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Psychiatric neurosurgery: a historical perspective

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Why intervene surgically to treat psychiatric disorders? Certainly, past efforts have been marked with ambiguous results at best and have been associated with ignoble circumstances at worst. Yet, the impetus to explore the surgical options in psychiatric treatment has once again arisen.

The legacy of Moniz, Fulton, and Freeman

The birth, flourishing, and demise of psychosurgery in the early twentieth century may serve to caution our current endeavor to intervene surgically in psychiatric patients. In the hands of the most prominent physicians and Nobel laureates of the age, despite the best of intentions, such intervention led to virtual worldwide banning of a seemingly promising surgical venue. This is the tale of a treatment whose promise remains largely unknown and unfulfilled even today. Why the descent from mainstream "miracle" to medical anathema?

When Paul Broca presented his case of patient M. Leborgne ("Tan") in front of the Parisian Anthropological Society meeting in 1861, he ushered in the age of localization (Fig. 1). Localization married the concepts of behavior and function with a precisely defined anatomic neural substrate. Before this, Franz Joseph Gall's phrenology (Fig. 2) tried to localize function based on cranial landmarks, but it was Broca's work that looked specifically to the brain. It was the concept of localization that allowed the surgical intervention on neural function. It was the first step at unlocking the "black box."

Medical scientists and clinicians soon seized on the idea of localization in the treatment of mental disorders. In the late 1800s, Friedrich Goltz performed experiments on dogs in which removal of the temporal lobes resulted in animals that were more tame and calmer than the ones not operated on [1]. In 1891, drawing from these animal studies, a Swiss psychiatrist named Gottlieb Burckhardt (Fig. 3) reported the results a series of surgical procedures in which he drilled holes in the heads of six severely agitated psychiatric patients and extracted sections of their frontal lobes [2]. Although in Burckhardt's series of six patients, three were considered "successes" and two "partial successes," pressure from his colleagues led him to abandon his efforts.

It might seem surprising, almost inconceivable, that such a rapid leap from animal experiments in the laboratory to clinical practice on human beings could take place; however, it is this phenomenon that is fundamental to understanding the rise and ultimate fall of psychosurgery in the twentieth century. Indeed Burckhardt's report itself ends with a bold challenge to the fundamental practice of medicine:

> Doctors are different by nature. One stands fast in the old principle: "*primum non nocere*"; the other states: "*melius anceps remedium quam nullum*." I belong naturally to the second category...Every new surgical approach must first seek its special indications and contraindications and methods, and every path that leads to new victories is lined with the crosses of the dead. I do not

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Fig. 1. Paul Broca. (Available at: www.uic.edu/depts/mcne/founders/page0013.html.)

> believe that we should allow this to hold us back… [3]

"First, do no harm (*primum non nocere*)" versus "Better an unknown cure than nothing at all (*melius anceps remedium quam nullum*)." The battle line for psychosurgery in the early twentieth century was drawn. It is this fundamental struggle between the obligation of the physician to remain cautious and the desire to help those in need that would define the efforts to intervene surgically in the mentally ill.

In 1929, at the age of 30 years, John F. Fulton became the chairman of Yale University's Department of Physiology (Fig. 4). His research interest was an extension of Sherrington's thought: to reveal the relations among neural systems, it was necessary to cut the connecting pathways in progressively higher neuroanatomic levels of the system. The lower level thus becomes disconnected or "disinhibited" and reveals itself through changes in neurologic behavior. Fulton applied this approach to frontal lobe function in chimpanzees, yet he found that "turning to questions involving perception, learning, memory, and other higher intellectual faculties, *objective data are far more difficult to obtain*." [4] This discovery would echo the troubles clinicians would have a decade later as the proliferation of lobotomy raged out of control. In the short run, however, it led Fulton to collaboration with a recently hired psychologist, Carlyle Jacobsen.

Then, in 1935, another fateful meeting occurred. At the Second World Congress of Neurology in London, Fulton and Jacobsen presented their work showing behavioral changes in chimpanzees after ablation of frontal lobe areas (Fig. 5) [5]. Fulton and Jacobsen made the observation that frontal lobe ablation could result in the lessening of "anxiety states" in chimpanzees [6]. In attendance at that meeting was a Portuguese neurologist by the name of Egas Moniz and an American neuropsychiatrist by the name of Walter Freeman (Figs. 6 and 7).

Drawing from Fulton and Jacobsen's data as well as synthesizing case reports of neurosurgeons operating on various frontal lobe lesions at the time, Egas Moniz made this observation in 1935:

> It is necessary to alter these synapse adjustments and change the paths chosen by the impulses in their constant passage so as to modify corresponding ideas and force thoughts into different channels… By upsetting the existing adjustments and setting in movement in other [connections], I [expect] to be able to transform the psychic reactions and to relieve the patient thereby [7].

Moniz made the critical analytic jump linking the seemingly irrational behaviors and thoughts of psychiatric patients with an anatomically "normal" but disordered neural substrate—a concrete neural substrate which, when altered in a surgical fashion, would result in definitive change of the seemingly ethereal entities of thought and mind itself. His plan was to sever the white matter bundles connecting frontal lobe regions with the rest of the brain, the frontal leukotomy. He convinced a young neurosurgeon in Lisbon, Almeida Lima (Fig. 8), to undertake the procedure, and a series of 20 patients commenced. Despite this bold leap into human clinical practice, Moniz realized that his inspiration from animal data was a tenuous one: "…it is not possible to obtain experimental subjects among animals… [There simply existed too] great a difference between the psychic life of man and that of animals… [8]"

