THE LOWER QUADRANT LEUCOTOMY.*

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In recent years efforts have been made to analyse the part played by the frontal lobes in the integration of personality. The pioneer work of Bianchi (1922) based on pathological lesions in human subjects, and on experimental bilateral ablations in monkeys, dogs and foxes, still appears to be as true to-day as when originally enunciated. Sherrington (1901) also described the changes following destruction of the frontal lobes. It was noted that such animals lost the power to learn and to enjoy themselves. They had no curiosity, but became restless, hyperactive and easily distracted. Brickner (1936) studied over many years a patient with bilateral frontal lobectomy who showed a diminished ability to synthesize abstract thoughts. Goldstein (1941) found that patients with frontal lobe damage lose their power for abstract thought and this is replaced by concrete behaviour, as shown by object grouping tests and their use of words. Similarly Penfield and Hebb (1940), in a case of extensive lobectomy for an infiltrating oligodendroglioma in an intelligent housewife, described a lack of ability for complex planning, such as is necessary for preparing a meal of several courses. Jefferson (1937) was unable to find any deficiency in cases of unilateral lobectomy. Rylander (1939), on the contrary, after lobectomy for tumours was able to detect changes similar to those found by Goldstein, and in cases with frontal lobe injury he found a lack of social sense. These patients were embarrassingly outspoken, and sometimes showed excessive activity or fatigue. Hebb (1945) concluded that studies on pathological lesions of the frontal lobes were not very helpful, owing to the lack of precision of the lesions due to the uncertain extent of the pathology.

All these studies failed to show any precise localization of function, and it began to be felt that the effects of leucotomy were dependent upon the quantity of fibres destroyed rather than their localization. This agrees with Lashley's statistical work (1929) on rats learning to run mazes of different complexity, which showed that it is immaterial as to which primary receiving areas are removed, for the loss of learning power is proportional to the amount of cortex destroyed. The studies of Freeman and Watts together with that of many others, particularly McLardy and Meyer (1949), seem to indicate that interruption of thalamo-cortical fibres is the essential lesion, but it should be stressed that these fibres are a two-way system thought to function by resonance from thalamus to cortex and back again. The exact significance of this is of course unknown.

More recently it has become increasingly appreciated that there is an extensive localization of autonomic function in the frontal lobes. The more this has been studied the more widespread it appears, and it is now known to extend into the temporal lobes and cingulum. Fulton (1951) divides the frontal areas into a lateral and a medial region. The medial region consists of the cingulum, the back part of the base of the frontal lobe, the tip of the temporal lobe and the amygdaloid nucleus. This complex has been called the " visceral brain." In extensive studies on monkeys who have been trained in learning techniques, it has been shown that excision of the lateral region of the frontal lobe upsets their ability to learn, but this is only slightly affected if the lesion is confined to the medial region. To this degree there would appear to be some localization of function in the frontal areas.

* From a paper read at the Northern and Midland Divisional Meeting of the R.M.P.A. held in Sheffield, April, 1951.

It would seem that the mechanism which governs the integration of behaviour is something which is very widespread, and may be located not only in the cortex, but also in the basal ganglia and perhaps even in the brain-stem and medulla. This may be the reason why large areas of brain can be removed without apparently altering the basic personality. In spite of this, and with little or no knowledge of what disorganization has taken place in the brain of a patient with a psychosis, one still hopes by means of a local excision to affect some beneficial change.

It is possible, therefore, that the effect produced by leucotomy or by destruction of the thalamo-cortical fibres depends upon the impairment of resonance in the visceral brain. Recent work on psycho-somatic inter-relationships seems to indicate that this has an important significance in those mental disorders where there is predominance of subjective appreciation of abnormal visceral sensations. In this way quantitative destruction of the fronto-thalamic fibres becomes significant, and if the " cingulum fronto-temporal complex " is the main localization of autonomic representation, then destruction of fibres from these areas will presumably effect a change in these patients, though this may be only one facet of the disturbed workings of their whole brain. No doubt this fibre system can be interrupted with a small destructive lesion placed at some strategical position, dependent upon the facts of anatomy. Our only difficulty is to know exactly where this spot lies. It is this search to obtain the maximum therapeutic effect with a minimal well-placed lesion which is the basis of the numerous different operations designed in the course of the last five years. The very complexity of the clinical material which has been submitted to operation is one reason why recognition of the best operation for the best type of case has been so long in forthcoming. In fact, one is only just beginning to recognize something about what we are trying to accomplish, and how to do it. It is with this object in mind that we have explored the leucotomy question, using the full and the lower quadrant incisions in a parallel series of cases, and we are beginning to feel that it is the deep lower and perhaps central cut which produces the best result without leaving too much frontal lobe deficit. In this operation the upper fibres are preserved, but it is impossible to say in a study such as this which particular areas have been left intact, although these may be revealed ultimately by the studies of Meyer and McLardy. In the meantime, localized excisions may add to our further knowledge of this aspect of the problem.

