Selective Anterior Cingulotomy: A Psychosurgical Evaluation*

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This report concerns our experiences with 110 patients with severe emotional imbalance who were treated by selective anterior cingulotomy.

Historic Rationale

In 1937 Papez\(^1\) enunciated the theory that reverberant circuits in the limbic system supplied the mechanism to mediate and express emotional experience. In the years 1947-1951 Fulton\(^1\) urged neurosurgeons to focus their attention on the anterior cingulum and medial orbital areas as optimum target zones for affective disorders; he pointed out that lesions in either region had no effect on learning disability in monkeys whereas ablations of the prefrontal convexity severely restricted this faculty. In 1958 MacLean\(^1\) amplified the limbic circuits involved to include the medial forebrain bundle. Ward\(^2\) predicted improvement in anamnestic behavior from ablation experiments of area 24 in Macaques; he also observed widespread autonomic effects from stimulation of this area, as did Pool and Ransohoff.\(^3\)

These experimental observations were reinforced by clinical cases of cerebral tumors in the frontal and temporal lobes by Keschner, et al.,\(^4\) and Strauss and Keschner.\(^1\) During the past decade, Malamud\(^5,6\) has stressed the relationship between psychotic states and the limbic system; recently he reported in detail 18 autopsied cases with limbic tumors. Many of his cases had epileptiform discharges and a clinical picture of schizophrenic or affective psychosis indistinguishable from the purely psychiatric form of these illnesses.

These observations led neurosurgeons in various centers of the world to test the effect of cingulate lesions in neuropsychiatric disorders. Livingston\(^7\) used an open operation, excising a 4 cm strip of cingulum along the roof of the anterior horn; in a study of 41 cases he noted striking changes in affect, a pleasantness and contentment of mood coupled with the absence of hostility and fear. In Paris, Le Beau\(^8\) reported similar post-cingulotomy results in patients with agitated behavior and obsessive-compulsive states, and he commented on the absence of mental deficits following the procedure. At about the same time Whitty\(^9\) reported striking success in patients with affective disorders, and almost uniform failure in those with schizophrenia; he used a two-stage open ablation procedure in area 24.

Sano\(^10\) noted beneficial sedative effects from lesions of the posterior hypothalamus, anterior thalamic nuclei, cingulum, and hippocampus. Foltz and White\(^11\) reported relief of pain and drug addiction following cingulate lesions and noted their best results occurred when anxiety and depressive states co-existed with pain. Ballantine and co-workers\(^1\) reported excellent results in 30 of 40 patients with severe psychiatric disorders featured by anxiety and depression; they used bilateral stereotaxic lesions placed in the cingulum 3 to 4 cm posterior to the tip of the frontal horn. In Australia the current experience of Dowling and Bradley\(^2\) is highly favorable in the treatment of severe psychoneuroses and affective psychoses with cingulate lesions placed just anterior to the frontal horn of the ventricles.

Material

Approximately two-thirds of our patients accepted for investigation and subsequent surgical treatment were classified as having intractable psychoneuroses that had proven resistant to psychiatric treatment; one-third of our cases fell into the group of affective psychoses (Table 1). A small number of transitional disorders were treated surgically.

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Diagnosis | No. of Cases | Percent of all Cases
---|---|---
**Intractable Psychoneuroses (all types)**
Anxiety-tension states | 24 | 21.8
Obsessive-compulsive | 37 | 34.0
Anxiety hysteria with conversion disorders | 10 | 9.0
Others (schizo-affective, rare early schizophrenia) | 4 | 3.6

**Affective Disorders (all types)**
Manic-depressive psychosis (including manic states, agitated and endogenous depression) | 31 | 28.0
Involutional psychosis | 4 | 3.6

68.4%

31.6%

TABLE 1
Distribution of 110 cases

when studies of their personality components indicated the likelihood of a successful result.

