectomy, returned to his work and did well for four years after a long illness of obsessional neurosis with mild features of depression, but then relapsed with an almost pure depressive illness which responded dramatically to orbital leucotomy. Another patient derived considerable benefit for seven years after cingulectomy but then relapsed and committed suicide.

In a third group have been placed seven patients in whom more recently cingulectomy has been

TABLE IV
CINGULECTOMY FOR AGGRESSIVE STATES

Diagnosis	No.	Result	
		Greatly Improved	Some Benefit
Epilepsy with aggression	4	2	2
Paranoia with aggression	3	3	—
	7	5	2

performed for relief of severe aggression either within the compass of a paranoid illness or in association with epilepsy (Table IV). This was of course a further logical development from the earlier animal work, and Le Beau (1952, 1954) had reported favourably on its effects in epileptic patients and those with considerable mental retardation, classifying 15 of 20 as good results. So far we have been similarly impressed with our few cases. Thus all our seven patients derived some benefit, five markedly so. Before operation they had been given a very poor prognosis and the prospect of indefinite retention in hospital. Three have returned to full work and the fourth, although still prevented from so doing by frequent epilepsy, has had no more antisocial aggressive attacks which previously had terrorized a neighbourhood.

Complications.—Among these 34 patients there were no operative deaths. There were two complications after operation. One patient developed a local osteitis of the bone flap which cleared subsequently with limited surgery, and in the other patient there was a transient phase of raised intracranial pressure due probably to venous thrombosis which also subsided satisfactorily.

The mild personality changes noted in these cases have been reported earlier (Tow and Whitty, 1953). These are even less than after orbital leucotomy but we think similar, although quantitatively less. In this regard we differ from Le Beau and Petrie (1952) who feel that the changes after cingulectomy are qualitatively as well as quantitatively different from other leucotomies.

Urinary incontinence for a day or two after operation was commoner than after orbital leucotomy although in all cases it had cleared within the first post-operative week. This sphincter disturbance may well reflect the relations between the autonomic nervous system and the cingulate areas.

The risk of epilepsy was small. Only two of these patients who did not have an epileptic history developed fits for the first time after operation. In one a single attack occurred on the fifth post-operative day, and in the other attacks of an inhibitory type began three months after operation.

The operation of cingulectomy is a significant one when considering specificity of frontal lobe function. The concept of the cingulate gyrus as the cortical representation of autonomic function and its connexions with the hypothalamus in the "visceral brain" is of course pertinent. In some of our patients operated on under local analgesia, the cingulate gyrus has been stimulated and vomiting, incontinence, and momentary arrest of respiration noted (Lewin and Whitty, 1960). Cingulectomy may interrupt a reverberating circuit formed by hippocampus, fornix, mamillary bodies, anterior nucleus of thalamus, and cingulate gyrus, and it is interesting that it is the obsessional disorder which seems to respond best of all to this particular operation.

Our present policy is to regard cingulectomy as the operation of choice for the classical syndrome of obsessional neurosis and also for the young patient with obsessional symptoms and a marked anxiety state where operation is necessary and where it is particularly important to have the least post-operative personality change: young, because in the older patient an orbital undercut is effective, and is a simpler and safe procedure.

Conclusions

It seems permissible at this juncture to draw a few broad conclusions. There is no doubt that there are now available limited procedures which will produce results at least comparable in benefit with standard leucotomy and without the serious side-effects of the more extensive operation. This paper has illustrated two of them. Standard leucotomy is rarely indicated as the first operation of choice and indeed it seems that the stage is now reached where if a limited procedure is considered unlikely to give considerable benefit, then surgery is not advisable and the operation of standard pre-frontal leucotomy can be abandoned. The difficulty at present is that one cannot predict with sufficient accuracy the full effects of leucotomy nor are the standards of selection of patients for operation secure. In such a distressing illness as schizophrenia, for example, the fact that a small proportion of patients will improve to a considerable degree means that the operation is called for both by psychiatrists and by patients and relatives. Yet this should not lead to further indiscriminate trial of operation but encourage a more detailed selection of those patients most likely to benefit. In recent years clinicians have already come some way with this in symptomatology, but there are other factors to consider, some indication of which has been given which it would seem wise to explore further. All would agree that surgery is not the treatment for schizophrenia as such and

the aim should now be to define as closely as possible the small group where in the present state of our knowledge surgery still offers considerable relief from otherwise incapacitating symptoms.

A limited operation is the procedure of choice where surgery for affective disorders is indicated. The results from various centres, together with the experimental evidence on which these operations are based, make cogent arguments for directing surgery to the orbital cortex for symptoms of anxiety and depression and to the cingulate gyrus for aggression and obsessional disorder. However, comparisons with other limited procedures are notoriously difficult to make and there is as yet no agreement as to what is the most appropriate operation for a particular disorder. The good results reported with other limited operations are significant when considering whether the differences in effect of these various operations are quantitative rather than qualitative or if there is specificity of function in the frontal lobe as some of these results would appear to suggest. Rostral leucotomy yields good results for affective disorders and this operation has been carefully analysed by Pippard (1955). It should be noted, however, that this author advises caution in performing the rostral operation for depression due to the risks of hypomania supervening. He found that half the patients showed some intellectual deficit, though usually mild. They were more frequent with the blind operation and absent with the open rostral operation. Petrie (1956) reported only minimal intellectual deficit after the open rostral operation, but McKissock (1951) abandoned the open approach for the closed procedure since the results of the former were indifferent with only 30% good results. These intellectual changes need careful comparison with the effects of other limited procedures, for previous work would suggest that the more the supero-lateral surface of the frontal lobe is involved the greater the chance of intellectual deficit. Orbito-medial undercutting has a high incidence of epilepsy, up to 16%, as indeed has topectomy of areas 9, 10, and 11 (Pool, 1949). Stereotactic techniques can produce results comparable to a standard leucotomy but not, as yet, consistent limited results.

The emphasis in this paper on the complications and the mild but definite personality and other changes which follow all limited procedures on the frontal lobe should not be allowed to distort the overall picture. It should not obscure the benefits that these selective operations may confer on a selected group of patients who have failed to respond to all other appropriate psychiatric measures, have been ill for many years, and are totally incapacitated by their illness and likely to remain so. Any

operation on the normal cortex will lead to some change but this may only be detected if our standards of assessment are fine enough. In judging operative results, although loss has to be weighed against gain, it should be remembered that it is not always possible to assess accurately therapeutic loss and gain when comparing these patients before and after operation. The present reserve in this field of surgery is a healthy one; but until there is an alternative, selective leucotomy can relieve otherwise intractable mental suffering.

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