Stereotactic surgery for the relief of suicidal and severe depression and intractable psychoneurosis

**The 21st Alex Simpson-Smith Memorial Lecture delivered at
The West London Hospital, 4 July 1968**

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AS AN ADJUNCT to the psychiatric treatment of suicidal and recurrent depression the operation of bifrontal stereotactic tractotomy now offers relief to a high percentage of cases who have failed to respond to conservative measures including drugs and electro-convulsive therapy given over a period of years, and produces this effect without attendant risk of epilepsy, mortality or harmful personality change.

The surgical treatment of mental illness may be regarded as the surgery of the emotions. Since primitive emotions are damaging emotions in psychiatry it might well be concluded that the isolation of primitive cortical areas would be significant in contributing to the results achieved.

Monitz (1936) had shown that the injection of alcohol into the frontal lobes of seriously disturbed schizophrenic patients could produce occasional improvement, the improvement being in the emotional sphere, resulting from a diminution in the intensity of emotional reaction to delusions or hallucinations, and since emotion is dominant over intellect, an improvement in intellectual capacity from diminished emotional distraction. Had this initial observation been followed by adequate physiological and anatomical studies to establish the basic mechanism underlying this emotional change before attempts were made to elaborate surgical treatment, the progress of surgery in this field might have followed a smoother course, but, unfortunately, despite the fact that the anatomical pathways which constituted the objective of surgical treatment had not yet been fully established, the operation of pre-frontal leucotomy was devised which transected the central area of the white matter in both frontal lobes, sacrificing areas of considerable importance in intellectual function in order to divide the unknown pathways subserving

emotion contained within them. Numerous inaccuracies complicated this blind procedure; in some, apparent movement of a blunt instrument in the brain merely distorted tissue without cutting so that certain patients had little or no operation performed. In others, serious blemish to intellect and personality resulted. A high incidence of epilepsy, the occasional occurrence of organic physical damage, such as hemiplegia, together with a diminution in capacity for the enjoyment of either work or leisure (Ström-Olsen & Tow, 1949) which resulted from division of all fibres concerned in emotional appreciation, left an impression which was not readily forgotten. Not only has leucotomy been generally abandoned, but in many clinics even more modern methods are regarded with mistrust as being too dangerous to employ.

In 1948, at the foundation of the Health Service, the period of over-enthusiastic employment of leucotomy performed in mental hospitals was ending. Many psychiatrists were abandoning all forms of surgical treatment. In other regions neurosurgical units continued to employ more accurate operations on limited cortical areas performed by a variety of techniques according to the individual preference of the operator, which produced results superior to leucotomy, but throughout the 20-year period there has been a progressive decline in most areas in the number of patients operated upon.

The early success of drug treatment led some to believe that within a few years all other methods would become obsolescent and surgery would no longer be required. Drug therapy has been successful, yet numerous patients remain incapacitated with chronic and intractable illness despite the use of all conservative measures. Depression, which constitutes nearly 50% of psychiatric practice,

contributes a large quota to these intractable cases, recurrent depression being a particularly difficult problem for the psychiatrist, carrying as it does a considerable suicidal risk. Herbert & Jacobson's (1966) review shows that not only has the number of geriatric admissions to mental hospitals more than doubled over a 10-year period, but of the patients so admitted 52% were suffering from depression. Depression is therefore the principle cause of mental hospital admissions in the elderly. When drugs and electro-convulsive therapy fail in the management of such cases, attention must turn once again to the prospects presented by surgery.

Stereotactic surgery now provides a means of producing accurate lesions of small size at selected points in the nervous system where concentrations of nerve cells or fibre pathways possessing a specific function permit some small area of anatomical destruction to produce widespread physiological effects. The accuracy of approach, with minimal disturbance of tissue, ensures that beneficial effects of stereotactic operation are produced in isolation without associated dysfunction of the nervous system. I have shown that this principle can now be applied in relation to the control of emotion (Knight, 1969). Owing to the influence of emotion in depression and psychoneurotic states it is possible to influence many syndromes satisfactorily by operation at a site where connections of primitive cortical areas concerned with instinctive and emotional activity converge beneath the corpus striatum. Stereotactic tractotomy differs from leucotomy in every possible respect in accuracy, location and clinical effect. Operation under X-ray control ensures complete accuracy and eliminates the errors resulting from deviation of blind incisions. Anatomical lesions are formed in an area which cannot be reached by leucotomy. Clinically no harmful effects have been observed.