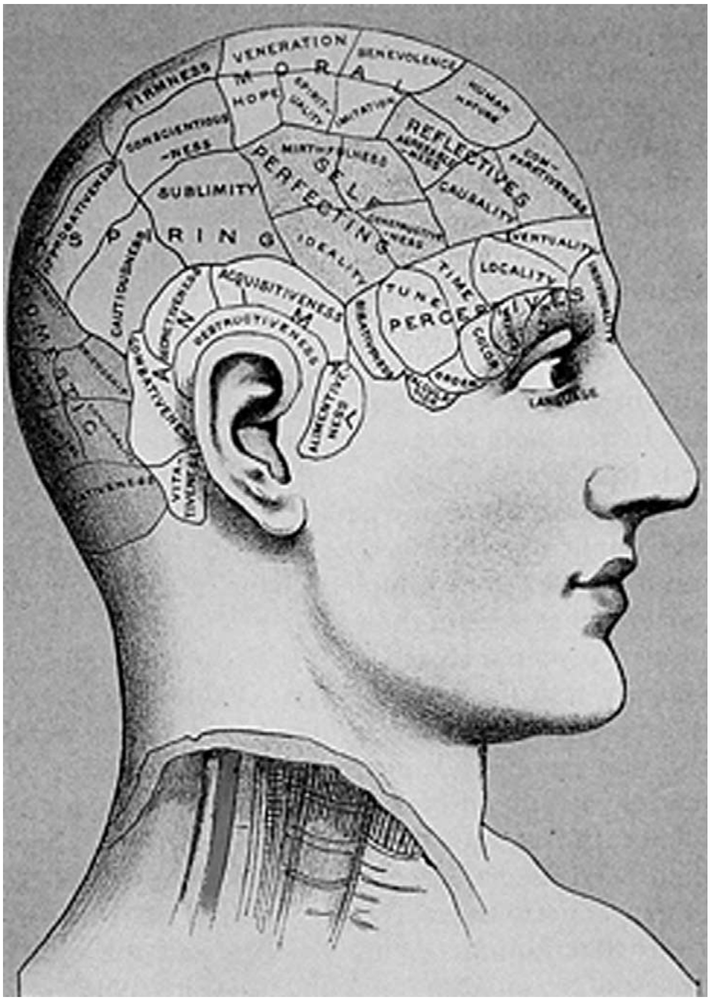

Fig. 2. Phrenology localization scheme. (Available at: www.artsci.wustl.edu/~mjstrube/psy315/phrenology.jpg.)

In 1936, Walter Freeman chanced on Moniz's initial communications regarding frontal leukotomy in the obscure journal *Lisboa Medicina.* His contemporaries who treated psychiatric maladies with psychotherapy, useless prattle by his account, had frustrated Freeman, a neuropsychiatrist of the "organicist" school, who held that psychiatric illness had a tangible basis in neuropathophysiology. Freeman, too, recognized that the scientific basis for the procedure was "naive"; nevertheless, here was "something tangible, something that an organicist like myself could understand and appreciate" [9]. For Freeman, a therapy that was untried and possibly dangerous was better than the status quo. Freeman wrote to Moniz in May of 1936, telling him of his inspiration and his intention to apply Moniz's procedure in the United States.

Why would scientists of such renown as Moniz and of such promise as Freeman be so hasty in applying such a radical and virtually unfounded remedy? Why did *melius anceps remedium quam nullum* become so much more important and more seductive than *primum non nocere*? Why did "do something" become more imperative than "first, do no harm"?

Medicine is an art that is not practiced in the idealized bubble of science. Science is the realm of theory, hypothesis, and the experimental model. It deals with the currency of truth and hard fact. Medicine is where science meets all the human foibles, hopes, prejudices, and desires to

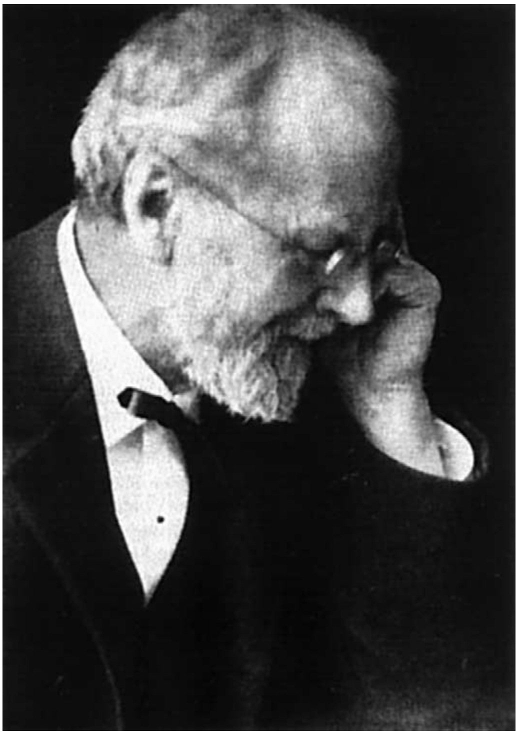

Fig. 3. Gottlieb Burckhardt. (*From* Feldman RP, Goodrich JT. Psychosurgery: a historical overview. Neurosurgery 2001;48:647–59; with permission.)

Fig. 4. John F. Fulton. (Available at: www.epub.org.br/cm/n02/istoria/lobotomy.htm).

"do something." "[Medicine] is more wrapped up in human, time-dependent concerns than is generally admitted" [10].

Nowhere was this desire to "do something" stronger than in the field of psychiatry at the dawn of the twentieth century. Indeed, there were no drugs or medical procedures available that were used to treat the specific symptoms of mental illness. Even with the advent of powerful drugs, such as barbiturates, there was little ground gained in the ability to change the emotional and mental dynamics of psychiatric disease. "Therapeutic nihilism" was the philosophy of treatment among psychiatrists at this time, because patients were allowed by default to languish according to the natural history of their disease. Then, beginning in the 1930s, a wave of "somatic" therapies began to "revolutionize" psychiatric practice (Fig. 9). The most important of these "shock" treatments were injections of metrazol (camphor), insulin-induced hypoglycemic comas, and electroconvulsive therapy, all designed to trigger convulsions and states of unconsciousness in the patient. Although extremely welcomed because of their clinical "effectiveness," in these early versions, shock therapies were dangerous and difficult to manage. Insulin-therapy was cost- and labor-intensive, because these patients required constant vigilance from nurses and medical staff. Furthermore, patients were terrified of entering into the near-death states of insulin coma. The seizures of metrazol and electroconvulsive therapies, unmodified by anesthesia or muscle relaxants, often had the byproduct of spinal and long bone fractures. Yet, these unfortunate side effects were tolerated because of the ability of these "somatic" treatments to alter the clinical course of a patient's mental disease and, more importantly, increase the number of discharges from inpatient facilities.

The economic environment of inpatient psychiatric care in the nascent twentieth century is also central to understanding the widespread adoption of such a risky and uncertain treatment as psychosurgery by the medical community. The inpatient psychiatric institutions of the early twentieth century had become a vast network of juggernaut institutions, some containing as many as 10,000 patients. Inpatient admissions were climbing at an alarming rate. By 1940, there were 480,000 psychiatric inpatients, equal to the total