Our series covers the years 1950-1967 during which 110 patients underwent bilateral one-stage procedures. Revision was necessary at a later date in seven cases, making a total of 117 surgical procedures. Seventy-one percent of our patients were females, 29% were males, with an average age of 44.1 years at the time of surgery. Both the youngest (24 years) and the oldest (73 years) patients suffered from obsessive-compulsive states. Duration of symptoms prior to surgery averaged slightly more than 6 years; during this period the vast majority of patients had a maximum of psychiatric treatment apart from rare cases that showed unusual features. Data from psychiatric, psychological, medical, electrical, and computer sources proved invaluable in deciding whether there was a suitable indication for psychosurgery.

We excluded the following categories of mental illness for purposes of this study: 1) well-established schizophrenia of the hebephrenic, catatonic or paranoid form; 2) pure characterological disorders (sexual, criminal, and constitutional psychopathy); 3) organic encephalopathy recognized to be irreversible; and 4) reactive depressions that usually prove to be self-limited. The standard psychological battery supplemented by the Minnesota Multiphasic Personality Inventory proved helpful in the selection and rejection of cases for operation.

Technical Considerations

All cases were operated on under intratracheal anesthesia using pentothal combined with a nitrous oxide-oxygen supplement. A preoperative lumbar pneumoencephalogram was carried out. The patient was positioned supine with the head elevated 25° from the horizontal plane and fixed exactly in mid-position on a cassette-holder. The superior approach was used with bilateral trephine openings placed 4.0 cm anterior to the interaural line and 4.0 cm lateral to the midline. The frontal horns were then cannulated and probes positioned medial to the anterior margin with the tips 5 to 7 mm from the midline (Fig. 1). These were quickly checked with Polaroid films or the image intensifier. For lesions in the lower rostral portion of area 24, the depth from the surface of the cortex averaged 5.5 to 6.0 cm. Anterior-posterior variation was within 1.5 cm, with no lesions more than 1.0 cm posterior to the sphenoidal ridge (Fig. 2).

The size of the lesion varied from 0.8 cm (grade 1) to 2.0 cm (grade 2+) with the grading dependent on preoperative studies. By varying the size of the lesion and using different combinations in the dominant and non-dominant hemispheres, the surgeon gained some flexibility in management. Early in the series electrolytic lesions were used but in recent years interruptions with a graduated cingulotome under x-ray or image intensifier control has proved very satisfactory and reduced the operating time. Our present cingulotome is a slim periosteal elevator with
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Fig. 1. Probes are positioned 5 to 7 mm from the midline of area 24 at the anterior margin of the frontal horns.

Fig. 2. Location of cingulotomy lesions in rostral portion of area 24. Anteroposterior range is 1.5 cm.

a 3 mm tip having a shaft with a graduated centimeter scale for depth. Transverse markers in the handle are aligned parallel to the flat edge of the tip and serve to orient the operator. In the present design a lateral excursion of 1.5 cm, for example, is reflected in a medial sweep of the tip to produce a transverse cingulate incision of the same length.

Whether the cingulate lesion is made by electrolysis, cryosurgically, using a radiofrequency generator, or with a cingulotome, does not seem significant; a satisfactory result depends on the proper selection of cases followed by accurate regulation of the size and placement of the lesions.

**Results**

**Psychiatric Evaluation.** Cases followed from 1 to 17 years were classified in six categories to evaluate the surgical results (Table 2). Patients in the “well” group are normal in the accepted sense, have returned to productive activity in business or household duties, and are free of medication or psychiatric supervision. Those who are “greatly improved” function effectively in society, are employed on a part-time basis, but need occasional psychiatric attention or intermittent medication. Those who are “improved” have made a reasonable social adjustment aided by regular psychiatric care and medication but are not employed gainfully or fully able to manage a household unaided. No patient in any of these three groups has required electroshock or rehospitalization.