I was led to this development in 1959 (Knight, 1960) as the results of observations in a large series of patients treated by the operation of restricted orbital undercutting which I devised in 1950 (Knight & Tredgold, 1955). This operation produced excellent results in depressions and in the period from 1950 onwards when the general usage of leucotomy was declining, 620 patients were treated by this method in my Unit. It was originally designed to interrupt fibres ascending to the posterior orbital cortex, for experimental evidence has shown that ablation of this area in higher animals would produce tranquillity and loss of fear (Livingston *et al.*, 1948 b). It was, however, eventually to lead me into other channels of thought. It consisted of the formation of an incision 2 cm wide in each frontal lobe extending backwards from the frontal pole for 6 cm at the height of 1 cm above the orbital cortex

FIG. 1. (a) Orbital aspect of the left frontal lobe showing Area 13 (hatched) and Area 14 (stippled). (b) Orbital aspect of the right frontal lobe showing site of incision employed, 1.8 cm wide situated 1 cm from middle line and extending to 6 cm from the frontal pole. The last 2 cm corresponds to Area 13 (see a).

(see Fig. 2). The posterior 2 cm of the incision overlay Area 13 and also part of Area 14, which lies internal to this area (see Fig. 1). Observations indicated that the maximum effect was produced from the terminal 2 cm of this narrow incision.

In ten cases of depression where a 5-cm lesion had been employed without benefit, I re-operated, extending the lesion for 6 cm and obtained improvement. The formation of the posterior part of the incision behind the plane of leucotomy scars encountered up to 4 cm from the frontal pole produced numerous successes, even in patients who had had two or three previous failed leucotomies. It seemed that there must be a concentration of fibres in relation to the terminal 2 cm of the incision where it entered the substantia innominata (see Fig. 2), the unnamed space beneath the head of the caudate nucleus, division of which might possibly produce an adequate relief of symptoms without the necessity of disturbing other areas of the brain, and one wondered whether this might prove to be the target

FIG. 2. Sagittal section of left frontal lobe showing the situation of the 6-cm incision and (A-A) the last 2 cm in the substantia innominata overlying cortical Area 13. The thalamo-frontal radiation passes between the caudate nucleus (5) and putamen (6). The posterior vertical leucotomy incision is seen to cross the corpus striatum before entering the posterior orbital region. (Reproduced by kind permission of Professor Stelmasiak and the Polish State Medical Publishers from: *The Anatomical Atlas of the Human Brain and Spinal Cord*.)

for a stereotactic operation. Yet, little was known of the function of this area in relation to emotional activity. It was certainly far removed from pathways concerned with emotional tone and emotional appreciation.

Papez (1937) had regarded the hippocampus, hypothalamus and cingulate gyri as a probable anatomical substratum of the emotions. Close integration between these areas was provided by the anatomical circuit via the hippocampus, fornix, mamillary body and mamillo-thalamic tract to the anterior nucleus of the thalamus from which projections pass through the dorsal part of the internal capsule to the anterior cingulate region of Area 24 and the posterior cingulate region of Area 23 (see Fig. 3). It was thought that return pathways from Areas 24 and 23 passed posteriorly to the cingulum and retro-splenial regions, and thence to the hippocampus, and if this were so this circuit which maintains a constant cycle of functional relationship between primitive cortical areas would not be interrupted by operation in the region of the substantia. Le Gros Clark (1948) had shown that pathways from the hypothalamus which are

FIG. 3. Diagram showing the circuit-fornix (F), mamillary body (M) and the mamillo-thalamic tract (MT). The anterior nucleus of the thalamus (A) connects to the anterior cingulate region 24 and posterior cingulate region 23. Arrows indicate the return pathways from the posterior cingulate region to the retro-splenial area. The thalamo-frontal pathway from the dorso-medial nucleus of thalamus (M2) to cortex of frontal lobe passes above the level of the substantia innominata (Sub.). Connections from anterior cingulate region Area 24 to substantia and from amygdaloid nucleus (Amy.) to this area are also indicated.

important in emotional appreciation are relayed from the dorso-medial nucleus of the thalamus to the neocortical agranular areas of the frontal lobe through the thalamo-frontal radiation which passes through the anterior limb of the internal capsule well above the level of the substantia innominata (see Fig. 3). I eventually found that the functional significance of the substantia lay in the fact that connections from primitive areas of cortex which are concerned in emotional reaction, some of which were assumed to pass by other routes, in fact passed beneath the caudate nucleus and traversed the substantia in order to gain access to the third ventricular region where emotional responses are produced. The older portions of the neopallium are located in the transitional cortex of the anterior cingulate and posterior orbital gyri and in the medial and inferior parts of the temporal lobe. Stimulation and ablation experiments had shown the fundamental importance of these areas in relation to autonomic activity and emotional reaction.