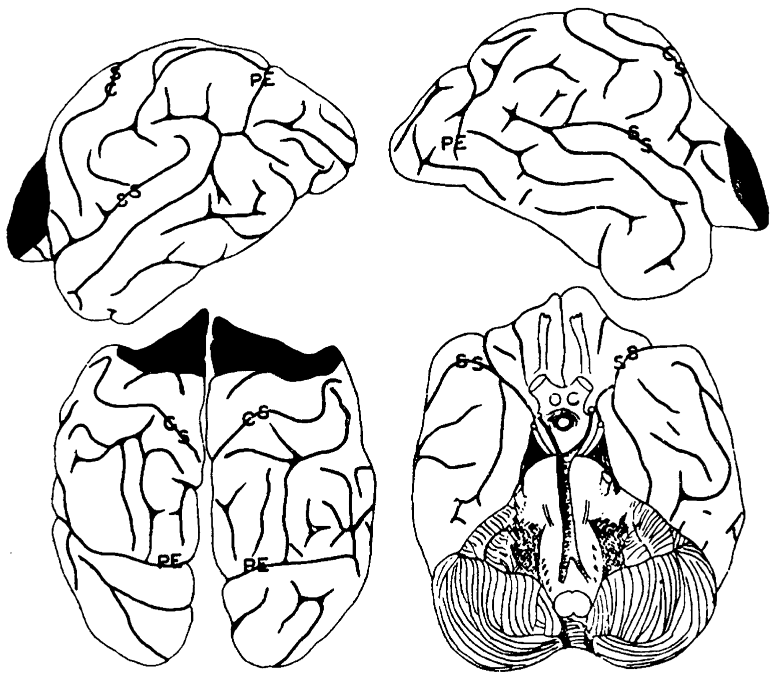

Fig. 5. Cortical areas ablated in Fulton's experiments. (*From* Egas Moniz centenary. Scientific reports. Lisbon; 1977. p. 146; with permission.)

number of beds in all nonpsychiatric hospitals combined [11]. As the number of admissions increased, the discharge rate decreased. With the lack of effective therapies, the rate of recoveries dropped. Evidence mounted that any patient hospitalized for longer than 2 years would stay until death. The mathematics of this situation led to vast overcrowding and inhuman conditions (Fig. 10). It was not uncommon for institutions to house twice the number of patients for which they were designed. Scenes of 100 cots placed side by side in a ward built for 25 leading to elderly patients climbing over one another to use the toilet pervaded the inpatient psychiatric landscape [12]. Albert Maisel's pictorial essay in the May 1946 edition of *Life* magazine described the inpatient mental health system as "little more than concentration camps on the Belsen pattern." Even the psychiatrists themselves began to lose hope. In a communication that appeared in *Psychiatric Quarterly* in 1945, one psychiatrist equated inpatient psychiatric admission as being "identical with doom" [13]. Therapeutic nihilism coupled with an overcrowded and economically overwhelmed inpatient psychiatric system was fertile ground for an untested, untried, and largely scientifically unsupported "miracle." Freeman brought the miracle of Moniz to the United States in 1936.

Freeman, having convinced a young neurosurgeon by the name of James Watts to work with him (himself a former student of Fulton's), began a series of patients in September of 1936. They considered their initial patient, A.H., a resounding success. In their initial communication they noted: "She was well dressed, talked in a low, natural tone...showed excellent appreciation of her changed condition. Her husband asserts that she is more normal than she has ever been" [14].

This was a middle-aged woman who suffered from "agitated depression," having had a habit of wild outbursts in which "she exposed herself before the window and urinated upon the floor" [15]. Emboldened by their success, they rapidly proceeded with an increasing number of patients. They also modified the Moniz procedure, abandoning the Moniz leukotome for a dull flat knife known as a bistoury (Fig. 11) and approaching from the side as opposed to the top (Figs. 12 and 13). The Moniz procedure, frontal leukotomy, became the Freeman-Watts technique, the prefrontal or standard lobotomy.

Within a year, Freeman and Watts were eager to share the results of their successes with the

Fig. 6. Egas Moniz. (Available at: www.epub.org.br/cm/n02/historia/lobotomy.htm.)

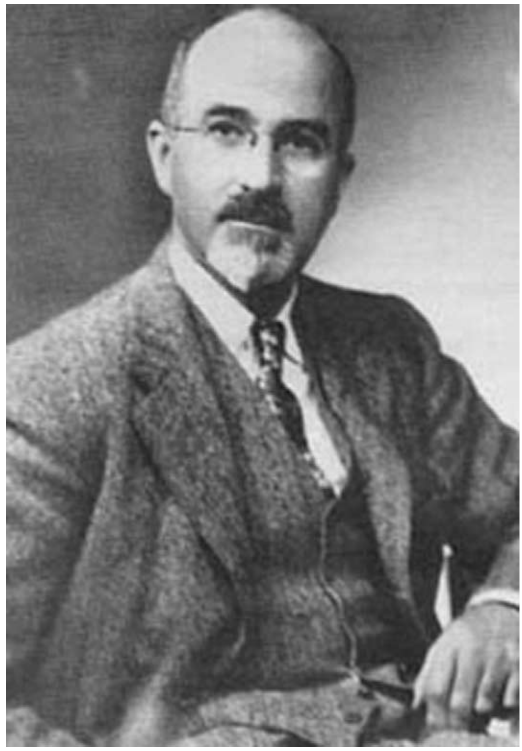

Fig. 7. Walter Freeman. (Available at: www.epub.org.br/cm/n02/historia/lobotomy.htm.)

professional community. Freeman would note that the choosing of patients based on disease type was critical to the procedure's success, with depressive and obsessional types faring best and schizophrenics faring worst (in fact, five of six schizophrenics in his series showed no improvement) [16]. The initial response from the professional community, especially among psychiatrists, was hostile. They believed that the procedure was too radical and too unfounded in its scientific basis. One psychiatrist wrote: "[It is like] burning down the house to roast a pig ... What has Moniz accomplished?... No one knows... least of all Moniz" [17].

Initially, Fulton rose to defend the work of Freeman and Watts. Although he acknowledged the tenuous scientific link between animal studies and clinical practice, he thought that there was rich opportunity for research and significant promise for the procedure. Using his professional reputation among neurologists and psychiatrists as well as his ties to neurosurgeons (indeed, he was the Harvey Cushing Society's second president), he echoed the need for a procedure to relieve the overburdening of the national psychiatric hospitals. He was in solid support of the medical community proceeding with the operations but predicated this support on the concept of carefully designed clinical trials in elite academic institutions [18]. Fulton won support for the Freeman, Watts, and Moniz procedure, but his warnings fell on deaf ears. The procedure was soon to spread throughout the medical community.

By the end of 1937, James Lyerly, a well-respected community neurosurgeon and a founding member of the Harvey Cushing Society, began applying the Freeman-Watts technique in Florida. He modified the Freeman-Watts procedure that he believed was a "blind" one by using a brain speculum so that the white matter to be cut was exposed to visual inspection. In 1 year, Lyerly had operated on 19 patients and presented his results at the meeting of the Florida Medical Association. Four previously chronically institutionalized patients had already been discharged. None died. None had any "serious complications." Lyerly called the procedure, "nothing less than miraculous" [19]. Other neurosurgeons took notice. Francis Grant, Chief of the Neurosurgical Service at the Hospital of the University of Pennsylvania,

Fig. 8. Almeida Lima. (*From* Feldman RP, Goodrich JT. Psychosurgery: a historical overview. Neurosurgery 2001;48:647–59; with permission.)