Case Material.

The material under review consists of the first 250 operations of prefrontal leucotomy performed on cases in the Middlewood Mental Hospital. The selection of patients has been largely determined by such factors as long duration of illness, intractability and failure of sustained benefit from other methods of treatment. A constant technique was developed, using either a full or a lower quadrant incision in an almost equal number of cases, the choice being arbitrary at first but finally restricted to lower cuts for depressive states, and full incisions for schizophrenic, manic and psychopathic patients. The full standard leucotomy incision was used exclusively from 1943 until 1946, after which time the lower quadrant operations were commenced (Table I). From this time onward there has been an increased discharge-rate owing to the inclusion of cases with affective disorders, almost to the ultimate exclusion of other types of psychoses.

Table I.—250 *Leucotomies*.

Year.	Operations.		Discharges.	
	Full.	Lower.	No.	%.
1943	6	—	2	33
1944	11	—	4	36
1945	6	—	2	33
1946	6	20	11	42
1947	15	13	19	68
1948	21	11	17	53
1949	51	70	79	65
(Part) 1950	5	15	13	65
Totals	121	129	147	59

The distribution of the cases according to age-groups is shown in Table II, together with the discharge-rate. These figures suggest that the chance of a favourable outcome from leucotomy increases with the age of the patient, the discharge-rate reaching a maximum of 76 per cent. in the 51 to 60 age-groups. Relapses, on the other hand, were greatest on the younger 21–30 age-groups, due to the preponderance of the less favourable schizophrenics. It is interesting to note that advanced age could not of itself be considered a contra-indication to leucotomy.

TABLE II.—*Age-Groups.*

Age.	Operations.		Discharges.		Relapsed.	Died.
	Full.	Lower.	No.	%.	No.	No.
11–20	5	2	1	14	—	—
21–30	36	22	26	45	9	2
31–40	38	18	30	54	2	1
41–50	24	16	27	67	1	1
51–60	13	33	34	76	3	1
61–70	3	33	24	66	2	1
71–80	2	5	5	71	1	1
Totals	121	129	147	59	18	7

TECHNIQUE.

Pre-operatively the patients were given omnopon and scopolamine, and in all but eight cases the operations were carried out under local analgesia. It was felt that any inconvenience arising therefrom would be outweighed by such advantages as avoidance of some anaesthetic complications, the observation of the patient's reactions during brain section, and the desirability of leaving a conscious, actively moving patient at the termination of the operation, thereby facilitating nursing supervision and prompt detection of any post-operative complications.

The operative technique conformed to that of the Freeman-Watts method, using a lateral approach. Burr holes were made 3 cm. behind the outer rim of the orbit, and 6 cm. above the zygoma. The brain fibres were incised by a sweep of the brain cannula after the fashion of McKissock (1943), the section being made just anterior to the plane of the coronal suture. In these operations particular attention was paid to the localization of the sphenoidal ridge, the sweep of the cannula being made just in front of this point, and section of the orbital fibres was verified by feeling the tip of the cannula on the orbital plate. In the lower quadrant operation the cannula was then carried upwards to only 1 cm. above the centre of the burr hole, thereby making sure that the fibres of the central segment were cut. In the full leucotomy the brain cannula was carried upwards towards the vertex.

In the diagram of the operative fields (Fig. 1) it will be seen that the burr holes are positioned at the middle point of the anterior cranial cavity, and that an incision from a level 1 cm. above this point carried down to the orbital plate should incise about two-thirds of the white matter, i.e., rather more than the orthodox lower quadrant operations. In fact, the operation in our series of cases would be better described as a ventral two-thirds coronal incision calculated to cut through those central and lower segments of white matter which McLardy and Meyer (1949) found to be the closest anatomical correlates of improvement after leucotomy.

GENERAL RESULTS.

The over-all results in this present series of 250 cases compare favourably with the findings in many other large group analyses, although it should be emphasized that two-thirds of our cases were suffering from affective disorders. All the patients have been under observation for at least one year after operation, those discharged being interviewed at home as well as the out-patient clinics.