Smith (1945) and Livingston *et al.* (1948a) had obtained respiratory and vascular responses from a continuous zone of cortex extending from the anterior cingulate gyrus to the posterior orbital surface. In monkeys, stimulation of the anterior cingulate region of Area 24 produced autonomic responses such as are seen in association with emotion, including dilatation of the pupils, erection of the hair, change of blood pressure, pulse and respiration, and even vocalization. Stimulation of the posterior orbital cortex also produced autonomic responses. Bailey & Sweet (1940) and Delgado & Livingston (1948) observed changes in respiration, blood pressure and gastric motility, and similar effects had been obtained in the human by pre-leucotomy stimulation by Livingston *et al.* (1948a). It was perhaps significant that these changes can be the accompaniment of intense emotion. Ablation experiments confirmed the influence of primitive agranular areas on emotional reaction. Excision of the anterior cingulate gyrus in monkeys produced alteration in the emotional reaction to environment, with loss of fear of humans, diminished aggression, increased tameness and lack of appreciation of danger (Ward, 1948). Whitty (1955) remarked that these behavioural changes seemed to be linked with the anterior portion of the cingulate gyrus because when similar extirpations were performed in the posterior cingulate gyrus they were not observed. He also drew attention to the similarity between certain of the behavioural changes and those produced by Bucy's (1941) temporal lobectomy preparations suggesting that as far as function is concerned anterior cingulate and anterior temporal regions may be two parts of one mechanism. Excision of the orbital gyri in higher animals also

produced quiescence and increased tameness (Livingston *et al.*, 1948a). Evidence, therefore, indicated that those areas of the forebrain subserving autonomic function also formed the background of emotional reaction and affective behaviour. These observations suggested that a maximum influence would be exerted in psychoneurotic patients by an operation which interrupted the connections from these areas, but although individual areas could be isolated by operations such as cingulectomy (Lewin, 1961) or undercutting, the wide distribution of the agranular cortex on the medial aspect of the hemisphere in the cingulate region, on the under-aspect of the frontal lobe in the primitive cortex of Walker's (1940) Area 13 and 14, and in the temporal lobe in the amygdaloid nucleus had made it impossible to secure a combined effect by surface lesions. Fibres from each of these areas may, however, be divided within the substantia at a point of concentration beneath the caudate nucleus and putamen.

Glees *et al.* (1950) had shown, contrary to previous belief, that fibres from the anterior cingulate cortex of Area 24, that part from which autonomic responses can be obtained, instead of passing backwards to the retro-splenial regions could be traced into the posterior part of the orbital cortex, passing through the septal cortex into the posterior portion of Area 14 which lies beneath the substantia, and since stimulation of these fibres will produce autonomic responses they must possess further hypothalamic connections passing through the substantia which may be divided in this zone.

Le Gros Clark & Myer (1951) had demonstrated projections from the posterior orbital cortex to the ventro-medial hypothalamic nuclei bilaterally and these also pass beneath the putamen and caudate nucleus and traverse the substantia before they gain access to the third ventricular region. A projection from the amygdaloid nucleus and pyriform lobe (Nauta, 1961) sweeps up and passes into the posterior portion of the substantia before turning back and running caudally towards the hypothalamus to reach the dorso-medial nucleus of the thalamus whence it is distributed to the frontal cortex. An important return pathway from the hypothalamus to the amygdala has also been confirmed (Powell, Cowan & Raisman, 1963). Lesions within the substantia therefore interrupt fibres from the anterior cingulate region and will undercut and isolate the posterior orbital cortex of Area 13 and parts of Area 14, and will divide a projection to-and-from the amygdaloid nucleus, and a localized lesion at this point would be expected to exert an influence on the emotional activities subserved by these areas. A lesion at this site will selectively divide fibres concerned in emotional reaction whilst leaving the hippocampus-fornix system and most

FIG. 4. Sagittal section of left frontal lobe. Arrows indicate the course taken by fibres from the anterior cingulate region to Area 14 in the orbital cortex. Fibres from Area 13 pass inwards beneath the corpus striatum. A projection from the amygdaloid nucleus enters the posterior lateral portion of the substantia on a more superficial plane (as indicated by the broken line) and traverses the posterior portion of the zone to reach the hypothalamus. (Reproduced by kind permission of Professor Stelmasiak and the Polish State Medical Publishers from: *The Anatomical Atlas of the Human Brain and Spinal Cord*.)

of the thalamo-frontal pathways undisturbed for the preservation of normal emotional tone and emotional appreciation.

