PAIN “RELIEF” BY FRONTAL CINGULUMOTOMY*

ELDON L. FOLTZ, M.D., AND LOWELL E. WHITE, Jr., M.D.

Division of Neurosurgery, University of Washington, Seattle, Washington

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Relief of pain as a clinical problem has faced physicians since man first began to attempt treatment of his own ailments. Drug therapy was found to be only partly successful in such treatment, and destructive operations on the primary pain-conducting pathways of the peripheral and central nervous system evolved, such as peripheral nerve section, dorsal rhizotomy, and spinthalamic tractotomy. These precise neurosurgical procedures achieved adequate differential sensory (pain) deprivation of the areas involved, but in many instances the “psychogenic” component of the patient’s reaction to his disease was not altered and the complaints of disabling pain continued. In some instances prefrontal lobotomy was effective in stopping the complaints of pain.27,30,38 However, these procedures were done in a variety of ways to produce a relatively massive nonspecific destruction of frontal-lobe white matter16–18 and shortly became rather unpopular because of the significant and at times devastating deterioration of personality.

Certain beneficial effects of prefrontal lobotomy were recognized early such as the immediate modification of the morphine-withdrawal syndrome.27,30 Further experimental study of this phenomenon indicated that the frontal cingulum fasciculus (Fig. 1), a white-fiber tract of the medial hemisphere destroyed anteriorly by most lobotomies,17,18 might be important as a mediating bundle carrying frontal-lobe modifying influences to autonomic effector areas, and that its specific destruction could greatly reduce and modify the autonomic phenomena that follow withdrawal of morphine.5,6 Since emotion and autonomic phenomena were so closely related,8,14,35 it was attractive to extrapolate that these influences from the medial frontal lobe via the cingulum might be in the “emotional sphere.” Furthermore, Papez20 previously had implicated the cingulum in his anatomical theory of emotion. Other investigators already had drawn inferences relating the cingulate area with a number of autonomic-psychogenic factors.4,8,17,13,21,36,29,31,32 This concept of the functional significance of the cingulum has been supported by recent anatomic and physiologic studies of the limbic system and its many interconnecting fasciculi.3–7,9,19,25,34,35 These studies show that the cingulum consists of multisynaptic pathways connecting the medial frontal cortex, the anterior thalamic nuclei25 and the rostral mid-line and intralaminar nuclei7,8,19,24 with the hippocampal formation24,35 (Fig. 2). Therefore, it was attractive to postulate that transection of the cingulum might be of benefit in those clinical cases of intractable pain in which marked emotional factors appeared to contribute to the intolerable situation.5,6

In this project our intent was to modify the patient’s emotional response to the life-threatening situation which he faced so that his expressions of fear and anxiety no longer augmented critically whatever pattern of organic pain was present to produce intolerable suffering.

METHODS

Selection of Patients. Over a 7-year period, patients who were presented for consideration of treatment of their intractable pain were reviewed and interviewed on multiple occasions in an effort to estimate the degree to which their emotional status was augmenting their complaint of pain. The type of

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pain was not considered critical in the decision, nor was the lesion causing this pain considered critical. In all cases, the chief complaint was intractable pain producing the patient’s disability and hospitalization. Our intent was to determine whether the patient showed prominent emotional factors in his complaint that could affect adversely the results of adequate destruction of specific pathways of pain. Sixteen patients met the criteria set up, based primarily on: 1) outward evidence of anxiety; 2) preoccupation with their illness to the point of depression or near depression; 3) demonstrable emotional lability in the situation of interview with inappropriate crying, etc. In 14 cases, psychiatric help on a consultant basis was sought through the cooperation of a member of the Psychiatry Department. In 2 instances, the neurosurgical decision that cingulotomy was warranted was in opposition to the psychiatric opinion.

In most instances, the patients selected for cingulotomy were chronic “pain problems” who had been hospitalized for long periods of time. Frequently, they had had multiple operations directed toward their primary disease, and several had been operated on specifically to relieve pain.

The operation and its expected results in all instances were reviewed carefully with the patient and members of the immediate family. The expressed intent of the procedure was to “relieve suffering” by modifying the patient’s reaction to his painful situation. No patient was accepted for cingulotomy without realization on the part of the patient and the family that the patient probably would be a somewhat different person following the operation, but nevertheless improved in regard to his complaints of pain and evidence of suffering.