A comparison of results between the lower and the full incisions, analysed in Table III, shows 70 per cent. lower quadrant cases discharged in the affective group of disorders as compared with 62 per cent. after full incisions. Such a discrepancy might well be accounted for by the tendency to favour a full incision for the relatively severe cases. Yet it would seem that the lower incision will produce

results equal to that of the full incision in selected cases. In the schizophrenic and psychopathic sub-groups there is little significant difference in the results of the two types of operation, and we therefore propose to pool the combined results and consider the group as a whole, comparing it with other large group results, and mentioning the type of incision only where it seemed to have significance.

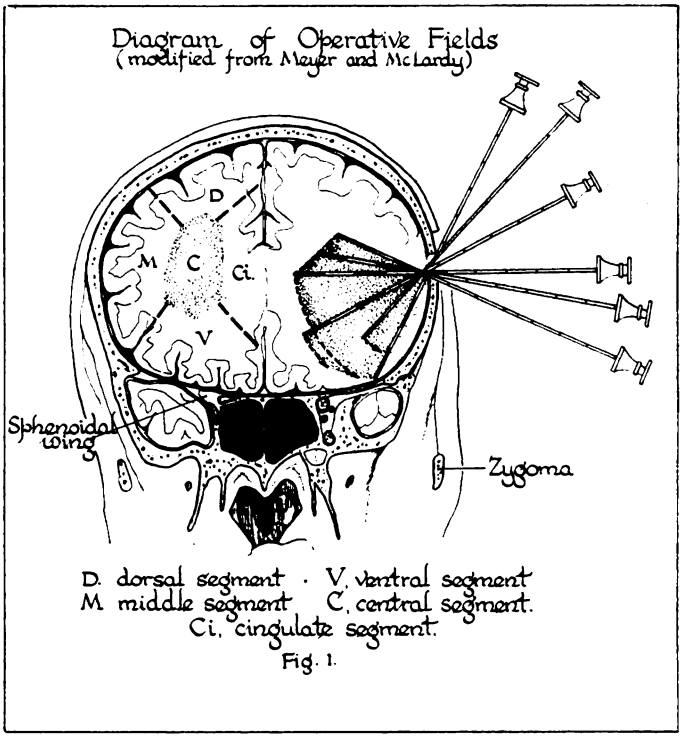

FIG. 1.—Diagram of operative fields (modified from Meyer and McLardy). D, dorsal segment. V, ventral segment. M, middle segment. C, central segment. Ci, cingulate segment.

TABLE III.—*Comparative Results in Diagnostic Groupings of Full and Lower Incision.*

	Total No. of cases.	Sex.		No. of operations.		No. of discharges.		No. of relapses.		Per cent. still discharged.	
		M.	F.	Full.	Lower.	Full.	Lower.	Full.	Lower.	Full.	Lower.
Affective	146	25	121	45	101	32	79	4	8	62	70
Schizophrenic	64	33	31	48	16	16	7	3	2	27	31
Paraphrenic	8	3	5	8	—	2	—	—	—	25	—
Psychopathic	26	11	15	17	9	3	2	—	1	17	11
Neurotic	6	2	4	3	3	3	3	—	—	100	100
Totals	250	74	176	121	129	56	91	7	11	40	62

In assessing the results of leucotomy Stengel (1950) utilized the useful concepts of " relative " and " absolute " as applied to degrees of recovery, and we have followed this method in drawing up Tables IV and V illustrating the results of operation in this series of cases. Relative results are related to the severity of the patient's pre-operative condition, graded as symptom-free, much or slightly

https://doi.org/10.1192/bjp.98.412.389 Published online by Cambridge University Press

improved. Such relative results are shown in Table IV, in which the cases are grouped according to diagnostic categories. The affective disorders constituted the largest group with 146 cases, and of these 30 per cent. were symptom-free and 42 per cent. were much improved. In the schizophrenic group of 64 cases, only 3 per cent. could be considered symptom-free and 17 per cent. much improved. Although only 2 per cent. of the affective disorders were not improved by operation, there were 40 per cent. of failures in the schizophrenic group, thus indicating the poor prognosis in this condition. The improvement-rate for the 250 cases was 81 per cent.

