CEREBRAL HEMISPHERECTOMY
REPORT OF A CASE TEN YEARS AFTER OPERATION
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Since 1928 when Dandy described removal of the right cerebral hemisphere, this operation has not been enthusiastically received because of the generally discouraging results. In review of 13 cases of hemispherectomy in the literature, certain considerations have become clearer concerning (1) the selection of cases, (2) the technic of operation, (3) the resultant disability and ultimate prognosis of the patient, and (4) the proper evaluation of the procedure.

The indications for cerebral hemispherectomy are limited. It should not be considered except in cases of gliomas that are located well away from the midline and that have not invaded too deeply into the basal ganglia. This rules out the usual case of glioblastoma multiforme, with its propensity for advancing across the midline through the corpus callosum. Consequently, the indications narrow down to the occasional slowly growing oligodendroglioma and astrocytoma involving the middle portion of the hemisphere. If a tumor so situated is already causing progressive hemiparesis, the patient is more willing to accept the permanent postoperative disability.

Of the 5 patients operated upon by Dandy,1,2 1 died in 48 hours of hemorrhage; 1 died in 2 weeks from pneumonia; 1 died in 3 months with a recurrence, and 1 died in 3½ years with a recurrence. A follow-up study of the 5th patient beyond the 2nd postoperative week is not available.

Zollinger17 described a patient who expired with meningitis 17 days after left hemispherectomy. Walker15 reported a patient in whom the right cerebral hemisphere was removed by Evans, but the subsequent degree of disability was not detailed. Rowe13 reported the case of a 38-year-old woman subjected to right hemispherectomy and emphasized particularly the psychiatric findings.

Dr. W. James Gardner, of the Department of Neurosurgery of the Cleveland Clinic, has resected the right cerebral hemisphere in 5 patients with brain tumor.4,5,8,9,11 One died of meningitis 29 days after operation; 2 patients died with recurrence after 15 months and 3 years, respectively; 1 died 4 years after operation from an intracranial injury caused by a fall down cellar stairs. The 5th patient is still living 10 years after the hemispherectomy.

In contrast to the patients in Dandy’s series, whose motor infirmities were severe, all 4 of our patients who survived the immediate postoperative period were able to walk unaided by cane or crutch and were able to dress themselves and to do light work after the operation. In all cases the relative
freedom from severe physical handicap and gross mental defect after removal of almost half the cerebrum was striking.

The outstanding clinical symptom in this artificial defect of the brain was a contralateral hemiplegia. This partial paralysis of the contralateral face and limbs, however, did not resemble in every way the classic spastic hemiplegia due to cerebrovascular thrombosis or hemorrhage. The chief difference was the manner in which the upper extremity hung loosely from the shoulder as the patient walked. The limb could be more easily manipulated than in the typical case of spastic hemiplegia. However, on the affected side the tendon reflexes were hyperactive, and the Hoffmann response was consistently positive in all the patients. All patients could elevate the shoulder and had some ability to abduct and adduct the arm and to flex and extend the forearm at the elbow. However, there was a uniform lack of power of the wrist movements and of the fingers. A weak grasp was the maximum response of the affected hand even years after operation. The opponens function of the thumb was entirely absent, and voluntary movement of the individual fingers was impossible.

On the lower left extremity these patients demonstrated a fairly well-retained voluntary control of both thigh and leg movements. Volitional control of the ankle and toes was absent. In every instance on the affected side the tendon reflexes were hyperactive, ankle and patellar clonus could be elicited, and there was a strongly positive Babinski toe reflex.

With all these abnormal signs on the upper and lower limb, evidence of impairment of axial muscles of the neck, spine, chest, and abdomen was lacking. For instance, none of the patients demonstrated marked disparities in movement of girdle muscles, in the action of the ribs during respiration, or in the tone of the muscles of the abdominal wall.

The degree of facial palsy in these patients showed considerable variation. In some instances the left angle of the mouth was immobilized to both voluntary and mimetic stimulation. In other cases the facial weakness was almost imperceptible. In no patient did the facial paralysis involve the upper portions of the face as it does in peripheral or Bell’s palsy.

This unique type of hemiplegia is the result of a mechanically induced brain defect of known extent. Decortication of one side of the body produces the greatest disability in the mouth, the hand, and the foot. These parts have the most completely lateralized representation in the cortex. Hughlings Jackson expressed this conviction in his early observations of cortical function. He stated that movements of the fingers, which have a most specialized and highly differentiated motor behavior, have the least bilateral cortical control.