Fig. 9. A patient undergoing insulin shock therapy. (*From* Pressman J. Last resort. Psychosurgery and the limits of medicine. Cambridge: Cambridge University Press; 1998. p. 159; with permission.)

and W. Jason Mixter at the Massachusetts General Hospital began performing lobotomies in 1938. By 1939, J.G. Love of the Mayo Clinic traveled to Florida to learn the procedure from Lyerly so that he could start a series of lobotomies.

With the publication of Freeman and Watts' *Psychosurgery* in 1942, the fervor over the success of the lobotomy spread from the professional community to the lay community. Using his flair for the dramatic, Freeman dispensed with the customary scientific format and instead presented what was equivalent to pulp nonfiction:

> Surgeon: Well, the operation is over now anyway, isn't it?
>
> Patient: Yes, I'm glad it is. You know I wasn't dreading this particularly. I'm glad you did it under local because I wanted to see what it was all about.
>
> Surgeon: Did you feel anything particularly during the operation?
>
> Patient: No, there wasn't any real pain except when the first needle went in. Drilling through the skull was rather peculiar, but it didn't hurt at all. Now, it's just as if that vague unformed apprehension that has been with me all these years suddenly cleared up [20].

The lay public was especially taken with Freeman and Watts' book. One state hospital superintendent wrote to Freeman that his 17-year-old daughter read it and told him: "Daddy, this is the most interesting medical book that I have ever seen. Even I can read it and understand what I am reading about" [21]. Soon, lay publications, such as *The New York Times, Time, Life, Newsweek,* and *Reader's Digest*, were sensationalizing the successes of the prefrontal lobotomy.

Once both the profession and the public recognized lobotomy as a treatment of vast potential, its fate ceased to be in the hands of Fulton, Freeman, or any one person. Psychosurgery's fragile connection to the laboratory and the scientific community would begin to grow weaker and weaker. Fulton once envisioned the psychosurgery effort as an experimental one, the task of rigorously controlled academic institutions and off limits to the community practitioner. Now, every aspect of the medical community was participating in the psychosurgery "miracle." A "clinical drift" effect was evident as the procedure became free from any constraints. Initially, Freeman and other fervent supporters of lobotomy warned that the procedure should be used

Fig. 10. The Incontinent Ward, Byberry State Hospital. (*From* Pressman J. Last resort. Psychosurgery and the limits of medicine. Cambridge: Cambridge University Press; 1998. p. 149; with permission.)

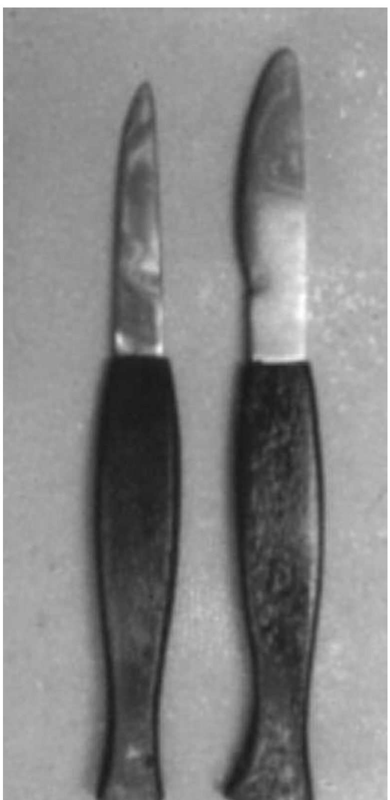

Fig. 11. Examples of bistoury knives. (Available at: www.gggodwin.com/17-18m.jpg.)

sparingly in cases of schizophrenia because of its poor clinical effect compared with other psychiatric diseases; however, they were ignored in the desire to "do something" for a group of patients who had no alternative form of therapy available.

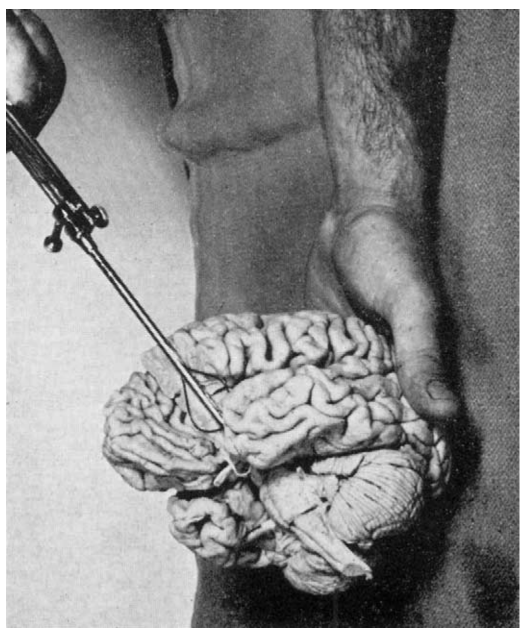

Fig. 12. Demonstration of the approach of the Moniz procedure (frontal leukotomy). (*From* Hitchcock E, Laitinen L, Vaernet K. Psychosurgery. Proceedings of the Second International Conference on Psychosurgery. Charles C. Thomas: Springfield; 1972; with permission.)

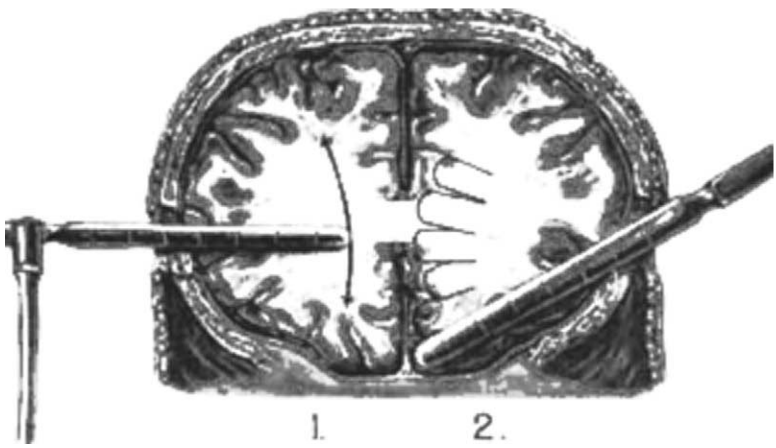

Fig. 13. Demonstration of the approach in the Freeman-Watts procedure (prefrontal or standard lobotomy). (*From* Freeman W, Watts J. Psychosurgery: in the treatment of mental disorders and intractable pain. 2nd edition. Springfield: Charles C Thomas; 1950; with permission.)