By 1960, therefore, it seemed appropriate to utilize this region for a stereotactic operation (Knight, 1964). Although restricted undercutting was being employed with benefit it had its risks. There was an epileptic risk of 10%, of whom half had recurrent post-traumatic epilepsy. There was a 5% risk of personality blemish and a mortality of less than 1%, particularly in hypertensive subjects (Sykes & Tredgold, 1964). To avoid these defects resulting from cutting in the brain it was decided to form equivalent bilateral lesions by the insertion of radioactive seeds under X-ray control into areas corresponding to the last 2 cm of the undercutting incisions. The technique of this operation was developed in association with the Department of Radiology and Department of Physics at the Royal Postgraduate Medical School. It was necessary to produce a lesion having length and breadth, but little depth, in order to avoid damage to the striatum. I had shown (Knight, 1943) that posterior leucotomy incisions which entered the posterior orbital areas produce harmful autonomic disturbances, which Meyer & McLardy (1948) concluded were related to

bilateral damage in the region of the striatum (see Fig. 2). To produce a lesion which would not affect the striatum I was advised to use seeds of radioactive yttrium (^{90}Y) which would only yield a necrotic dose of β -emanation up to 2 mm from the seeds' surface. Since the radioactive life of yttrium is 96 hr the necrotizing effect is produced in the early stages after operation and the seeds subsequently become inert.

Wire markers inserted into the incision at undercutting operation revealed the relationship of the target area to skull markings: posteriorly it lay 1 cm above the base of the anterior clinoid process and in the anterior-posterior view it was in relation to the inner third of the sphenoid ridge extending to within 1 cm of the middle line. Using these points as a guide four rows of yttrium seeds were implanted within the target area. The skull markings indicated the site of the posterior and inner angle of the plane to be irradiated and correspond to the posterior tip of the posterior and innermost seed. With the stereotactic device *in situ* this point was marked on the X-rays and the aiming tube of the stereotactic apparatus was corrected first in the lateral plane and then in the transverse plane until it was directed accurately at this point. The implanting needle was

FIG. 5. The second stage of the stereotactic operation. A group of six seeds has been implanted on the left; the stereotactic device has been inserted on the right; the distance between the two knobs on the aiming needle corresponds to the distance from the lowest knob to the centre of rotation of the instrument. The target point has been marked on the X-ray and a line projected from this point through the centre of rotation to cross the perforated scale indicates the correct aiming point for the target in this plane.

then inserted, the depth of implantation being controlled by the millimetre screw adjustment to allow for the length of the extruded seed. The first seed was inserted so that its posterior end reached to the target point, the needle was withdrawn 1 cm to allow for the implantation of an anterior seed, and then by a series of adjustments the lateral rows were inserted and the process was then repeated on the opposite side.

The technique of this procedure has been fully described elsewhere (Knight, 1965). Further experience has indicated that it is possible to narrow the area of destruction by omitting the lateral row of seeds. We now employ a three-line implantation. I have matched the radioactive dosage against the results in 250 cases. The best results were obtained with a dosage between 37,500 and 50,000 rads on the day of implantation. A three-line implantation produces a necrotic area 2 cm in length, 1 cm in width and $\frac{1}{2}$ cm from above downwards containing yttrium seeds embedded in greyish connective tissue. The edge of the cyst consists of softened tissue to a depth of from 1.0 to 3 mm. Elsewhere there was no macroscopic abnormality other than the puncture

marks produced by the implanting needle. This operation has fulfilled its primary objective of preserving the benefits obtained by orbital undercutting but eliminating mortality and harmful post-operative effects.