TABLE IV.—*Relative Results in 250 Leucotomies.*

Reaction types.	Total No. of cases.	Symptom-free.		Much improved.		Slight improvement.		Not improved.		Died (direct).	
		No.	%.	No.	%.	No.	%.	No.	%.	No.	%.
Affective	146	42	30	61	42	34	23	4	2	5	3
Schizophrenic	64	2	3	11	17	25	40	26	40	—	—
Paraphrenic	8	—	—	1	15	3	35	4	50	—	—
Psychopathic	26	—	—	7	27	12	46	5	19	2	8
Neurotic	6	—	—	3	50	1	17	2	33	—	—
Totals	250	44	18	83	33	75	30	41	16	7	3

TABLE V.—*Absolute Results: Patients Discharged.*

Reaction types.	Total operations.	Total discharges.		Grade I discharges.		Grade II discharges.		Died after discharge.	Relapsed; readmitted.		Still discharged.	
	No.	No.	%.	No.	%.	No.	%.	(No.)	No.	%.	No.	%.
Affective	146	111	76	83	56	28	19	3	12 (4)	10 (3)	100	68
Schizophrenic	64	23	36	6	10	17	27	—	5	21	18	28
Paraphrenic	8	2	25	1	12	1	12	—	—	—	2	25
Psychopathic	26	5	19	2	7	3	11	—	1	20	4	15
Neurotic	6	6	100	3	50	3	50	1	—	—	5	83
Totals	250	147	59	95	38	52	21	4	14	9	129	51

Figures in brackets represent relapses discharged again.

Absolute results, on the other hand, indicate the measure of the return of the patient's condition to what he was prior to the onset of illness, and to the standards of mental health as judged by the relatives on his return home. Such results are reflected in the discharge-rates as shown in Table V, the degree of recovery being indicated by Grades I and II. The former denotes a good remission of symptoms, a full adaptation to home environment with little or no disturbing personality defects. Under Grade II is placed those patients showing only a partial remission of symptoms, a moderate adaptation to home life, little or no occupation, and in some cases disturbing personality defects. The significant feature of Table V is the high Grade I discharge-rate of 56 per cent. in the affective disorders, and the disappointing results in schizophrenia with only 10 per cent. The Grade II patients are of variable stability, discharge depending more upon the tolerance and sympathy of the relatives, so that in this group there are always potential relapses and re-admissions. Most of the discharged schizophrenics belong to this category. Analysis of results in the other groups is shown in the tables, but their numbers are too small for valid comparisons, and will be briefly considered under their respective headings. We are inclined to the view that absolute results are the only ones worth considering, and what matters most is whether the patient can be restored to a useful life outside the hospital.

RESULTS ACCORDING TO DIAGNOSTIC GROUPS.

Affective Disorders.

It is well recognized that the best results from leucotomy are found in the affective reaction types, particularly in the involutional melancholias and agitated depressions. Thus a review of the literature by Crown (1951) revealed good results

in one-half to two-thirds of these cases. Our group as a whole comprised 146 cases of affective psychoses, analysed in Table VI, and divided into two groups, those with single, and those with recurrent melancholic attacks. The majority of these could be regarded as typical involutional cases. Separate consideration is given to manic and schizoid cases. It is noteworthy that although the depressed patients as a whole gave the high discharge rate of 75 per cent., this figure would have been 82 per cent. were it not for the relapse-rate of 13 per cent. in the recurrent group. It would thus seem that the tendency to recurrence may persist despite leucotomy. The Grade II discharges in the melancholics frequently showed mitigation and fragmentation of the depression, with resulting partial remission of symptoms described by Stengel (1950). The depressive mood in these cases is either broken up into short episodes or is reduced in intensity to a degree that is more bearable.

TABLE VI.—*Affective Disorders : Discharge-rate in Various Sub-groups.*

	Total No. of cases.	Average age.	Grade I discharges.		Grade II discharges.		Relapsed ; readmitted.		Maintained discharge.	
			No.	%	No.	%	No.	%	No.	%
Melancholia (1st attack)	52	57	28	54	11	21	—	—	39	75
Melancholia (recurrent)	68	54	45	66	14	20	8	13	51	75
Mania	15	43	4	27	1	7	2	40	3	20
Schizo-affective	11	35	6	54	2	18	2	25	6	54
Totals	146	52	83	56	28	19	12	10	99	61

Of the 15 manic patients, 5 were discharged, two of whom relapsed, giving a final discharge rate of 20 per cent. Inferior results in manic states have also been found by Stengel (1950), Partridge (1950) and by Greenblatt (1951), who suggested that the results in leucotomy in chronic manics is just as poor as those in hebephrenics. Nevertheless, of our 12 manic cases remaining in hospital, 7 were more or less improved. A full leucotomy was usually carried out on patients in a manic phase.