Psychosurgery's most ardent proponent ironically exemplified this clinical drift. At the end of World War II, prefrontal lobotomy was entering its heyday. Freeman, however, was looking to expand the use of his procedure. Gone were the days of "surgery of last resort"; Freeman wished to operate on a "better grade" of patient, including those recently institutionalized as well as those not hospitalized. Freeman was frustrated with Watts' veto power over patients who he believed were not disabled enough by their illness. Freeman thought that the rate-limiting step to psychosurgery's dissemination was, in fact, the neurosurgeon, being too few in number and too expensive in cost. Thus, with an ice pick, Freeman severed psychosurgery's final ties with its roots, those of neurosurgery itself.

Drawing from an obscure report of an Italian psychiatrist, Amarro Fiamberti, Freeman developed the transorbital lobotomy, a ghastly procedure in which the frontal white matter is cut by a metal spike inserted through the thin bony orbit above the eye [22]. Freeman's initial choice to accomplish this procedure was the common ice pick (Fig. 14). Although Freeman refined the common house tool into what he called a "transorbital leucotome," he envisioned the procedure being able to be performed by any surgically untrained physician after the most minimal instruction, with "every physician his own lobotomist" [23]. By 1948, Freeman, with ice pick in hand, traveled across the country to fulfill what he considered was an unanswered need (Fig. 15). It did not take long for Watts to sever his ties with Freeman. Like other neurosurgeons, he was horrified at the ghastly treatment that the patient received under Freeman's new procedure. Patients were not draped in sterile linen, and there was no surgical backup if a hemorrhage did occur. Yet, "free" from his restrictive association with Watts, Freeman operated in earnest. Freeman and Watts recorded 625 operations between 1936 and 1948. By 1957, Freeman had lobotomized another 2400 patients [24]. In one 12-day period, he operated on 225 patients. *Time* magazine heralded the age of "mass lobotomies" [25].

Fulton was appalled at Freeman's new course of action. "What are these terrible things I hear about you doing lobotomies in your office with an ice pick?. . .Why not use a shot gun" [26], Fulton's incredulous missive to Freeman seethed. Freeman did not relent, claiming that the transorbital procedure was "much less traumatizing than a shotgun and almost as quick" [26]. Their conflict exemplified their personal philosophies regarding the leap from laboratory to clinic and the growing chasm between psychiatric neurosurgery and its physiologic roots. Fulton believed that the most reliable and safe medical knowledge came from a combination of basic animal research coupled to a few rigorously designed and executed clinical trials. Fulton realized that the complete lack of reliable objective testing methods available to psychiatry at the time made it impossible to track lobotomy's efficacy from any scientific point of view. Conversely, the most important question to Freeman was, "Did it work?" [27]. What counted to Freeman were not intelligence tests but the

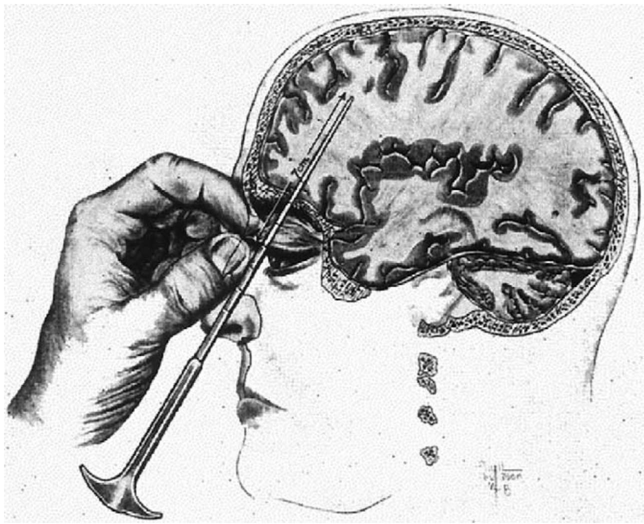

Fig. 14. Freeman transorbital ("ice pick") procedure. (*From* Freeman W, Watts J. Psychosurgery: in the treatment of mental disorders and intractable pain. 2nd edition. Springfield: Charles C Thomas; 1950; with permission.)

successful return of patients to everyday life. *Primum non nocere* versus *Melius anceps remedium quam nullum*. Yet, even as psychosurgery's most ardent scientific proponents began to question the widespread use of lobotomy, the procedure had become as mainstream a treatment as appendectomy. The awarding of the Nobel Prize to Egas Moniz in 1949 typified the simultaneous legitimization of lobotomy amid growing concerns regarding its efficacy and side effects. From 1936 to the mid-1950s, approximately 20,000 psychosurgical procedures, virtually all frontal lobotomies of some form, were performed in the United States [28].

Then, it was over. Ironically, it was a surgeon who helped end the "golden age" of psychosurgery and usher in the pharmacologic age of psychiatry. In 1952, Henri Laborit, a surgeon in Paris, was looking for a way to reduce surgical shock in his patients. Having tried antihistamines, generally used to fight allergies, he noticed that when he gave a strong dose to his patients, their mental state changed. No longer did they seem anxious about their upcoming surgery; in fact, they were rather indifferent. A fellow surgeon passed the word to his brother-in-law, a psychiatrist named Pierre Deniker. Deniker's interest was piqued, and he ordered some chlorpromazine to try on his most agitated and uncontrollable patients.

The results were stunning. Patients who had stood in one spot without moving for weeks and patients who had to be restrained because of violent behavior could now make contact with others and be left without supervision.

In 1954, the U.S. Food and Drug Administration approved chlorpromazine, and it took the field of psychiatry by storm. The death knell for psychiatric neurosurgery was sounded; yet, in Freeman's case, it fell on deaf ears. Freeman carried on his one-man war. He was relentless in his attempt to convince his colleagues to perform more of his procedures. On occasion, Freeman would dump shoe boxes crammed with letters from "grateful" lobotomized patients onto the desks of skeptical colleagues. They remained unconvinced. Freeman died in 1972 at the age of 76 years [29].

Yet, as this interest waned, technologic developments, especially in the realm of stereotaxis, ushered in a second wave of psychiatric neurosurgery.

The stereotactic era

Indeed, the first modern neurosurgical procedure for psychiatric disease, the frontal leukotomy, sought to interrupt white matter tracts associated with the frontal lobes. This procedure started as a rather extensive one and became more refined as the volume of brain in the surgical target became smaller. As the experience with frontal lobotomy increased, there was some suggestion that minimizing cortical damage and focusing on the white matter tracts could retain efficacy while minimizing side effects. This trend

Fig. 15. Freeman in a Winnebago. Freeman often traveled the country, performing his transorbital procedure. (*From* Pressman J. Last resort. Psychosurgery and the limits of medicine. Cambridge: Cambridge University Press; 1998. p. 406; with permission.)

toward increasingly discrete subcortical lesions culminated in the application of stereotaxis on psychiatric neurosurgical procedures. The second wave of psychosurgery was born.