Two hundred and seventy cases have been operated upon without mortality. Anti-convulsive therapy has not been employed in the post-operative treatment and recurrent fits have not been observed. One patient aged 79 had a single fit 8 months after operation which was not repeated. A woman aged 65 with cerebral atrophy exhibited right-sided Jacksonian epilepsy 2½ years after operation. This has been fully investigated and no electroencephalographic abnormality has been detected in the region of the operative scar, and it seems improbable that this disturbance in the motor cortex, which could well result from natural causes, could be causally related to an operation in the frontal pole. Harmful changes in personality do not occur. There may be a temporary phase in which personality defects develop for a while, but these settle down well with rehabilitation. Many patients complain of a temporary feeling of fatigue which may last for weeks

FIG. 6. (a) Pre-operative photograph of patient after 10 years of chronic depression with ten suicidal attempts. (b) Post-operative photographs 10 days after operation. (c) Two years later, having in the meantime undergone deep X-ray therapy for carcinoma of breast.

and sometimes for several months and which has to be overcome during rehabilitation. In elderly patients there is sometimes a complaint that memory is a little less reliable than it was, but the overall impression is that any defect which exists is very slight and does not constitute a handicap or blemish to the patient. There is certainly a total absence of the so-called leucotomy syndrome. In general the post-operative personality is bright (see Fig. 6b) particularly in depressive syndromes with the release of normal emotion previously suppressed; manic reactions and hyperactivity have not been observed. Patients retain or regain their capacity for enjoyment of work and leisure, and those improved by operation resume a normal occupation appropriate to their age and physical condition.

Symptoms may be relieved immediately after operation or a slow, gradual improvement may continue progressively over a period of months. The operation must always be supported by psychiatric rehabilitation to overcome phases of over-relaxation or temporary personality change, to re-establish the patient's confidence to accept responsibility, and to integrate him again into an active environment. It is useless to expect to obtain uniform results by operation alone. In general we have found that during the phase of rehabilitation it is advisable to limit drug therapy to a minimum. Certain patients who have undergone prolonged treatment develop addiction to the drugs which they have been receiving and it has been found that operation not only relieves the patients' symptoms but also their dependency on drugs. Partial relapse to a lower grade may occur as a temporary setback during rehabilitation, to be followed by stabilization

at a satisfactory level. Permanent relapse has occurred chiefly in patients of poor personality. In a few cases relapse has been due to defective psychiatric support and the absence of any attempt at adequate rehabilitation. In those who do well operation reduces the intensity of emotional reaction to a degree which is either adequate to relieve symptoms entirely, or to render patients accessible to psychiatric treatment which was ineffectual before. They are still capable of feeling normal fear, grief and tension, but no longer react excessively so that the stresses do not excite excessive reaction.

A housewife, aged 37, following the death of her father, had for 10 years exhibited depression involving ten suicidal attempts, of which seven occurred in the last 5 years—the last had resulted in a temporary paralysis of her left arm from cerebral anoxia. She stated quite definitely that she intended to kill herself, and that she would do so because she was convinced that she could obtain no help from existing methods of treatment. Following operation she made a satisfactory recovery and became once again a happy married woman, deeply interested in the running of her house and her family, and warm and normal in emotion. A particularly gratifying feature was her emotional reaction to her young son who had been growing up during the 10 years of illness. During that time she had had no feeling towards him, but after operation she developed a normal maternal love. Two years after operation she discovered that she had developed cancer of the breast. She held an objective discussion with the surgeon as to whether she should have an amputation or deep X-ray therapy, choosing deep X-ray therapy in order to avoid mutilation as she had already been

TABLE 1. Post-operative statistics of the first 100 cases showing results recorded following repeated interviews in January 1966

Diagnosis	Total	Free from medical care				
		Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Chronic depression	48	26 A, 20 B, 4 C, 2	9 A, 6 B, 1 C, 2	11 A, 10 B, 1	2 A, 1 B, 1	
Chronic anxiety state	21	6 A, 3 B, 1 C, 2	4 A, 1 B, 1 C, 2	9 A, 5 B, 3 C, 1	2 A, 1 B, 1	
Obsessional compulsive states	13	6 A, 3 B, 1 C, 2	3 A, 2 B, - C, 1	2 A, 2	2 A, 1 B, 1	
Hypochondriasis	5	1 A	2 B, 2	1 A	1 A	
Schizophrenia	3	1 A		2 A, 2		
Hysteria	3			1 B		
Chronic pain	4			1 C	3 B, 1 C, 2	
Reactive depression to physical disability. Heart failure and gastric cripple	3				3 A, 1 B, 2	
Total	100	40	18	27	15	