The small group of 11 schizo-affective cases was made up of patients with manic or depressive episodes showing a bizarre content suggestive of a schizophrenic admixture. Their disorder was predominently emotional, and their inclusion amongst the affective group seemed justified by a discharge-rate of 54 per cent. Partridge (1950) obtained 46 per cent. discharges in a group of 35 cases with a similar mixed psychosis.

An analysis of certain prognostic factors in the affective disorders is given in Table VII. The presence of delusions did not adversely affect the discharge-rate, and there was a higher percentage of good results in reactive depressions as compared with an endogenous group showing psychotic heredity. The duration of illness seemed to play but little part in the outcome, although the results were slightly better when the duration was less than two years.

TABLE VII.—*Prognostic Factors in Affective Disorders, mostly Depressive.*

	Total cases.	Grade I discharges.		Grade II discharges.		Total discharges.	
	No.	No.	%	No.	%	No.	%
Delusions	38	20 (1)	52	8 (2)	21	25	66
Heredity	45	21	46	14 (5)	31	30	66
Reactive	25	19 (1)	76	2	8	20	80
Hypertensive	20	11	55	5 (2)	25	14	70
Duration under 2 years (1st attack)	32	19	59	8	25	27	84
Duration over 2 years	20	9	45	3	15	12	60

Figures in brackets indicate relapses after discharge.

https://doi.org/10.1192/bjp.98.412.389 Published online by Cambridge University Press

It is of interest to find that good results from leucotomy were obtained in 11 out of 20 hypertensive cases with depression. A full incision was carried out in three patients, one of whom was discharged. The blood-pressures ranged from 185 to 230 systolic and 100 to 140 diastolic, and their ages varied from 47 to 74 with an average age of 59 years. There were no post-operative deaths, and only one case of epilepsy occurred in this series. We feel justified in concluding that hypertension should not contra-indicate leucotomy. The total discharge-rate was 70 per cent., not counting two cases who relapsed, but there was no evidence of any striking changes in the blood-pressure after recovery from the effects of operation.

Schizophrenia.

There were 64 schizophrenics in this series of cases, and only 6 patients, or 10 per cent., made social recoveries.

TABLE VIII.—*Schizophrenic Sub-groups.*

	Total cases.	Grade I discharges.		Grade II discharges.		Total discharged.	
		No.	%	No.	%	No.	%
Hebephrenic	14	—	—	6 (2)	43	4	28
Catatonic	40	5 (1)	12	8 (1)	20	11	27
Paranoid	10	1	10	(3)	30	3	30
Totals	64	6	10	17	27	18	28

Figures in brackets indicate relapses after discharge.

Table VIII further shows that there was little significant difference in the three sub-groups of hebephrenia, catatonia and paranoid states, the total discharge rate being 28 per cent. Such disappointing results from the standpoint of recovery is reported by all investigators.

TABLE IX.—*Results in States of Apathy after Full and Lower Incisions.*

	Total No. operations.		Total No. discharges.		Readmitted, relapsed.		Per cent. discharged.	
	Full.	Lower.	Full.	Lower.	Full.	Lower.	Full.	Lower.
Melancholic	10	26	9	18	2	—	70	69·2
Schizophrenic	32	13	9	6	1	1	25	38·4
Totals	42	39	18	24	3	1	35·7	59

In Table IX a comparison is made between the results of lower and full leucotomy in states of melancholic and schizophrenic apathy refractory to electro-convulsive therapy. A discharge rate of 70 per cent. was obtained by both types of operation in the melancholic group, but the schizophrenics appear to do better with the lower incision. It must be stressed that the figures in the latter group are perhaps too few to warrant reversal of the accepted teaching that once a schizophrenic has ceased to be excited the time for leucotomy has passed. We therefore agree with Garmany (1948) that tension may not be the only prognostic guide, since some tense depressives are not cured by leucotomy, while a few placid schizophrenics are.

Paraphrenia.

In 8 cases of chronic delusional psychosis with hallucinations and aggressive trends a full leucotomy was performed. Two cases were discharged, and of the 6 remaining in hospital 2 were improved. One of the discharged cases made a good social recovery, although the delusions remained in the background. The results as a whole are similar to those in paranoid schizophrenia.

https://doi.org/10.1192/bjp.98.412.389 Published online by Cambridge University Press

Aggressive Psychopaths.