In 1947, Wycis and Spiegel introduced the dorsomedial thalamotomy [30,31], the first subcortical stereotactic neurosurgical procedure performed on human beings and the model on which all modern psychiatric neurosurgical procedures are based.

The four psychiatric neurosurgical procedures currently in use are cingulotomy, capsulotomy, subcaudate tractotomy, and limbic leukotomy, which are all stereotactic interventions. These procedures are typically performed on the severe and refractory psychiatric patient. First, a patient must meet Diagnostic and Statistical Manual of Mental Disorders (DSM IV) criteria for a particular psychiatric disease such as obsessive-compulsive disorder (OCD) or affective disorder. Next, a patient must fail several rounds of treatment with multiple psychotropic medications combined with appropriate psychotherapy before he/she is considered for surgical treatment. Therapeutic failure is determined by quantitative analysis using the most appropriate and accurate psychiatric batteries of tests available, such as the Yale-Brown obsessive-compulsive scale (Y-BOCS), the Clinical Global Impression (CGI), and the Hamilton Depression scale for depression (HAM-D). When surgical treatment is ultimately considered, a multidisciplinary team consisting of psychiatrists, neuropsychologists, neurologists, lawyers, clergy, bioethicists and neurosurgeons is assembled to make sure the patient in question is both refractory and appropriate. Although many of the following studies of psychiatric neurosurgery have had significant flaws, most notably, the inherent bias of a nonrandomized non-double-blind study and the lack of objective functional imaging techniques, they do suggest a viable means of treatment for a subset of patients who may have no other options. The procedures themselves are described below. Their safety and efficacy for their main current indications, intractable OCD and depression, are considered at length in the article by Greenberg and his colleagues in this issue.

Cingulotomy

Surgery on the cingulate gyrus dates back to observations in the 1940s that severing fibers from the cingulate gyrus led to a decrease in anxiety type states [32]. In 1952, Whitty et al [33] reported their cingulectomy, in which a 4-cm × 1-cm section of cingulate gyrus was resected bilaterally. In 1967, Ballantine et al [34] introduced the modern stereotactic procedure in which a lesion, localized by air ventriculography and made using thermocoagulation, was made bilaterally in the anterior cingulate. The lesion is typically made bilaterally 2 to 2.5 cm from the tip of the frontal horns, 7 mm lateral from the midline, and 1 mm above the roof of the ventricles (Fig. 16). The procedure performed today has been refined using the latest in stereotactic equipment and imaging techniques. Stereotactic cingulotomy is the most frequently reported neurosurgical procedure for psychiatric disease in the United States and Canada.

Capsulotomy

Developed in Sweden by Lars Leksell and by Talairach in France, anterior capsulotomy has been in use for refractory psychiatric illness since 1949. There are two forms of this procedure, both of which are stereotactic operations. One technique involves the use of radiofrequency, and the other uses gamma radiation to make the lesion. In either case, the target area is between the anterior third and middle third of the anterior limb of the internal capsule at the approximate level of the foramen of Monro. Specifically, the ideal target lays 17 mm from the midline, 10 mm rostral to the anterior commissure, and 8 mm above the intercommissural line. The lesion is approximately 15 to 18 mm in length and 4 to 5 mm in width (Fig. 17) [35,36].

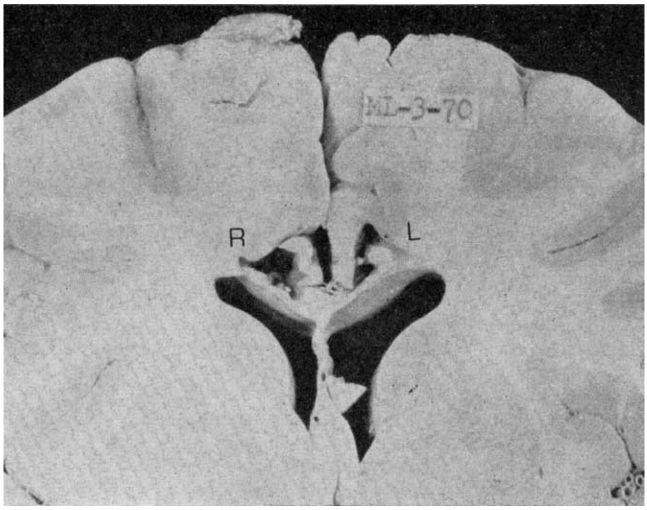

Fig. 16. Typical cingulotomy lesions. (*From* Laitinen L, Livingston K. Surgical approaches in psychiatry. Proceedings of the Third International Congress of Psychosurgery. Lancaster: MTP; 1973; with permission.)