Sensory disturbances in these patients were not as profound as one might conclude from textbook concepts. It was evident that the type of sensation which was preserved was that which has been best described by Head under the term “protopathic or vital sensation.” The more profound loss consistently occurred in that type of sensation which he designated as “epicritic
or gnostic sense.” This loss of epicritic sense, however, did not apply to the trigeminal area of the affected side, for in all cases two-point discrimination and awareness of light touch was preserved over the skin of the face, although this type of sensitivity was never as good as it was on the unimpaired side.

This preservation of so-called cortical or epicritic sense over the trigeminal zones can best be explained on the basis of bihemispheric representation. Experiments by Woolsey and Fairman indicate that even in certain mammals there is evidence of bicortical representation of trigeminal epicritic sensation. They postulate two sensory areas in each hemisphere. Their “sensory area I” receives impulses from both trigeminal areas as well as from the entire contralateral half of the body. However, even in the decorticated half of the body below the trigeminal zones of our patients there was some evidence of a preservation of sensory functions which are ordinarily assigned to the cortical levels. The patients were able to localize the site of a painful stimulus within 2 or 3 metameres. They were also able to recognize roughly in what position the decorticated arm or leg was passively placed. Vibratory sense was preserved over the entire affected side, although it was moderately impaired. These evidences of some preservation of position sense, of vibratory sense and of definite although poor localization of painful stimuli seem to indicate that there may be, as Woolsey and Fairman have suspected, some ipsolateral corticalization of the old sensory system in their “sensory area II” which, they believed, received impulses from both sides of the body.

Probably of greater concern to the neurosurgeon is the danger of global aphasia when there is uncertainty as to which hemisphere controls speech function. Zollinger is apparently the only writer who recorded the results of a left hemispherectomy in a right-handed patient. In this case the aphasia was incomplete. Several hours after operation the patient answered “all right” to all questions and showed her teeth on command. The following day she became more alert than before operation and added “yes” and “no” to her vocabulary. On the 2nd postoperative day “thank you” and “sleep” were added. On the 3rd postoperative day she used the words “good-bye” and “please” and showed a more accurate use of words. The next day she used “yes” and “no” apparently with a full understanding of their meaning. Zollinger says, “It was my impression that vocabulary could have been gradually increased by training.” Evidently an elementary vocabulary was retained in the non-dominant hemisphere and was increased somewhat by postoperative guidance. Nielsen and others have collected evidence indicating that Broca’s area is not invariably located in the “dominant” hemisphere and that apparently there are some people in whom the function of Broca’s area has shifted from one hemisphere to the other. On record are several cases in which “handedness” was located in one cerebral hemisphere and “speechedness” in the other. Apparently such a phenomenon occurred in the patient to be presented.
Two of our patients who were tested with an audiograph after hemispherectomy showed an almost uniform loss of 5 to 10 decibels in both air and bone conduction in the contralateral ear. This is in agreement with Tunturi's findings on audio-frequency localization in dogs. He concluded that each ear is represented bilaterally in the auditory cortex of each hemisphere but that this representation in each cortical area is stronger for the contralateral ear.

All patients studied by visual field examination showed a homonymous hemianopsia after cerebral hemispherectomy. Dandy indicated that the hemianopsia was complete in the 3 patients whom he studied. All 3 of our patients in whom visual fields were charted showed definite sparing of macular vision. Rowe also recorded macular sparing in his case. Reports by Penfield and Evans indicate that, with fair uniformity, the macula is spared bilaterally when only one occipital lobe is removed. When the optic tracts are unilaterally interrupted anterior to the occipital lobes there may be either macular sparing or macular splitting. Apparently the result depends entirely on the individual affected. It seems reasonable to assume that the macular fibers may be more completely represented bilaterally in some persons than in others.

Mental changes following removal of most of one-half of the cerebrum are surprisingly mild. Rowe described in detail the mental deviations of a female patient. For several weeks after operation she lacked normal inhibitions. There was a wide range of mood and a temporary impairment of recent memory. She gradually became more normal over a period of 6 months until she showed only a slight lability of mood and a talkative disposition. She was mentally active and her intelligence quotient was the same as it had been 1 year previously. Dandy stated that his patients showed no evidence of impairment of intelligence or of memory, although some were more facetious than they had been prior to their illness and had less ability to concentrate for a long period of time. Penfield stated that the defect produced by a frontal lobectomy is "a lack of capacity for planned administration" and "the loss of power of initiative." Study of our cases has indicated that this is the most accurate description of the mental defect produced by removal of the right cerebral hemisphere. None developed antisocial tendencies or became a public charge.