The shortest follow-up case (case 100) is 6 months; the longest (case 3) 4 years from December 1961. Certain elderly patients had died from natural causes during the period of review. The post-operative category is expressed in five groups: Grade 1: No symptoms, no treatment required; Grade 2: slight symptoms but no treatment required; Grade 3: improved, with persistent symptoms requiring treatment; Grade 4: unchanged; Grade 5: deteriorated. Pre-operative disablement is indicated in each group. (A) Totally disabled, in mental hospital; (B) socially disabled, outside mental hospital unable to work; (C) psychiatrically disabled, working part or full time, requiring constant psychiatric help with drugs or ECT

FIG. 7. Diagram of the influence of operation in recurrent endogenous depression, on recurrent mental hospital admissions showing the number of admissions in the 5-year period before and after operation. The duration of earlier treatment ante-dating the 5-year pre-operative period is recorded on the left, together with the number of in-patient admissions during that period. S, Denotes suicidal risk recorded; /, indicates limit of follow-up; D, denotes death.

sterilized as part of her psychiatric treatment. She has satisfactorily withstood the impact of this serious stress, exhibiting no more than the normal anxiety of any woman, and has obtained an excellent clinical result in so far as this second illness is concerned.

A retrospective study of results in 250 cases is being conducted as a Mental Health Research Fund Survey by Dr Rolf Ström-Olsen, and expert psychiatric assessment will thus become available. We have from time to time published statistics based upon the follow-up studies of patients by personal interview and the reports from referring psychiatrists which indicate the potentiality of this method. All the patients treated had previously received full psychiatric treatment for a period of years without benefit.

Endogenous depression is particularly favourably influenced in some 70% of cases. The recurrence rate in recurrent depression which is generally attributed to the normal course of the disease is strikingly modified by operation so that recurrent admissions to mental hospitals which characterized the pre-operative course were no longer observed (see Fig. 7).

Good results were obtained in approximately 50% of cases of obsessional illness and in 50% of anxiety states. Patients with mixed syndromes combining anxiety, depression and hysterical features, although improved by operation, seldom become free from treatment. Occasional success could be obtained in the treatment of hypochondriacs provided that there was a sufficient intensity of suffering. Operation has little to offer in the treatment of hysteria, and is useless in the treatment of chronic pain or reactive depression to physical disability. The results are influenced by many factors—the basic personality of the individual, the environment to which he must return, the degree of support and opportunity for work, or emotional experience. A woman aged 50 with a happy home and family to return to might be expected to do better than an elderly patient with no home and no relatives who must return to a mental hospital environment. Certain patients in this category may remain a little sad from natural causes. In these circumstances it is remarkable that so many elderly patients do so well.

This atraumatic operation can be performed in patients of advanced years and poor physical condition, including hypertensive subjects. Numerous successes have been obtained in the oldest age group (Knight, 1966). In the first fifty cases six patients above the age of 74, the oldest being 86 and 83 years, respectively, suffering from depression and recurrent depression, became completely free from symptoms—relief can therefore be extended to geriatric patients, many of whom suffer severely in

FIG. 8. Diagram of the results in the first fifty cases showing the age of the patient, degree of improvement in psychiatric symptoms, duration of illness (in years) and psychiatric state. RD, Recurrent depression; D, chronic depression; HYP., hypochondriasis; OBS., obsessional; ANX., anxiety state; HYS., hysteria.

FIG. 9. (a) A bed-ridden patient aged 79 with a 16-year history of melancholia with twelve mental hospital admissions and three suicidal attempts. Prior to operation she was mouthing, muttering and restless. She chewed her lips into a mass of granulation and was suffering from hyperstatic changes. (b) Three months after operation; living at home. (c) Six months after operation; visiting friends.

the depressive illness of old age, a point of obvious economic significance in view of the increasing number of such patients admitted to mental hospital beds.

Further work is in progress in relation to the relief of drug addiction. A reduction in the drug requirement of patients on high doses of barbiturates and tranquillizers is an immediate feature following operation in cases of psychoneurosis, and this may be employed as a therapeutic measure in the treatment of drug addiction.

Experience in the undercutting series had shown that operation could be employed with success in barbiturate addiction and also in chronic alcoholism where the patients were drinking to escape from a tension situation (Knight, 1964), or when addiction was the product of depression. We have employed the stereotactic operation in a patient suffering from a chronic anxiety state who combined barbiturate addiction with a high alcoholic intake, and have recently used it in a heroin addict. In Dr Ström-Olsen's experience in one case of heroin addiction, withdrawal of the drug was successfully accomplished after orbital undercutting, whereas withdrawal had been impossible before operation owing to the intensity of the withdrawal symptoms, which were modified by operation.