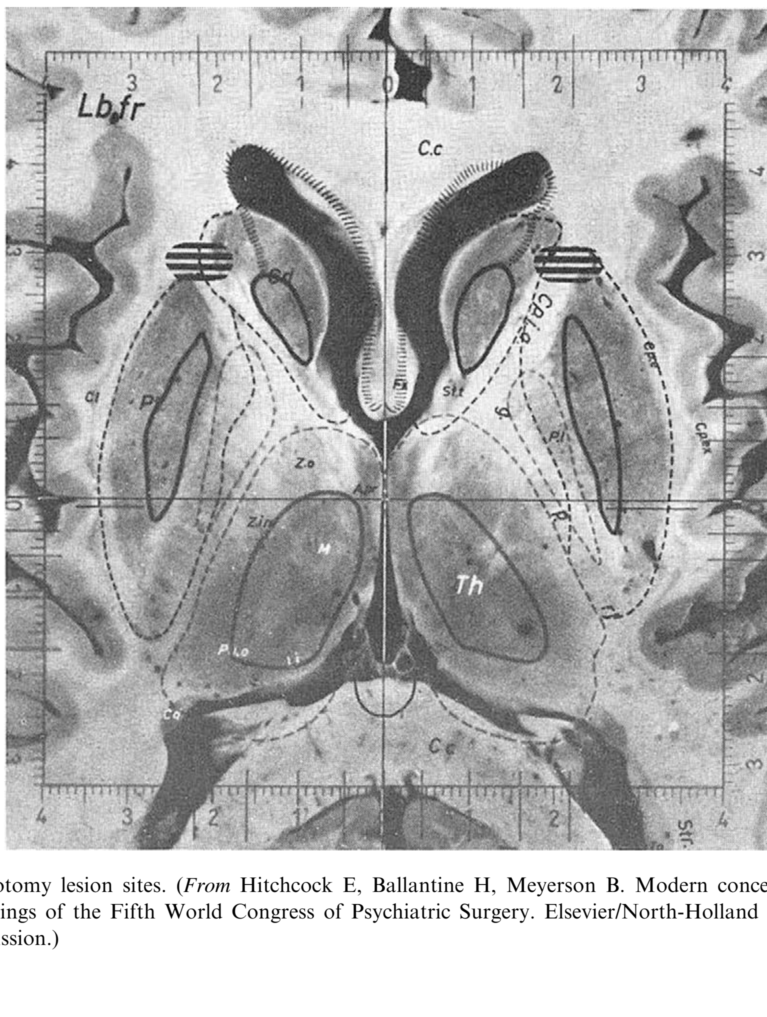

Fig. 17. Capsulotomy lesion sites. (*From* Hitchcock E, Ballantine H, Meyerson B. Modern concepts in psychiatric surgery. Proceedings of the Fifth World Congress of Psychiatric Surgery. Elsevier/North-Holland Biomedical Press; 1979; with permission.)

Subcaudate tractotomy

Another stereotactic procedure geared toward interrupting fibers from the orbitofrontal cortex to the thalamus is subcaudate tractotomy (innominatomy). Developed by Knight in 1965 in London, the operation was designed to relieve depressive, anxiety, and obsession symptoms while minimizing postoperative epilepsy and cognitive/personality deficits [37,38]. The lesion is created by multiple 1-mm × 7-mm rods of yttrium-90, a beta-emitter that releases lethal radiation to tissue within 2 mm. These rods have a half-life of 68 hours, after which they become inert. The target site, a region of white matter localized beneath the head of the caudate known as the substantia innominata, has traditionally been localized by ventriculogram. A stereotactic apparatus places the rods after bilateral burr holes are made just above the frontal sinus and 15 mm from the midline. The lesion itself lays at the anteroposterior level of the planum sphenoidale, extending from 6 to 18 mm from the midline and being 20 mm long in an anteroposterior direction (Fig. 18). Initially, placing two rows of four rods each made the lesion. Later studies, having refined the technique, have created the lesion by radiofrequency thermocoagulation [39].

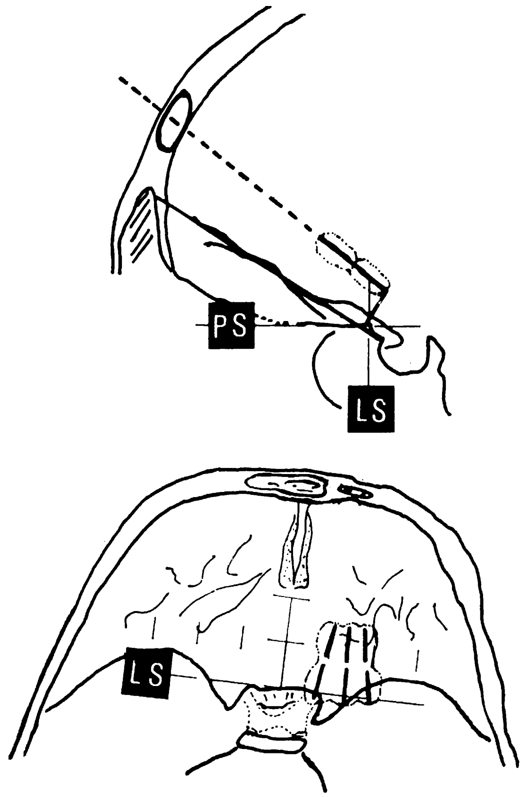

Fig. 18. Sites of subcaudate (basofrontal) tractotomy lesions. (*From* Laitinen L, Livingston K. Surgical approaches in psychiatry. Proceedings of the Third International Congress of Psychosurgery. Lancaster: MTP; 1973; with permission.)

Limbic leukotomy

Although the other three aforementioned procedures each target a single anatomic substrate, a fourth procedure is designed to interrupt fibers at two separate areas, one involving a frontothalamic loop and the other involving an area of the Papez circuit (Fig. 19). Called limbic leukotomy, the procedure was developed in England by Desmond Kelly and Alan Richardson in the early 1970s. The operation itself consists of three 6-mm thermocoagulative or cryogenic lesions in the lower medial quadrant of each frontal lobe (to interrupt frontothalamic connections) and two 6-mm lesions in each cingulum (Fig. 20).

What now?

Despite the fact that neurosurgery for psychiatric illness decreased in frequency in the latter half of the twentieth century and that neurosurgical technologic developments like stereotaxis vastly improved the quality of the surgical intervention itself, the negative bias toward its practice continued to grow. Like the human behavioral example of Newton's third law of motion, the fervor with which psychosurgery was welcomed in the first half of the twentieth century became an ardent backlash against what was regarded as a reckless and sinister procedure. In the United States, charges of abuse and allegations of surgery for social control culminated in the establishment of a National Commission in 1977. This board examined all the neurosurgical procedures performed in the United States from the freehand frontal lobotomies to the stereotactic lesioning procedures. Careful emphasis was taken to review the efficacy and safety of these procedures. The National Commission's findings were surprising, as the Chairman reported in his review: "We looked at the data and so they did not support our prejudices. I, for one, did not expect to come out in favor of psychosurgery. But we saw that some very sick people had been helped by it" [40].

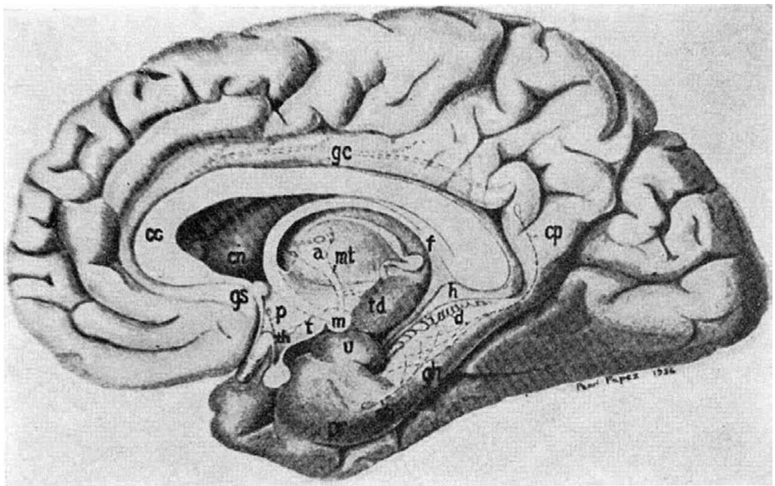

Fig. 19. Papez circuit. (*From* Laitinen L, Livingston K. Surgical approaches in psychiatry. Proceedings of the Third International Congress of Psychosurgery. Lancaster: MTP; 1973; with permission.)