Three patients were rated “slightly improved,” a borderline result in which betterment over their preoperative status was judged to be under 20%. They are not employed, being maintained as outpatients under regular psychiatric treatment with medication, therapy, and occasional electroshock treatment (EST). However, they have not required hospitalization, which contrasts favorably with their multiple admissions prior to operation. The limited benefits in this group were probably related to the deterioration secondary to repeated EST and prolonged drug administration. There were five “unimproved” cases. Two of these had characterological disorders so well masked beneath emotional and psychotic overlay that clinical evaluation proved erroneous. In effect, cingulotomy exchanged one set of psychiatric difficulties for another. One patient, diagnosed a manic-depressive psycho-
sis, improved briefly after surgery and then deteriorated with an evident paranoid schizophrenia. Another patient who had anxiety hysteria with depression was greatly improved after operation and then lapsed under extreme familial and financial stress including the breakup of a marriage of long standing; this patient required rehospitalization and regular psychiatric attention. The fifth patient of this group showed no worthwhile results due to persistent organic encephalopathy with occasional convulsions. These cases in the “unimproved” group were operated on early in our series and their selection might have been avoided by today's refinements in psychological screening.

One patient was classified “worse” although her preoperative status was desperate and the risk of surgery recognized and explained to the family. A brainstem thrombosis in the immediate postoperative period was a major complication.

Eight patients in the “well” or “greatly improved” group were followed from 2 to 11 years postoperatively and then could not be traced due to change of residence to out-of-state or out-of-country. If we consider this long follow-up period and our specific instructions to be notified of any significant problems, it seems valid to continue their same classification. During the period of this study, seven patients died of unrelated causes from 3 to 16 years after surgery (carcinoma, or coronary occlusion). Two of these cases were rated as poor results, five as good results.

**Postoperative Course.** There were no deaths and only one major complication following 117 surgical procedures, a statistically significant figure indicating that risk is negligible.

Mild mental confusion is common from the second to fifth postoperative day and transient incontinence occurs at the same time in approximately one-third of cases. We have never observed lasting incontinence following cingulotomy. When there is a history of any convulsive tendency, anticonvulsive medication is stepped up in the immediate postoperative period. Affective “overshoot” is not unusual during the first 3 weeks; patients having marked depression or psychomotor retardation will seem relatively euphoric, while hypomanic or agitated cases often appear too relaxed or inert. In our experience this overshoot is a favorable omen for proper emotional balance in the future and indicates that selective grading has been reasonably accurate.

**Follow-up Course.** During this long postoperative follow-up period no patient has committed suicide. At present, it seems reasonable to reassure the family that this hazard will be greatly reduced by properly designed cingulate lesions. Clinical study and psychological testing has shown a marked lessening of anxiety, phobias, hostility, depression, and obsessional thinking, with restructuring of ego strength. Intelligence quotients were maintained or actually improved when these destructive emotional forces were removed; patients who have had

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**TABLE 2**

*Results in 110 cases*

<table>
<thead>
<tr>
<th>Group</th>
<th>Result</th>
<th>No. of Cases</th>
<th>Percentage of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Well</td>
<td>78</td>
<td>71.0</td>
</tr>
<tr>
<td>2</td>
<td>Greatly Improved</td>
<td>18</td>
<td>16.4</td>
</tr>
<tr>
<td>3</td>
<td>Improved</td>
<td>5</td>
<td>4.5</td>
</tr>
<tr>
<td>4</td>
<td>Slightly Improved</td>
<td>3</td>
<td>2.7</td>
</tr>
<tr>
<td>5</td>
<td>Unimproved</td>
<td>5</td>
<td>4.5</td>
</tr>
<tr>
<td>6</td>
<td>Worse</td>
<td>1</td>
<td>.9</td>
</tr>
</tbody>
</table>

**Good Result** 91.9%

**Borderline Result** 2.7%

**Poor Result** 5.4%
a cingulotomy have returned to banking, engineering, aircraft procurement, and many other types of complex intellectual pursuits.