**Technique of Cingulotomy.** Fig. 1 demonstrates diagrammatically the anatomical location of the cingulum fasciculus in enough detail only to demonstrate a logical surgical approach to the frontal cingulum to achieve severance of this tract by electrocoagulation. Using a limited air study, coagulating electrodes are placed in the cingulum under roentgen-ray control with the patient awake.

Preoperative medication is minimal, using only a small dose of atropine prior to coming to the operating suite. The last narcotic dose preoperatively is given on the usual schedule in each case.

Fractional pneumoencephalography or ventriculography is necessary for roentgen-ray controlled positioning of the electrodes. With the patient sitting upright on the operating table with his head in the optimum position for ventricular filling, lumbar or cisternal puncture is performed and 13–20 cc. of filtered air are injected slowly. After withdrawal of the needle, the patient is helped slowly into the supine “brow-up” position on the table, with cervical spine slightly anteflexed.

The shaved anterior half of the head is prepared and draped for bifrontal burr holes or preferably twist-drill holes (3/16 inch). A mid-line measurement is made from the nasion 9 cm. posteriorly to a point just anterior to the coronal suture. The exact mid-line position of the point may be checked by an anteroposterior roentgenogram, securing a #12-gauge wire over the presumed sagittal suture line from nasion to lambda.
The relative position of this wire to the actual mid-line of the skull can be ascertained easily from the roentgen ray. Measured lateral correction of this mid-line point 9 cm. posterior to the nasion is then accomplished. From this point, 1.5 cm. is measured laterally on each side, identifying the optimal point for entrance of the electrode. After local infiltration with Xylocaine, a stab wound is made through the scalp and a 3/16-inch twist-drill hole is made through the skull on each side. The direction of such a small opening in the skull may be critical and therefore the drill is directed toward the inner canthus of the homolateral eye in the coronal plane, and toward a point midway between the ear and the external canthus in the parasagittal plane. (In early cases, a burr hole was placed through the skull on each side at this point, using a single transverse incision in the scalp for the necessary exposure.)

The dural opening is made by use of cutting cautery. The 14-gauge, 10-cm. long electrodes, marked in centimeters and insulated with Formvar, are inserted to a depth 3.5 cm. below the cortex on each side, directed only slightly medially toward the falx, and angled posteriorly toward the midpoint of zygoma or even toward the auditory canal (for posterior lesions).

If the initial radiological check showed no air in the ventricles, ventricular puncture can be done through these holes on one side to inject 8–10 cc. filtered air directly into the frontal horns of the ventricle. If the needle is placed deeply enough in the ventricle, air will enter both frontal horns though unilateral filling may be satisfactory.

With the electrodes in place, anteroposterior and lateral films of the skull should show the tips of the electrodes at a point 5–6 mm. above the superior ependyma of the frontal horns (allowing for thickness of the corpus callosum) and 1–2.5 cm. posterior to the tip of the frontal horns in the lateral views. In the anteroposterior roentgenogram the tip of the electrode should be 1.3 cm. from the mid-line, medial to the superior-lateral angle of the frontal horn of the ventricle (Fig. 3).

In the first 6 cases, multiple (3) lesions were made in each cingulum by directing the electrode more anteriorly and then more posteriorly than this point, making lesions successively at each placement.

The lesions are made with the electrocautery unit (Bovie), using a setting that gives a coagulative lesion after 20 to 30 seconds. A satisfactory lesion is assured if a mild vibration is transmitted through the electrode during contact, or if there is necrotic, slightly charred white matter on the tip of the electrode on withdrawal. Closure of incisions is done in the standard manner.

In two cases, stimulation of the cingulum was carried out prior to coagulation. A standard Grass stimulator, model 120, with variable voltage and duration of pulse was used. The stimulation in both instances was concomitant with a striking increase in agitation, and evidences of fear and apprehension, but neither patient could describe the sensation. The clinical situation unfortunately was not conducive to pursuance of further observations at the time.

Local anesthesia was acceptable in all cases to date. Frequently, an agitated, apprehensive, jittery patient suddenly changed to a complacent, cooperative one with the simple introduction of the electrode into the region of the cingulum. A change in affect and psychomotor activity usually occurred when the lesions were made.