Stereotactic operation has been employed in a patient aged 26, a heroin addict suffering from deep depression who from the age of 19 had used 'half a T' of marijuana daily. He had married at 21 and became seriously depressed after the break-up of his marriage $3\frac{1}{2}$ years prior to operation. Three years before operation he started taking heroin,

grains $\frac{1}{4}$ th. At first this dose made him violently sick 'but I persevered and in 18 months I had got up to 8 grains a day'. He then went to a doctor to get registered and was put on intravenous methadone, but he would still buy heroin if he wanted to do any work or meet his friends, taking in addition heavy doses of Tofranil and Medinal which he had received regularly throughout the period of 4 years on account of his severe depression and insomnia. He then decided to try and give drugs up. In-patient treatment in a mental hospital with the administration of Mandrax failed entirely and he took to heroin again for a period of months. Under treatment by Dr Dale Beckett he was maintained on 60 mg of methadone twice daily. Without this he would develop shaking, cramps and tension. He lay in a darkened room all day as the light hurt his eyes. He was practically unable to sleep even with the methadone and heavy doses of chloral and Medinal at night. After operation he has had no methadone except on the 1st post-operative day. He has given up codein for his headaches because he thinks it contains opium, and only takes Hypon for headaches, and Medinal at night. 'I don't need drugs, thanks'—'Why?'—'Because I don't want to commit suicide any more—I have had a couple of goes at that with sleepers'. Time will tell whether this effect is lasting.

The main value of the operation is in the treatment of depression in all its varied forms. In depressive stupor very marked relief may be obtained. An elderly lady aged 75 confined to a mental hospital presented a pitiful picture—she remained mute and inactive, gazing sadly before her, occasionally casting

her eyes upwards in supplication. She never spoke except occasionally begging her Maker to take her, but, if questioned as to how she felt, she would say that her head was empty, all empty, that everyone looked as if they were dead, and all around her was a black mist. Within 3 weeks of operation she was talking and engaging in making a multi-coloured rug, although denying that she was in any way improved. Six weeks later she was living with her daughter in the country, looking after her grandchildren, doing the dusting and a little cooking, and had developed once again a bright and happy disposition, realizing the great change which had taken place in her.

Melancholia

A melancholic male aged 46, with five mental hospital admissions in 4 years, full of self-reproach, guilt and unworthiness, was actively suicidal and attempted to starve himself. In a state of complete psychomotor retardation, he would not speak, eat or drink, and lay in bed with his head covered with the bed clothes. Following operation in 1963, within 4 months he was taking an adequate interest and was optimistic about his future. He has since returned to regular employment in the Gear Box Assembly Section of a large car factory.

Recurrent depression

A man aged 79 suffering recurrent depressions recurring over 24 years, with four suicidal attempts in 2 years and six mental hospital admissions, on his last admission having attempted suicide with an overdose of tablets on the previous day, tried to hang himself behind a door with a bandage on the day following admission. After operation in 1962 he is reported to have a normal mood, to have retained his interest in sport, to be very sociable, to require no medication, and to be eating and sleeping well.

A female aged 81 suffered recurrent depressions necessitating mental hospital admission on fifteen occasions, the intervals between the attacks progressively decreasing, the last three occurring within 9 months. Between the attacks she was described as a wonderful old lady, full of enthusiasm for life. Her attacks would come on suddenly, increasing within a week to a retarded suicidal near-stuporous state. Increasing ECT was required to bring her round. Her psychiatrist wrote that she would die without treatment, but the stage had been reached when she was hardly fit to stand it. Operation in 1963 produced complete relief.

Agitated depression

A Methodist Preacher, aged 68, suffered severe agitated depression. His nights were spent sitting up

in bed calling on his Maker to take him, frequently repeating the hymn 'Where is the peace that once I knew?'. By day he entertained strong pyrogenic feelings towards the Church of Rome. Following operation in 1962 he reports in 1966 that he is 'continuing to enjoy good health in every way, continuing my preaching and service work and enjoying it. I may say that whilst I still recoil from sacerdotal elements in religion, I can regard those who practice them with tolerance and respect, the old fierce impatience is a thing of the past'.