The major complication in many of the recorded cases of cerebral hemispherectomy was the development of postoperative meningitis, which caused the demise of the patient. It should be emphasized that these operations were performed prior to the time that penicillin, streptomycin, and many of the sulfonamide agents became available.

CASE REPORT

A white man, aged 35, was admitted to the Cleveland Clinic in January, 1938, because of a history of progressive weakness of the left leg for the previous 2 months, complicated by jacksonian motor seizures starting on the toes of the left foot. There was some weakness of the left arm, and tendon reflexes were hyperactive on the
left. There was no evidence of a left facial weakness. He had no choking of the disks and no sensory disturbances. Visual fields were normal. A right frontoparietal craniotomy revealed the presence of a subcortical astrocytoma. There was doubt as to the advisability of removing the right cerebral hemisphere because the patient was definitely left-handed. He sighted with the left eye and wrote with the left hand. He used his right hand very clumsily and without evidence of ambidexterity. His father also was left-handed. It was assumed that the patient’s motor speech center was located on the right side. The problem was solved by trephining under local anesthesia over the supposed area of Broca in the right hemisphere and by injecting novocaine subcortically into that area until the left angle of the mouth was paralyzed. Fortunately, the patient’s speech was unaffected by this procedure, and it was there-
fore concluded that the patient had an intact motor speech center in the left cerebral hemisphere while his dominant hand center was in the right hemisphere.

On Mar. 3, 1938, most of the right cerebral hemisphere was removed. The resected specimen contained the claustrum, the putamen, most of the caudate nucleus, and approximately the outer 1/5 of the globus pallidus (Fig. 1). The chief structures remaining in situ on the right side of the brain were the hypothalamus, thalamus, and about 4/5 of the globus pallidus. Mesial portions of the hippocampal and fusiform gyri were spared also. The postoperative course was essentially uneventful. Three weeks after operation the patient developed sufficient use of the left leg to enable him to walk with some assistance. There was a complete paralysis of his left arm and a marked weakness of the left side of the face, most noticeable about the mouth. The mental symptoms in the immediate postoperative period were simply those of emotional blunting and some mental retardation. Speech was not affected.

The patient returned home and began a long period of readjustment. He undertook his old job of operating a small restaurant with the assistance of his wife. He was noted to be jocular, facetious, and fond of teasing his friends. His wife insisted that this was his normal behavior. He had some difficulty in concentrating and was not greatly concerned about the financial affairs of the family. He was inclined to dispose of serious matters with a shrug of his shoulders or with a nonsensical remark. Because of poor control over his right hand he was almost helpless in dressing himself, eating, and writing.

After several months he taught himself to walk without the aid of a cane. Gradually there became possible more individualized movements, such as crossing the left knee over the right, elevating the left shoulder, and even grasping feebly with the left hand. By great perseverance he has finally developed the dexterity of the right hand to the point where he is able to dress himself, to button his clothes, to use eating utensils, and to write his name. He has become rather
proficient in the use of his right hand in chopping wood and in doing odd jobs about the yard. Whereas he formerly was helpless when he fell to the ground, he now has developed a technic of picking himself up entirely unassisted. This notable improvement of motor function has been the result of a gradual readjustment over a 10-year period. Demonstrable improvement is continuing at the present time (Fig. 2). He would like to drive a car but is deterred from this by the combination of hemianopsia and hemiparesis.

EEG studies show a marked decrease in amplitude of the wave pattern over the right side of the head and a total absence of normal alpha activity from that region. Tracings from the left cerebral cortex show normal rhythm.

The sensory examination of this patient 10 years after hemispherectomy is informative. Sensation over the entire right side is normal and is intact to a line 2 cm. to the left of the midline. He complains of a "heavy, dull, doughy, numb feeling" over his left side from the neck down. He states that the left side of his face does not feel exactly like the right side, and explains, "It takes longer for a feeling to come through on the left side of my face." He has no spontaneous pains. The light touch of cotton wool can be perceived on the face but not on the remainder of the left side. When a camel’s-hair brush is dragged along the skin on the left side of the body it is appreciated as a collection of "unpleasant small stickers or pins." With his eyes closed, the patient states that this moving brush is experienced as a stationary or twisting stimulus.