Postoperative Care. No narcotic was given after operation and a careful record was kept of the patient’s spontaneous requests. Observations were made for mild signs and symptoms of withdrawal, such as rhinorrhea, abdominal cramps, diarrhea, restlessness, sweating, etc. The patient was allowed up and about as soon as he desired and was able to do so. Responses to questions concerning the preoperative pain were recorded and the nurses’ evaluation of the patients’ general reaction to nursing care was considered very

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Fig. 2. Schematic diagram (parasagittal section, cat brain) of cingulum fasciculus relationship to hippocampal and mid-line structures. C.C. = corpus callosum; Hipp. = hippocampus; 28 = entorhinal area; 49 = parahippocampal; 27 = presubiculum; D.F. = dentate fascia; A.T.N. = anterior thalamic nuclei; M.B. = mammillary body; M.Th. = mammillothalamic tract; M.N. = anterior mid-line nuclei. (From White et al. 38)
helpful. As normal hospital routine as possible was resumed the day of operation. Occasional headache was treated with analgesics. Aggressive efforts towards rehabilitation were instituted promptly.

Pathology of Lesions. Four of the 5 patients who have died were autopsied. Three of these showed adequate electrocoagulative lesions (Fig. 4).

RESULTS

Immediate results from the lesions usually were apparent in the operating room. Continued verbal communication was maintained with each patient during the operation in order to evaluate to some degree his emotional state and degree of pain. A complaining, uncomfortable, apprehensive patient usually showed a dramatic change in demeanor at the time the lesions were made. The patients became tractable, agreeable, and often showed a little vague disorientation. In 2 instances, this change occurred concomitant with simple insertion of the electrodes into the area of the cingulum prior to electrocoagulation.

A mild elevation of temperature often appeared in the second 24 hours postoperatively (100°-101°F.), but other than possibly signifying withdrawal of narcotic was ignored therapeutically. No patient who had been addicted required narcotics after operation. A change in affect usually was obvious, but not a severe flattening of affect nor marked lethargy or unresponsiveness. Extreme effects on reactivity did not occur. Mild confusion did exist in some for a day or two. In all instances, social activities thereafter were quite acceptable except for Case 1-2 whose social activities had always been a bit bizarre.

Narcotic-withdrawal syndromes that were recognized were very mild and relatively insignificant. The effectiveness of cingulumotomy on the narcotic-withdrawal syndrome is demonstrated in Table 1. Of the 16 patients, 14 were definitely addicted. Only 5 showed mild signs of withdrawal recognized in the first 72 hours after operation. These consisted of rhinorrhea, tremulousness, diarrhea, or abdominal cramps of mild degree. No signs of withdrawal were observed in the remaining 9 patients. It is apparent that our data are insufficient to state that bilateral lesions
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are necessary to achieve this desirable effect on the addict since very adequate modification of signs of withdrawal was achieved with the unilateral lesions also (Table 1).

Clinically, the 16 patients operated on were classified into three main groups, partly in retrospect (Table 2): Group I—psychogenic pain; Group II—organic disease with paroxysmal pain precipitated by emotion; Group III—neoplastic disease, organic pain, and strong emotional factors in their disability.

In the group with psychogenic pain, only 1 of the 5 patients had a primary organic disease (Case I-5, quadriplegia from poliomyelitis). One patient had temporal-lobe seizures which were presumed to be secondary to multiple operations on the right Gasserian ganglion in efforts to relieve right facial pain. All 5 patients had long-standing (2 to 15 years) complaints of pain that were incapacitating them for useful existence. One excellent result, 3 good results, and 1 only fair result occurred in this group. Only 1 has died, presumably poisoned (Fig. 3). Case I-4 in whom only a fair result was obtained, may not have had adequate lesions produced because of technical difficulties, but so far her status has not indicated need for reoperation.

The dramatic effect of cingulumotomy in the following case warrants comment.