Juvenile depression with masochistic tendencies

A seriously disturbed girl, aged 23, addicted to head bashing and self mutilation since the age of 10 who had previously failed to respond satisfactorily to cortical undercutting improved remarkably following stereotactic operation and has taken a post as Teacher in an Art School. In this case it is possible that the more accurate operation had a greater effect on fibres from the temporal lobe and amygdala which are significant in relation to the disturbed behaviour in temporal lobe epilepsy.

Many of the patients at present referred for treatment are sent as a last resort, but certain psychiatrists who have seen sufficient of the results now feel that referral should take place at an earlier stage when conservative measures have failed to gain control of a suitable case. Undoubtedly the feature which causes some clinicians to shun advising operative treatment is their fear of the mental impact of operation itself upon the patient. This should not be regarded as a contra-indication.

Our Psychiatric Social Worker is conducting a survey asking patients and relatives to express their views concerning the benefit of various forms of treatment. Replies have been received from approximately sixty-seven patients and relatives. In those who have not yet replied the percentage of success and failure corresponds to the average distribution of the series as a whole and, therefore, the sample is reliable. The results are of course biased by the fact that the enquiry has been sent to people, all of whom had previously failed to benefit from psychiatric treatment, but it does at least show the reaction of such cases to surgical treatment.

Forty-seven patients and forty-eight relatives consider that the operation has produced considerable improvement, thirteen and twelve respectively, slight improvement.

Contrasting surgical and psychiatric treatment, fifty-seven patients and fifty-nine relatives regarded surgical treatment as more effective, five and six as less effective.

Contrasting operation with drug treatment, forty-seven patients and fifty relatives reported

TABLE 2

	Patient's assessment	Relatives' assessment
1. Assessment of the effect of operation		
Considerably improved	47	48
Slight improvement	13	12
No change	5	7
Worse	1	—
No answer given	1	—
2. Assessment of surgical treatment compared with psychiatric treatment		
More effective	57	59
Less effective	5	6
No difference	2	1
No answer given	1	1
3. The effect of operation compared with that of drug treatment		
More relief	59	60
Considerable	(47)	(50)
Slight	(12)	(10)
Less relief	5	6
No difference	2	—
No answer	1	1
4. The effect of operation compared with that of ECT		
More relief	54	54
Considerable	(47)	(46)
Slight	(7)	(8)
Less relief	4	4
No difference	2	1
No ECT treatment	6	—
No answer	1	4
5. Patient's assessment whether operation was preferable to ECT		
Yes, 50; No, 5; No ECT treatment, 6; No difference, 2; No answer, 4.		
6. Patient's assessment whether operation was preferable to drugs		
Yes, 46; No, 8; No difference, 2; No answer, 11.		
7. Patient's assessment as to whether they would have preferred to have had the operation sooner		
Yes, 51; No, 15; No answer, 1.		

considerably more improvement, twelve and ten, slightly more improvement; and five and six, less relief.

In comparison with ECT, forty-seven patients and forty-six relatives reported considerably more relief; seven and eight, slightly more relief; and four less relief.

In the patients' personal assessment, fifty patients regarded operation as preferable to ECT, forty-six as preferable to drugs. Fifty-one would have preferred to have had their operation sooner, and fifteen would not.

From the patient's point of view surgical treatment may thus be regarded as a useful adjunct to the co-ordinated work of a psychiatric team.

I believe that there is a case for the provision of psychiatric sessions and a small number of special beds at neurosurgical centres in order to provide combined surgical and psychiatric departments working with the aid of the facilities for operation and neuroradiology which already exist at such centres. Patients could be referred for treatment in such units from hospitals in a wide area, thereby producing an accumulation of experience. If these Units were linked to Rehabilitation Units also possessing experience in the treatment of these cases, an opportunity would be provided for a co-ordinated service which could produce results of value.

Acknowledgments

I acknowledge with gratitude the invaluable help that I have received from many sources. My thanks are due particularly to Sir Wilfred Le Gros Clark and Dr Powell of the Department of Anatomy, University of Oxford, for their advice on neuro-anatomy. To Professor Steiner in the Department of Radiology and Dr Mallard in the Department of Physics at the Royal Postgraduate Medical School, for their co-operation in elaborating the operative technique, and to my numerous psychiatric friends and colleagues who have referred so many interesting cases over a number of years. The generosity of Professor Stelmasiak in allowing me to use illustrations from his *Atlas of the Human Brain and Spinal Cord*, on this and many other occasions, is deeply appreciated.

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