Localization was tested by having the patient place the forefinger of his right hand on the area of his skin stimulated. Light touch and pin prick were accurately localized in the area supplied by the left trigeminal nerve. In testing the remainder of the left side it was necessary to use a painful stimulus, because light touch was not appreciated. The patient complained bitterly throughout this testing period because he thought that the examiner was pressing harder than was necessary. A firm pressure with a dull object caused the identical type of pain that was elicited by a pin prick. The patient was able to localize these noxious stimuli remarkably well in the upper left portion of the body, especially in the distal portion of the arm, where he consistently designated the correct area within 5 cm. On the upper part of the body and the proximal portion of the arm he usually was correct within 15 cm. This ability to localize stimuli on the left side became progressively poorer toward the lower portion of the body and leg.

It was our impression that when a particular area on the left side was stimulated the patient was able to localize the stimulus to its particular metamere more accurately than to the designated area within the metamere. For instance, a stimulus to the lateral surface of the left knee was occasionally referred to the dorsum of the left foot but never to the medial surface of the same knee. The patient stated that stimuli on the left side below the face area were localized by the prolonged after-pain which lingered many seconds after the stimulus had been withdrawn.

Tickling and scraping lightly with the fingernails over the patient’s left palm and sole caused a very unpleasant burning, stinging feeling. Vibration sense over bony prominences was definitely preserved, although it was slightly diminished in the left leg and arm as compared with the right.

The patient showed a marked loss of two-point discrimination. This loss seemed to be entirely out of proportion to the loss of localizing ability for one point. When two points 5 to 10 cm. apart were employed, he could tell occasionally whether one point or two points were used. He recognized this, he said, only by the fact that "Two points hurt twice as much as one point." He was not able to localize two points
applied simultaneously to the left side below the face unless they were separated by several dermatomes.

The patient was not able to distinguish cool water from tepid water consistently, but either hot or cold water was quickly perceived as a painful stimulus. He has noticed that for these extremes of temperature there are often no differences in sensation which allow him to distinguish hot from cold; they are both painful. He is unable to enjoy winter outings because the cold causes his left side to become disagreeably painful, and when he becomes chilled there is a severe involuntary, persistent clenching of the left hand and flexion of the left arm at the elbow.

Passive movement was appreciated only if there was a sudden motion in a definite direction over a range of at least 15°. The arm or leg frequently could be moved over a distance of 20 to 25° without the patient’s knowledge if the change was made slowly and easily. If the movement was appreciated, the direction was consistently stated correctly. When the examiner placed the left limbs in a certain position, the patient was able to simulate this position fairly well with the limbs of the unaffected side. Position sense of the fingers and toes was entirely lacking. The patient stated that sensibility to pain was the same in both testes and on both sides of the glans penis. Abdominal and cremasteric reflexes were present bilaterally but were diminished on the left side. Strongly positive Hoffmann and Babinski responses were obtained on the left. Wrist, patellar, and ankle clonus could be elicited in the left extremities. The reflexes on the right side of the body were normal. Bladder and bowel function, sphincter control, and sexual activity were unaffected by operation.

Procaine hydrochloride block of the right stellate ganglion was performed. A good physiologic response was indicated by the resultant Horner’s syndrome on the same side. The patient spontaneously stated that the left side of his body had “more feeling in it and seemed 80 pounds lighter” following the block. He later claimed that the left arm and leg felt “easier to handle” for several weeks after the block. Objective confirmatory evidence of improvement could not be demonstrated. While no exact conclusions can be made from this experiment, it is surmised that the blocking of the sympathetic impulses to the right side of the head affected the circulation of the intact right thalamus sufficiently to cause the modification of sensation from the paralyzed side as the patient described it.

A conference with the wife of the patient gave us the clearest picture of his mental status 10 years after operation. He still worries little about finances and may spend his extra money with rather poor judgment at times, but he has never shown any asocial or antisocial tendencies. He takes home life seriously and continually occupies himself about the house and yard. He is personally immaculate, as he always was, and continues to keep his room in order and to store his belongings in their proper places. He likes to make short journeys, and he occasionally rides a truck to neighboring towns with his friends. He occasionally accompanies his cronies on trips to a hunting lodge where he stays in camp and tends the fire. He continues to be sociable and to amuse everyone with numerous stories. His disposition is generally good. He becomes emotionally upset easily, but these moods pass quickly. He has never exhibited a hypochondriacal attitude. His memory does not seem to be impaired. His wife states that he is still a good poker and pinochle player. He does not use intoxicating beverages to excess and does not show a decreased tolerance to alcohol. His health has been excellent. Both he and his wife are grateful that the operation was performed.
CONCLUSION

In carefully selected cases of slowly growing gliomas, cerebral hemispherectomy may be the treatment of choice. The sensory and motor postoperative changes are not utterly incapacitating if the paleostriatum and thalamus remain essentially intact. Mental changes are not profound.

REFERENCES