Case I-3, M.W., 68-year-old white female, had been suffering from intense burning vaginal and perineal pain for over 2 years. Thorough repeated examinations by the gynecologists, general surgeons, and internists had failed to reveal significant primary organic disease. She had been completely bedridden in the hospital for over 9 months, had received two series of electroshock therapy and severe flexion contractions of the lower extremities had developed because of her refusal to get out of bed or move her lower extremities. The Department of Psychiatry felt she had “severe depression with maximum anxiety.” The Department of Neurosurgery decided on

<table>
<thead>
<tr>
<th>Number</th>
<th>Patients</th>
<th>Mild Withdrawal</th>
<th>No Withdrawal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(first 48 hrs.)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>5</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

* Rhinorrhea, tremulousness, diarrhea, or abdominal cramps.

Fig. 4. Typical cingulum lesion produced by this method. CC = corpus callosum; CG = cingulate gyrus; X = cingulum.
TABLE 2
Summary of cases of cingulumotomy

<table>
<thead>
<tr>
<th>Clinical Groups</th>
<th>Chief Complaint</th>
<th>Results</th>
<th>Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I. Psychogenic pain (5 cases)</td>
<td>Face pain (2)</td>
<td>Good*</td>
<td>7 yrs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good</td>
<td>5 mos.†</td>
</tr>
<tr>
<td></td>
<td>Vaginal-perineal pain (2)</td>
<td>Excellent</td>
<td>4½ yrs.</td>
</tr>
<tr>
<td></td>
<td>Chest pain</td>
<td>Good</td>
<td>4 yrs.</td>
</tr>
<tr>
<td>Group II. Organic disease with paroxysmal pain related to emotion (5 cases)</td>
<td>Causalgia, arm</td>
<td>Excellent</td>
<td>6 yrs.</td>
</tr>
<tr>
<td></td>
<td>“Emotional” angina</td>
<td>Excellent</td>
<td>1½ yrs.</td>
</tr>
<tr>
<td></td>
<td>Atypical causalgia thigh stump</td>
<td>Poor; reoperation</td>
<td>8 mos.</td>
</tr>
<tr>
<td></td>
<td>Painful legs, disarticulated paraplegics (2)</td>
<td>Fair*</td>
<td>3 yrs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poor*</td>
<td>2 yrs.</td>
</tr>
<tr>
<td>Group III. Neoplastic disease, organic pain, strong emotional factors (6 cases)</td>
<td>Face, neck pain (3)</td>
<td>Good</td>
<td>4 days†</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good*</td>
<td>1 mos.†</td>
</tr>
<tr>
<td></td>
<td>Back, hip pain (2)</td>
<td>Excellent*</td>
<td>9 mos.†</td>
</tr>
<tr>
<td></td>
<td>Shoulder, arm pain</td>
<td>Fair</td>
<td>5 mos.†</td>
</tr>
</tbody>
</table>

* Unilateral cingulumotomy.
† Expired.

cingulumotomy because of the complaint of severe, incapacitating pain associated with complex emotional factors.

After cingulumotomy, the change was indeed striking. She ceased her continual whining complaints, began to take note of her external environment, and began to move about again. Within 2 weeks, she was up and walking for the first time in 9 months. Shortly, she was able to leave the hospital, returned home, and resumed her housework activities. On questioning her, the pain was still present but did not concern her now. Over a 4½-year follow-up, her complaints of pain have not returned to clinical significance.

Group II patients suffered from organic disease with paroxysmal pain precipitated by emotion. Among these 5 patients were 1 with causalgia of the left arm, 1 with atypical causalgia in the stump of the right thigh, and 2 with painful leg in traumatic paraplegia. The most striking case was a problem of severe angina pectoris (Table 2). Two results were most remarkable.

Case II-1. B.S., a 28-year-old white male, suffered a gunshot wound of the left brachial plexus 2 years previously. His left arm steadily had become more painful with causalgic type of burning dysesthesia, which was precipitated frequently by emotional instability as well as sensory stimulation to the extremity. The extremity showed a partial brachial-plexus lesion and early atrophic changes in the skin with marked vasomotor instability. The Department of Psychiatry had stated his basic personality was such that he required this pain as a “somatic crutch,” and that interruption of such support probably would cause a complete disruption of personality. Dorsal sympathectomy and stellate ganglionectomy had failed to give relief. Cingulumotomy was warranted because of the obvious anxious depression and striking emotional precipitation of his causalgic attacks.