In a group of 26 psychopaths of varied etiology but mostly epileptics, full leucotomy was carried out in 17 cases, and a lower incision in 9. The numbers are rather small for valid comparison, although the results favoured the full incisions. Improvement was obtained in 73 per cent., but only 5 patients could be discharged, and one of these relapsed. There was complete failure in 7 patients. McKay (1948) similarly reports improvement in two-thirds of his group of cases, with only an occasional discharge from hospital and full remission of aggressive trends.

Psychoneuroses.

Only six cases of this type were operated on, but three of these were much improved, including two obsessional and one anxiety case. The other three cases were hypochondriacs who showed little or no improvement.

Follow-up of Discharged Patients.

Out of the 129 patients still at home in April, 1951, all but 8 had been discharged for at least twelve months, and 40 for two years or more. During interviews with these patients at the clinics and their homes we were enabled with the help of relatives to form a judgment of their readjustments to life both at home and at work. It was found that 96 patients or 70 per cent. of the total discharges were working at their former occupations, adjusting at Grade I level, and this proportion was approximately the same in both the lower and the full section types of operation. No one was doing work of high calibre before they broke down, and the majority found no difficulty in resuming their occupation, especially as this was often looking after the house and family. In Table X an analysis is made of the work carried out by the 96 fully occupied patients. It will be seen that 64 females are performing household duties satisfactorily and 32 patients are in paid jobs. Fig. 2 shows the percentage of discharged patients with good or poor work adjustments in the different diagnostic categories.

Table X.—*Working Status of Grade I Discharges.*

Full time occupations.	Male.	Female.	Total.
Household duties	—	64	64
Labouring	9	—	9
Factory	2	5	7
Typists	—	3	3
Tool making	2	—	2
Clerks	—	2	2
Domestics	—	2	2
Salesman	1	—	1
Boiler fireman	1	—	1
Bakery	—	1	1
Gardening	1	—	1
Rope splicing	1	—	1
Nursing	—	1	1
Army (R.A.S.C.)	1	—	1
	—	—	—
Totals	18	78	96

Much has been written regarding personality changes following leucotomy, and it is uncertain how much is due to loss of control over pre-morbid traits, or to actual defects created by frontal lobe damage. We have found very few instances of disturbing personality defects in our patients discharged after lower quadrant incisions, and it is our impression that such disturbances are more likely to arise after full incisions, particularly if these are in a posterior plane. Partridge (1950), for example, found some frontal lobe defects in most of the discharged patients, as evidenced by a reduction of drive, activity and initiative, the patient being less critical of himself and others.

The difficulty of assessing the mental disabilities following leucotomy is well known, and there is often no decline of " test intelligence." Impairment of creative thinking or judgment in complex situations may have been present in our cases, but the level of adaptation required on discharge home was usually of such simple

character that difficulties seldom arose. This was certainly true of our elderly melancholic cases.

Out of the total of 147 discharges, 18 patients relapsed and were returned to hospital. Four of the relapsed melancholics soon returned home again after a short stay in hospital, and at the time of the final assessment 129 patients or 51 per cent. were still at home, 4 cases having died in the meantime. The relapse-rate was therefore 9 per cent., split up into 7 per cent. for the affective disorders

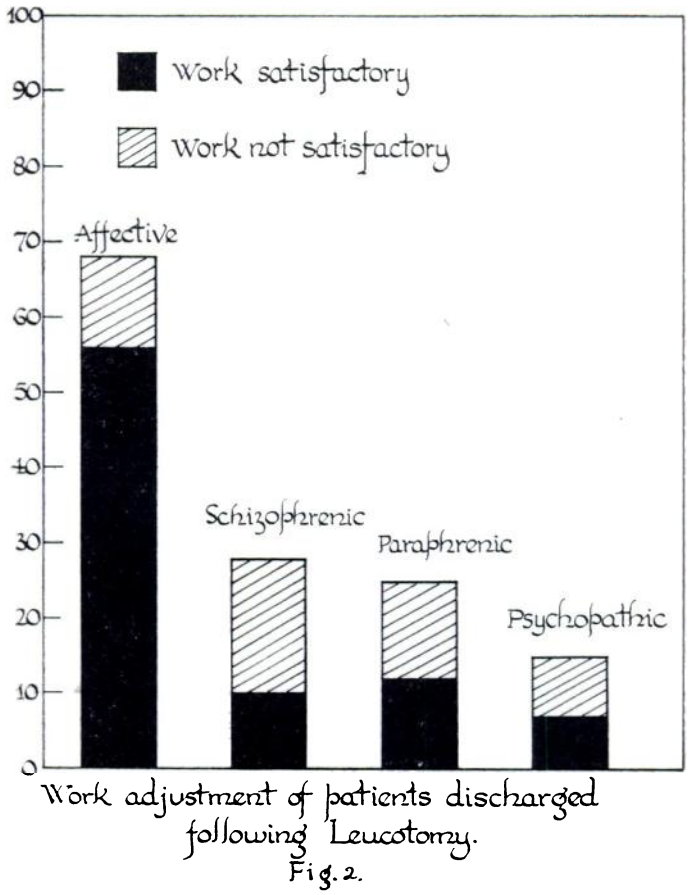

FIG. 2.—Work adjustment of patients discharged following leucotomy.