The following six cases are reported as representative of our series.

**Case Reports**

**Case 1.** A 40-year-old woman had a 20-year history of anxiety hysteria with conversion sensory symptoms and severe psychogenic pain leading to polysurgery and drug addiction. The past record included appendectomy, hysterectomy, lysis of intestinal adhesions, a negative explorative laminectomy for presumptive disc protrusion, a negative flank exploration for suspected glomus tumor, and repeated prolotherapy for intercostal neuralgia. The patient had received literally thousands of demerol injections and was an established codeine addict as well. Bilateral grade 2 anterior cingulotomy in March, 1950, gave prompt and lasting relief with no withdrawal symptoms. She has remained in good health for 17 years, with a consistent work pattern; follow-up this year indicated she was not only supporting herself but also an aged mother and an invalid brother.

**Case 2.** A 28-year-old woman had a history of recurrent depression over a period of 8 years, with postpartum accentuations following two deliveries. Repeated electroshock and sanitarium treatment gave no relief, and the patient's mother was given custody of the two children. At 24 years of age the patient had attempted suicide with barbiturate overdose but recovered without residual effect after 3 days of unconsciousness. She was admitted following a second suicidal effort; after recovery the clinical picture showed severe depression, agitation, and mutism. Anterior cingulotomy, grade 2 right and grade 1 left, was carried out. Recheck 1 year later showed a stable, cheerful, attractive young woman who no longer requires medication or psychiatric attention. She manages her own household and a multiple unit apartment.

**Case 3.** A 52-year-old man who was a supervisor of interplant and governmental communications in a major aircraft corporation had a 10-year history of intractable anxiety and tension increasing to frequent panic states. Somatization was manifest in headache, diarrhea, tachycardia, and visual blurring. Hypnosis, psychotherapy, tranquilization, and mood-elevating drugs were ineffective while electroshock gave only a fleeting response. The patient had often verged on suicide. Preoperative data showed a severe mixed psychoneurosis, anxiety, and depression, being well flavored with ruminative hypochondrasis. After undergoing bilateral cingulotomy, grade 1+, he has returned to steady work in supervising communications and special committees to improve corporate efficiency and economy.

**Case 4.** A 30-year-old housewife suffered from emotional illness which was rooted in childhood. The patient indicated that her father and her aunt both blamed her for her mother's death from advanced rheumatic heart disease, which had been precipitated by the patient's long and difficult birth. Her own marriage was marred by sterility secondary to endometriosis which required x-ray castration, and by a lack of sexual response. Profound depression and agitation developed with two abortive attempts at suicide while under psychiatric treatment. Demerol addiction became well established. For the 3 years prior to referral the patient had had intractable asthma, with four hospital admissions for status asthmaticus. Preoperative studies showed an advanced mixed psychoneurosis with elements of obsessional guilt, severe somatization, anxiety, and depression. Bilateral cingulate lesions were made in August, 1953, grade 1+ on the right, grade 1 on the left. Restoration of emotional balance was rapid and has been sustained for 14 years. Follow-up this year showed continued normal status; asthmatic attacks have practically disappeared. She is a stable responsible housewife, and has two adopted children.

**Case 5.** A 52-year-old woman had a psychotic history of 25 years' duration characterized by recurrent depression, agitation, and uncontrollable weeping. In the interim there were bursts of hyperactivity in community affairs, family travel, and her hobby of gardening. Self-accusation featured the downsings with illogical phobias concerning her own health and the well-being of
children and grandchildren. Sleep was impossible without soporifics. During these years she had repeated psychiatric attention, sanitarium care, electroshock, tranquilizers, and antidepressants. At the time of referral this patient was weak and poorly nourished, so extremely atactic from Stelazine and barbiturates that walking without assistance was impossible, and toxic to the point of memory loss with inability to concentrate or comprehend the examiner's questions. After preoperative supportive treatment, study confirmed the diagnosis of manic-depressive psychosis. A grade 1+ bilateral anterior cingulotomy was done. Postoperatively, the patient maintained a balanced, cheerful, communicative personality, returning to normal activities, a result no less gratifying to her long-suffering husband than to the patient. Although asymptomatic, she is still under periodic psychiatric guidance.