Following bilateral cingulumotomy, there was immediate complete cessation of emotional precipitation of his causalgic syndrome and, though he had a mild syndrome of withdrawal of narcotic, he rapidly became completely rehabilitated. He returned to his job as a draftsman, and apparently has maintained his compensated and stabilized personality for 6 years. Before operation he had separated from his wife, but after operation the family was reunited and has remained so since operation.
Case II-2. D.N., a 44-year-old white male, had had increasing anginal pains for the previous 13 years. A diagnosis of myocardial fibrosis had been established. Amputation of the left knee was done for arterial insufficiency, and he had had thoracic sympathectomy for pain in the chest and thoracic cordotomy for pain in the leg. He was so sensitive to emotional situations that he could not watch a TV football game without suffering extreme anginal pains while sitting quietly in his chair. He had been taking up to 20 nitroglycerin tablets per day for relief of angina at bedrest. Pain likewise was produced by minimal physical exertion. He was an addicted miserable patient who was said by the psychiatrist to show an "involutional depressive reaction, severe."

On Oct. 13, 1957, a right electrolytic cingulotomy was done. Immediately following operation his need for nitroglycerin fell off sharply to 2 to 4 tablets per day. Emotional precipitation of this angina was minimal. At 8 days, however, his emotionally precipitated angina returned. On Nov. 12, 1957, a left electrolytic cingulotomy was done, again with striking decrease in emotionally precipitated anginal pains (Fig. 5). Three weeks later the relief from emotional precipitation of angina allowed him to be sent home on pass for the first time in many months. He was free of anginal attacks under emotional stress but while home became so encouraged that he did more physically than had been advised and suffered another myocardial infarction. Thereafter, he was in and out of the hospital for the remaining 18 months of his life. He continued to show a striking loss of emotionally precipitated angina. Presumably, the demands on cardiac output made by his emotional reactivity preoperatively had resulted in myocardial ischemia producing the angina. This emotional liability causing such cardiac demand was modified markedly by the cingulotomy so that he was comfortable during the rest of his life if he stayed within the limits of physical exertion. His depression was much less following operation and no striking deterioration in personality occurred.

The other 3 cases in Group II represent the poorest results. Two patients with traumatic paraplegia, both suffering from pain in the lower limb, manifested severe anxiety but also showed a strikingly "inadequate personality." Both the patients had been suffering for over 4 years and whereas Case II-3 was followed for 3 years and was much more stable emotionally, his result was only fair. Case II-4 has been followed 2 years and is still a chronic complaining invalid. It is significant, however, that in both these instances only unilateral procedures were done and this may be quite meaningful. Reoperation probably should have been done.

Case II-3 also had a preoperative diagnosis of "inadequate personality" and in spite of a bilateral cingulotomy his result after the first operative procedure was poor. His second procedure was done 3 months later and at the present time his result is classified as good though the follow-up time is short.

Group III patients had neoplastic disease with organic pain and strong emotional factors involved in the total disability. These patients all suffered from cancer which was producing organic pain, but, in addition, marked emotional reaction to their pain and terminal disease had produced marked augmentation of their complaints of pain. All recognized that their disease would ultimately cause their death. All of the group showed depression and anxiety. The longest follow-up is 9 months and the shortest was 4 days. In the latter, Case III-2, myocardial infarction occurred on the 4th postoperative day. The patient showed no agitation or apprehension during this.

The effectiveness of bilateral as opposed to unilateral cingulotomy to obtain "pain relief" is not clear (Table 3). Of the 11 patients who had bilateral lesions, 4 of them had excellent results, 6 good results, 1 a fair result, and 1 a poor result. In the 5 with uni-
TABLE 3
Effectiveness of bilateral vs. unilateral cingulotomy (pain “relief,” withdrawal)

<table>
<thead>
<tr>
<th></th>
<th>Number Patients</th>
<th>Adequate Withdrawal Modification</th>
<th>Clinical Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral lesions</td>
<td>11 (9 addicts)</td>
<td>9 (all addicts)</td>
<td>Poor  Fair  Good  Excellent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1     2     5     4</td>
</tr>
<tr>
<td>Unilateral lesions</td>
<td>5</td>
<td>5</td>
<td>1     1     2     1</td>
</tr>
</tbody>
</table>

lateral lesion, 1 poor, 1 fair, 2 good, and 1 excellent results occurred. In both groups, modification of signs of withdrawal of morphine was satisfactory in all patients.