and 21 per cent. in the schizophrenics. Relapses were found to be particularly common (13 per cent.) in the recurrent melancholic group. One half of the 18 patients who relapsed after discharge did so in less than six months, but the others remained at home for longer periods, the maximum being $3\frac{1}{2}$ years.

POST-OPERATIVE COMPLICATIONS.

The total number of deaths in this series was 17, and of these, 7 could be considered as directly attributable to the operation, thus giving a direct mortality rate of 3 per cent., cerebral haemorrhage accounting for 4 of the 7 direct deaths.

Major fits occurred post-operatively in 14 cases or 6·6 per cent. of 210 non-epileptics. Although the numbers are small, analysis suggests that seizures are less frequent after lower incisions, the incidence being 5·1 per cent. against 8·6 per cent. after the full operations. No fits occurred in the small series of 16 schizophrenics submitted to a lower incision. In the affective disorders the incidence of

epilepsy was 5·9 per cent. after a lower incision, and 11·1 per cent. after full leucotomy. An analysis of the time of onset of the seizures further suggests that there is a greater tendency for the full leucotomy cases to develop " late seizures," i.e., longer than one month after operation, presumably as the result of scar-formation near the pre-motor area. Hofstatter *et al.* (1948) found no epilepsy in 85 patients after the low incision. Egan (1949) found two instances in 52 cases.

Urinary incontinence was rarely seen in our series of cases, and did not persist beyond the period of surgical convalescence except in a few deteriorated schizophrenics. A few elderly melancholic patients complained of urgency of micturition.

Discussion.

The main purpose of this paper is to review the results obtained by a modified prefrontal leucotomy using a coronal incision limited to the central and lower segments of the frontal lobes. Our cases consisted of a mixed group of psychotics, mainly elderly melancholics, and an opportunity was taken to compare the results with those found in a standard full leucotomy. The main conclusion derived was that even allowing for a natural bias in selecting the milder cases for the limited incision, the results on the whole showed little difference between the two types of operation, but demonstrated most certainly that the lower quadrant incision is adequate in the affective disorders of later life.

The lower quadrant operations reported by other investigators seem to have been devised to sever the lower or orbital segments only, but it seems likely that fibres in the central segments are also cut and, indeed, we suggest that it is better to do so. The development of the lower quadrant leucotomy seems to have arisen from observations on frontal lobe injuries, which suggested that a special significance should be attached to the orbital regions in relation to emotional states, and in the early days of leucotomy Freeman first experimented with the " core method," and found that cores placed in the lower parts of the frontal lobes produced a higher incidence of good results than those placed in the upper region. It was considered that injury to the orbital region tended to produce a syndrome of euphoria, over-activity and extraversion—a triad of symptoms which might counterbalance those found in many types of psychosis.

Hofstatter *et al.* (1945 and 1948) reported excellent results in 22 patients of paranoid and schizophrenic type, and also in a later group of 85 patients. They used a low coronal incision from a point 5 cm. above the zygoma, and this probably does not involve fibres of the central segment. Dax and Radley-Smith (1946), using variously placed minimal incisions, found the highest percentage of good results in a low vertical incision. Reitman (1948) further analysed these cases, and found the results to be better than any section of other areas of the frontal lobe.

Egan (1949) studied a group of 52 cases, mostly schizophrenics, in which a low vertical incision was performed, combined with a mid-zone horizontal cut designed to isolate the orbital lobes. The measurements used for point of entry are not given, but the results were considered to be inferior to the standard coronal incision, particularly in paranoid schizophrenia. Freeman and Watts (1950) advocate a lower quadrant coronal incision in the mild psychoses.