Case 6. A 54-year-old woman had a 10-year history of headache with frequent vomiting. She had used various medications including cafegone, percodan, barbiturates, codeine, and tranquilizers. Prior to referral, 70 electroshock treatments had brought considerable relief of pain but were followed by relapse and memory deficit. When referred for evaluation the patient was receiving four nembutal and two chloral capsules plus a minimum of eight doriden daily. A complete search for organic disease including pneumoencephalography was negative. Psychological studies confirmed an obsessive-compulsive state with psychogenic pain and deep-seated hostilities directed to her mother and stepfather. A bilateral grade 1 anterior cingulotomy was carried out. Her recovery was prompt, and all drugs were immediately stopped. There has been no cephalgia for the past 4 years. This patient's husband was a large newspaper distributor in Los Angeles; 6 weeks after surgery she returned to the detailed work of accounting and billing several thousand subscribers. She has continued to manage her household and do weekly volunteer charity work in a local well-baby clinic.

Discussion

It is not easy to communicate in words the composite preoperative misery of these 110 patients. When affective components were the dominant feature of the illness the result of cingulotomy was most rewarding. As psychological screening became more accurate, the personality changes that might be expected after cingulotomy could be predicted to the patient's family within reasonable limits.

To attribute the results of cingulotomy to any "placebo" effect or suggestion therapy is a theory that finally should be laid to rest. Ballantine, et al., noted that 10 of their 40 patients were benefited by a secondary operation. Our experience with seven revisions was similar. Livingston used four cases for purposes of controls; they had the usual skin incision, bone button removal, and similar postoperative routine; there was not the slightest improvement, and all four required cingulate isolation 1 to 3 months later.

Anatomical and technical considerations influenced the placement of our lesions in the most rostral portion of area 24. We wished to avoid the blunting and apathy that occasionally follows bimedial leukotomy when more widespread interruptions are made in areas 11, 12, and 25, added to area 24. In this series, lesions in area 24 were placed approximately 4 to 5 cm anterior to the site chosen by Ballantine, et al., and 1.5 to 2.5 cm anterior to that used by Foltz and White.

As a major integrating force in the limbic system, the cingulate gyrus is more than the source of a long-tract association bundle; precingular relays are abundant, and "spin-offs" to the hippocampus, amygdala, and anterior thalamic nucleus seem to play an important role. These latter connections may be critical in obtaining a favorable operative result. The improvement in somatic symptoms and vasomotor disturbances may relate to the known autonomic control exercised by the cingulate gyrus through its subcortical and hypothalamic connections. The superior approach with placement rostral to the anterior cerebral arteries has prevented injury to these vessels; the fact that the medial fibers are highly important provides an additional rationale for avoiding thermal stereotaxis contiguous to the anterior cerebral arteries. At present we emphasize the importance of larger lesions in the cingulum of the nondominant hemisphere for depressed states, and accentuate the dominant side for hy-
pomanic or agitated states. Selective gradations of size and laterality are facilitated by familiarity in interpreting the available preoperative data.

**Summary**

We have reported the results of 117 anterior cingulotomies in 110 patients followed from 1 to 17 years. Beneficial results were obtained in 91.9%, borderline improvement in 2.7%, and poor results in 5.4%. Statistically, the surgical risk was negligible.

Criteria for selection of patients and technical considerations related to the nature of the individual psychiatric disorder have been discussed. Our results add to the evidence that the cingulate projection system appears to play an important role in the maintenance of emotional balance.

**References**

2. Dowling, J., and Bradley, K. Personal communication.