The psychiatric diagnosis and its correlation with the clinical effectiveness of the cingulotomy are shown in Table 4. The preoperative psychiatric diagnosis shows that in those with an “inadequate personality” in addition to their other multiple complaints, the results were the least satisfactory. There were 3 of these individuals and 2 had poor results and 1 a fair result. There was no other common denominator in the psychiatric diagnosis that shows any significance in itself, though all 5 of the patients who had excellent results had depression as part of their diagnosis and most of those with a mixture of depression and anxiety showed good results.

The patho-anatomical results of cingulotomy by this technique are not evaluated completely as yet. Only three brains have been made available for postmortem study. The lesion in the cingulum as demonstrated in Fig. 4 is 4 months after operation and is considered a typical lesion of those studied so far. Fiber-tract degeneration studies are planned.

DISCUSSION

Whereas the number of patients studied in our series is not great statistically, the effectiveness of cingulotomy, unilateral or bilateral, in permitting abrupt withdrawal from addiction to narcotics seems apparent. In agreement with results in the experimental laboratory, the clinical effect of withdrawal is a modification of the aspect of hyperreactivity of the syndrome. The universal stabilization of these anxious, emotionally unstable patients by cingulotomy might indicate that the effect primarily is on the “psychic” component of withdrawal which reduces directly the severity of the “somatic” component.

Any seriously ill, disabled patient can be aided greatly by increased attention and contact with his physician on whom he is psychologically very dependent. Such an effect on any group of patients under clinical investigation is significant, and may make it difficult to conclude that the procedure, such as cingulotomy, is the primary cause of improvement. However, careful clinical observations and clinical analysis should clarify this. A critical case can often verify conclusions made under these circumstances, and Case II-4 is such a case in our group. In spite of bilateral lesions, it was obvious that this patient required much more than the usual support of interview after operation. Support of the family was solicited necessarily more vigorously than in the other cases, and re-operation was discussed but ultimately not advised. The clinical impression was that the patient either had received inadequate lesions or else the selection for operation was ill-advised. Several months later, she expired as a result of her primary cancer. Sections of the brain showed that in actual fact very minimal if any lesion had been made in the cingulum! Microscopic serial sections showed that the electrodes had been placed directly in the cingulum, and small microscopic lesions had resulted, but no electrolytic lesion of the usual nature had been produced. The fact that this probability had been
recognized prior to death and discussed at length tends to lend credence to the clinical observations that the lesions of cingulumotomy themselves are in fact critical in obtaining the results recorded.

It must be accepted that these patients are changed persons after the cingulumotomy, but the change is indeed subtle. It is most difficult to classify and describe the change that occurs, but it is obvious that effective lesions produced a definite stabilization of emotional lability that was present before operation. Much of the anxiety, which is so manifest in these ill, unhappy people, is no longer apparent. The patient with a good result simply is not as precipitously reactive to his own environment and his own situation as he was prior to operation. The anguished facies and evidence of suffering are modified markedly. The perception of pain as such does not appear to be modified, but the patient’s total reaction to pain and the threat to existence that it represents is modified markedly. Most of the patients stated they continued to have pain but it was “not distressing,” “not particularly bothersome,” “doesn’t worry me anymore,” etc.

The open operation of cingulectomy as practiced for a number of years produces many of the desirable results of cingulumotomy and some of the indications are similar. Resection of the cingulate gyrus, or cingulectomy, actually does destroy the underlying white-fiber pathways including a large part of the cingulum fasciculus. Cingulumotomy by electrocoagulation probably should be included as a type of “selective leucotomy” and has advantages of being a closed method, quite accurate, and easily done under local anesthesia with an awake patient. Likewise, it lends itself well to doing a minimal destruction at the first operation, and then increasing the size of the lesion as necessary.