There is considerable clinical evidence, therefore, in favour of the low vertical incision for use as a minimal leucotomy procedure, although its precise evaluation cannot be determined without correlation of clinical with anatomical findings. Much valuable work in this direction has been carried out by Meyer and McLardy (1949) on the brains of patients dying some time after leucotomy. These authors have, in addition to stressing the great variability of lesions produced by leucotomy, attempted to correlate the clinical improvement with the site and extent of the lesions found at autopsy. For the purpose of comparison they divided the coronal surface of the frontal lobes into five segments (Fig. 1), including a central and ventral or orbital segment. Their analyses failed to support the contention of specific psychological changes following orbital involvement, and they also indicated that no given coronal segment was always involved when improvement occurred. More segments were involved in the improved than in the unimproved group, but improvement correlated best with incision of the central and, to a lesser degree, the orbital segments.

The importance of the central segment is evident, since it collects fibres from most areas of the prefrontal cortex, and would therefore suggest itself as a con-

venient site for a minimal incision. On the other hand, the anatomical investigations suggest that the " optimum incision " should include the orbital as well as the central segment, and in our series of cases such an incision did in fact prove to be just as effective as the standard full operation. It is recognized that apathy constitutes one of the undesirable sequelae of the more posteriorly placed incisions, and in the full coronal incisions there may be a tendency to position the upper part of the cut too far back. This may be desirable in the aggressive and excitable patients, as is suggested by Dax and Radley-Smith (1946), but when apathy already predominates, it would seem that the full incision is better avoided.

Apart from the above-mentioned points, the results in our two groups of cases, one with a full and the other with a low coronal incision, were essentially the same, and compared favourably with the general average results from leucotomy reported by other investigators. Indeed, there has been a surprising constancy in the excellent post-operative results following the diverse procedures executed on the frontal lobes on patients with tension states. In this series there is a high percentage of affective disorders and a few schizophrenics. Most of these cases have undergone a smaller and more anteriorly placed incision than is customarily advocated, and our results would seem to demonstrate that in cases of depression, a lower two-thirds incision will, in the majority of cases, effect a satisfactory result without producing any personality defect. This was brought home to us by the attitude of relatives and people with whom the discharged patients live. When these people were questioned closely it was difficult to obtain any admission or indication that the patients fell short in adjusting themselves to their environment or life situation, in fact, in many cases the relatives insisted that the patient had now become much easier to live with than ever before. During the outside follow-up we could not help but be impressed by the gratitude of all concerned.

When this follow-up was started one of the authors had considered abandoning this closed procedure, but the universal good results of these discharged patients made it quite obvious that the operation was justifiable, for it should be borne in mind that many of these patients had already had two or three courses of shock therapy before leucotomy was considered. With this experience we have not hesitated to resort to leucotomy somewhat earlier, a procedure which can only be justified if one is certain to avoid any personality damage.

The percentage recovery and discharge figures worked out in these cases came somewhat as a surprise, and it would seem that good results can be effected in this type of material, provided that sufficient thalamo-cortical fibres are destroyed, without interfering with any particular aspect of the patient's personality. Such a destructive operation can only produce a favourable result in patients who have been well integrated and who have not broken down until comparatively late in life. The aged agitated melancholic will react better than any other after operation, provided his cerebral blood-vessels are not too arteriosclerotic. The reactive depression occurring as a sequel to life's stresses and strains does better than cyclothymic states, but a schizophrenic patient who has never reached an adult integration of the personality cannot be expected to gain much benefit by a destructive operation.

Summary.

The use of minimal incisions in the technique of prefrontal leucotomy is discussed, with particular reference to the lower quadrant incision and its correlations with clinical and anatomical studies.

It is suggested that the lower quadrant coronal leucotomy is an effective minimal operation provided that the central as well as the orbital segments of white matter are cut, and that it is particularly suitable for states of chronic melancholia.

These conclusions have been drawn from a clinical assessment of 250 consecutive leucotomies performed by the same surgeon on a mixed group of psychotics suffering in two-thirds of the cases from states of melancholia. A comparison was made of the results from a complete as opposed to a lower two-thirds coronal incision, all cases being followed up for a period of one to eight years. At the time of final assessment 70 per cent. of 129 patients still at home had made good social recoveries.

There was little difference between the over-all results of the two types of operation, the combined group of 250 cases showing 81 per cent. improved, and a final discharge rate of 51 per cent., including 68 per cent. for affective disorders

and 28 per cent. for schizophrenics. Excluded from these figures is 9 per cent. of discharges relapsed and readmitted to hospital. In the melancholic group the relapses were confined to cases with a history of recurrent attacks.

The operative mortality rate was 3 per cent., and there was a 6·6 per cent. incidence of post-operative epilepsy.

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