The National Commission was so impressed by the potential benefit of psychiatric neurosurgery that it recommended a review board be formed to study these procedures in a more scientific manner. This review board was never formed, however.

There are several reasons to continue to evaluate the role of neurosurgery in the treatment of psychiatric disease. Despite adherence to therapeutic guidelines and conscientious compliance, there still exists a population of psychiatric patients who are refractory to aggressive conventional treatment with medication and empirically proven psychotherapies. A particularly intractable population exists among OCD patients. By most reviews of current treatment strategies, approximately 10% of all OCD patients show an unrelenting downward course despite all psychotherapeutic and pharmacologic treatments [41,42]. Because it is estimated that 3% of the world's population suffers from OCD, this alone is a substantial patient population. Affective disorder, which includes major depression and bipolar disorder, similarly has a treatment-resistant subset of patients [43,44]. For some of these patients, surgery may still be a viable treatment alternative in the psychiatrists' armamentarium.

It should be made clear that the end point for untreated psychiatric disease is dismal. Setting aside the loss of productivity on both a personal and professional level, self-mutilation and suicide can be the final tragic outcome for a significant number of these refractory psychiatric patients. Treatment-resistant mental disorders, in any of their forms, must be looked on as degenerative and potentially fatal neurologic illnesses.

The promise of a modern undertaking of psychiatric neurosurgery is that it is no longer equivalent to lobotomy. We benefit from the technologic leaps that have occurred over the past 50 years. One of the challenges in treating psychiatric disease during the zenith of lobotomy was the quantitative analysis of patients throughout the course of treatment. Modern psychiatric testing batteries, such as the Y-BOCS, CGI, and HAM-D, allow for a more accurate and objective evaluation of patients undergoing psychiatric neurosurgical procedures in ways that were not previously available.

Neurosurgical practice has also grown tremendously since the heyday of frontal lobotomy. Today's neurosurgeon, bolstered by technologic advancements in stereotactic equipment coupled with the advent of intraoperative microelectrode recording, can hit physiologic targets with a degree of accuracy never before possible. Furthermore, techniques have been developed that allow the neurosurgeon to modulate neurologic function while minimizing the risk to the patient. Stereotactic radiosurgery, exemplified by such devices as the gamma knife, enables lesions to be made without any upfront risk to the patient. Perhaps the neurosurgical technical development that holds the most significance for psychiatric neuro-

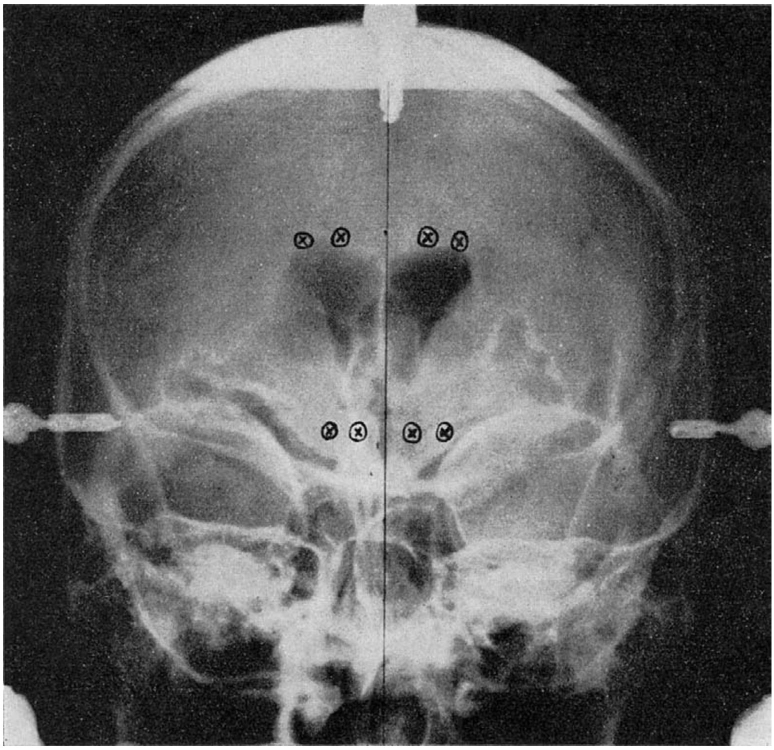

Fig. 20. Limbic leukotomy lesion sites. (*From* Laitinen L, Livingston K. Surgical approaches in psychiatry. Proceedings of the Third International Congress of Psychosurgery. Lancaster: MTP; 1973; with permission.)

surgery is deep brain stimulation (DBS). With its ability to modulate neuronal function without the necessity of a permanent lesion, DBS has already become the mainstay of the neurosurgical treatment of movement disorders. Because previous efforts to prove the efficacy of surgical intervention in psychiatric disease have been hampered by the lack of double-blind studies, DBS, with its inherent ability to be turned "on" and "off," might prove particularly useful.

Our knowledge of the pathophysiology underlying psychiatric disease has also grown. Today, state-of-the art imaging techniques, such as positron emission tomography (PET), functional magnetic resonance imaging (fMRI), and magnetoencephalography (MEG), allow the clinical investigator a noninvasive method of directly and precisely localizing brain function and anatomy. Although experimental, these imaging techniques allow us to evaluate human brain function directly without having the potential misdirection that animal models may entail. This highlights the difference between the surgical efforts for movement disorders and psychiatric disease: although the experimental animal model has bolstered movement disorder surgery, the inherent lack of valid animal models in the latter has hindered efforts. This intermediate link between animal physiologic models and clinical practice is a fundamental paradigm shift with respect to the initial efforts with lobotomy. As our knowledge of the circuitry underlying psychiatric disease increases, better surgical targets will become apparent. Such a link between functional imaging and surgical practice has already been demonstrated in the endeavors in chronic pain and movement disorders. Together, these tools can help to eliminate some of the shortcomings of past studies of psychiatric neurosurgical procedures.

As we re-explore surgery's role in psychiatric treatment, we have learned from the example of lobotomy that we must tread carefully. Our initial efforts, of course, must remain firmly in the realm of a limited number of academic institutions. Ultimately, because of the vast resources implicit in the multidisciplinary approach, psychiatric neurosurgery may never enter community practice. Despite all these improvements and the heeding of past mistakes, patients and clinicians alike must always be cognizant of the potential dangers in this task. Nevertheless, past efforts suggest that a real potential to benefit some extremely sick people may exist. It is up to future multidisciplinary endeavors conducted in carefully controlled centers of academic expertise to determine whether this potential is either real or folly.

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