The still uncertain aspect of this type of treatment is selection of the patient. In attempting to correlate the psychiatric diagnosis with the effectiveness of cingulumotomy, it may be that a bilateral lesion is not necessarily required to produce a good or excellent result. It appears in this group that patients who had anxiety and/or depression in one of various combinations had the best results from cingulumotomy. The results in Table 4 might suggest, then, that a person who has anxiety and depression, or a combination of these, likely would be a better candidate than one who shows an “inadequate personality.” This is in agreement with Lewin’s recent report on cingulectomy. Whether the anxiety with or without depression is caused by internal environment, as in Group I, or by external environment as in Groups II and III, does not seem to be crucial. The reaction to their total environment is of such a degree than an “emotional facilitation” of psychoneurotic or organic pain probably occurs, and the end result is a primary complaint of intolerable and incapacitating pain. Simple ablation by cingulumotomy by electrocoagulation probably should be included as a type of “selective leucotomy” and has advantages of being a closed method, quite accurate, and easily done under local anesthesia with an awake patient. Likewise, it lends itself well to doing a minimal destruction at the first operation, and then increasing the size of the lesion as necessary.

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<table>
<thead>
<tr>
<th>Preop. Psychiatric Diagnosis</th>
<th>Number Patients</th>
<th>Clinical Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. “Severe psychoneurosis with hypochondriasis, . . . with anxiety”</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2. “Severe depression,” . . . “with pain”</td>
<td>5</td>
<td>1 3 1</td>
</tr>
<tr>
<td>3. “Severe depression, maximum anxiety”; “reactive depression with anxiety”; anxiety and/or depression</td>
<td>6</td>
<td>1 1 4</td>
</tr>
<tr>
<td>4. “. . . inadequate personality”</td>
<td>8</td>
<td>2 1</td>
</tr>
</tbody>
</table>
lumotomy of some of the pathways that carry these “emotional influences” can produce a tolerable and comfortable clinical situation.

There is a need for better preoperative selection. Petrie has approached this problem from a psychologist's viewpoint, and her observations may be applicable to the situation facing the neurosurgeon attempting to relieve suffering. On the basis of Köhler's method for kinesthetic figural after-effect, patients divide into three relatively equal groups, namely the “augmenters,” “moderates,” and “reducers.” It would appear that our patients who benefited most from cingulumotomy would hit her classification of “augmenters.” Such a method may offer a more specific means of preoperative selection of patients for cingulumotomy rather than the relatively clumsy clinical evaluation that we have used.

CONCLUSIONS

1. A series of 16 patients who have undergone frontal cingulumotomy for intractable pain is presented.

2. The only preoperative requirements for cingulumotomy were a) chief complaint of intractable, prolonged pain; and b) a clinical evaluation that indicated a significant emotional “titer” in the patient’s intolerable situation.

3. Five patients were classified as “psychogenic pain,” and all showed at least “good” results. Five patients were classified as “organic disease with paroxysmal pain precipitated by emotion,” and 2 of these, 1 with causalgia and 1 with emotional angina, showed an exceedingly striking result. Six patients with neoplastic disease, organic pain, and strong emotional factors in their disability showed at least “good” results.

4. Fourteen of the 16 patients were addicted to a narcotic prior to operation, and abrupt withdrawal following operation resulted in only a minimal syndrome of withdrawal in 5, and none was recognized in the remaining 9.

5. Effective modification of the syndrome of withdrawal and adequate clinical results from cingulumotomy do not require bilateral lesions.

6. The effectiveness of frontal cingulumotomy presumably depends primarily on the basic substrate of personality and emotional reactivity of the patient.

7. Selection of patients for cingulumotomy has proved difficult by clinical techniques. It is suggested that psychological techniques of testing measuring general alterations of sensory perception may be helpful.

8. The clinical results from cingulumotomy lend support to the theory of Papez that the cingulum is a fiber pathway subserving emotion in man.

9. Cingulumotomy by electrocoagulation is a simple, safe type of selective leucotomy which is available for the relief of suffering in man.

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DISCUSSION

Dr. James G. Lyerly: When I was at the bullfight last Sunday, our guide reassured us that the spears and bars put in that bull's shoulders were painless because of the mental state and mental rage in which the bull was at the time. This brings up the point—which I have feel frequently in the past—that maybe I do not know how much pain a patient has. Is the pain limited, or, we might say, more highly developed in the higher forms of life, as in Homo sapiens? Of course, some people have pain more than others. Therefore, I think that pain is more or less a mental as well as a physical state. If you can put the patient's mind in the proper state, he will not have as much pain. If you do any blockage of nerve pathways in the brain that will lower that mental impression, you will largely relieve his suffering and pain.

Therefore, I think that is what we do when we perform prefrontal lobotomy or cingulotomy, as Dr. Foltz has described. Our original operation of prefrontal lobotomy, in which we cut the deep association fibers in the prefrontal lobe just anterior to the anterior horn of the ventricle, necessarily cut the cingulate pathway and, therefore, relieved not only mental impression and emotional states, but lowered high blood pressure and relieved a lot of the nervous-tension states and disorders that go along with suffering, pain and other forms of mental disorders.

I haven't had experience with this particular type of operation that Dr. Foltz described, in which he coagulates these cingulate pathways on the roof of the ventricle. I have had some experience with electrocoagulation in the prefrontal areas for blocking these pathways, as in the open operation. My feeling is that with coagulation deep in the tissues in operations that are not open there is uncertainty of the degree of coagulation, and the area of destruction, because of variation of the electric current from day to day and because electrocoagulation by machines vary from time to time. You set the coagulation current at a
figure of 5 for a specific number of seconds, and coagulate in an autopsy brain seeing what effect it will have, and on a subsequent day do the same thing at the same setting and you will find an entirely different effect. The electrocoagulation of prefrontal areas I found was not as effective as, and less uncertain than, the open operation in which the areas and the pathways can be cut under direct vision and control.

I had 1 fatal hemorrhage 6 days after operation by electrocoagulation. The patient got up and went to the bathroom and had a sudden massive fatal hemorrhage, perhaps from rupture of the anterior cerebral artery from electrocoagulation. I felt if I had done the open operation, this might not have happened.

My operation for intractable pain is more or less similar to that for other mental suffering as in the psychoses and anxiety states.

I think Dr. Foltz's operation of cingulotomy is logical and should be effective in relieving intractable pain. Personally, I would rather do the open operation.

Dr. Robert S. Dow: I would like to ask the authors if there were less of the unfavorable symptoms of the classical prefrontal lobotomy when these patients were seen postoperatively.

Dr. Henry T. Wy cis: We know the cingulum projects to and receives impulses from the anterior nucleus of the thalamus. In 1931 Dr. Spiegel and I made lesions in the anterior nucleus and we found there was a reduction of emotional reactivity in these patients. If you stimulate the anterior nucleus, you can produce an apnea which may be quite prolonged and require artificial respiration. If you make lesions in this region, you can produce a similar response as described today. Would you care to comment on that?

Dr. Eldon L. Foltz: Dr. Lyerly, it has been our practice to keep our finger tips on the electrodes when the lesion is being made. As a lesion is produced, the coagulation of white matter produces a minimal vibration which can be felt. Also, when the electrode is withdrawn, a small amount of coagulated white matter is present on the tip if an adequate lesion has been made.

I agree that the Bovie unit may produce variable coagulation lesions. We have been using a radiofrequency generator for some of the lesions.

Dr. Dow, changes do occur in persons who have this type of lesion. This excerpt from the full manuscript covers this important point: “It must be accepted that these patients are changed persons after the cingulotomy, but the change is indeed subtle. It is most difficult to classify and describe the change that occurs, but it is obvious that effective lesions produce a definite stabilization of emotional lability that was present before operation. Much of the anxiety, which is so manifest in these ill, unhappy people, is no longer apparent. The patient with a good result simply is not as precipitously reactive to his own environment and his own situation as he was prior to operation. . . . The perception of pain as such does not appear to be modified, but the patient’s total reaction to pain and the threat to existence that it represents is modified markedly.”

Most of the patients on whom we have operated have been rehabilitated to an active existence. We have had none in whom there has been marked deterioration of personality, a result not uncommon with the wider prefrontal lobotomy.

Dr. Wy cis, we did stimulate 2 patients and activated their electroencephalographic pattern strikingly. Marked “terror” was produced on the part of both individuals—a sensation they could not describe. The situation was not clinically amenable to further investigation at the time. This is part of our current project under way now.

As for anatomical connections demonstrable by studies of degeneration, especially in the instance of death 4 days postoperative, this type of work is currently under investigation. It was not our intent to include a study of anatomical degeneration in this report.