J Neurosurg 89:865–873, 1998

Historical vignette

Irving S. Cooper (1922–1985): a pioneer in functional neurosurgery

Kaushik Das, M.D., Deborah L. Benzil, M.D., Richard L. Rovit, M.D., Raj Murali, M.D., and William T. Couldwell, M.D., Ph.D.

Department of Neurological Surgery, New York Medical College, Valhalla, New York

Irving S. Cooper (1922–1985), the son of a salesman, worked his way through high school, college, and medical school to become one of the pioneers in functional neurosurgery. He developed several novel techniques for the surgical management of Parkinson's disease and other crippling movement disorders. A keen interest in the physiology of movement disorders was kindled by his doctoral research and continued during his neurosurgical training. He began to apply this knowledge to surgical practice in 1952 when he began his faculty career as Assistant Professor of Surgery at New York University. At the time, surgical treatment of parkinsonian tremor focused on various techniques used to interrupt the pyramidal tract. During a subtemporal approach for a cerebral pedunculotomy, he inadvertently injured and, subsequently, was forced to occlude the anterior choroidal artery. Much to Cooper's surprise, following emergence from anesthesia the patient's tremor and rigidity were abolished without any residual hemiparesis. This serendipitous observation, together with Meyer's earlier work on the role of the basal ganglia in motor control, helped focus surgical efforts on targets within the basal ganglia and, subsequently, within the thalamus to alleviate the movement disorders associated with Parkinson's disease. While at New York University, Cooper developed chemopallidectomy and, later at St. Barnabas Hospital in the Bronx (1954–1977), he used cryothalamectomy as a surgical technique for primary control of tremor in patients with Parkinson's disease. Cooper authored many original papers on surgical techniques and several textbooks on the lives of patients afflicted with Parkinson's disease and other crippling movement disorders. Although considered controversial, this fascinating and complex neurosurgeon made significant contributions to this field.

Key Words • **cryosurgery** • **dystonia** • **movement disorder** • **Parkinson's disease** • **thalamotomy** • **tremor** • **neurosurgical history**

Irving S. Cooper was born in Atlantic City, New Jersey on July 15, 1922 to Lewis and Lillian Cooper. His father, who was one of 11 brothers, worked as a businessman supplying kitchen equipment to hotels in Atlantic City. Irving had one brother, David, who also became a physician. During the Great Depression the family business experienced difficult times and at one point they were forced to leave their home and live with other families. As a result, young Irving worked during high school and college to help finance his education. He attended public schools as a child and enrolled in undergraduate studies at George Washington University in Washington, D.C. Cooper worked during college delivering meat to help pay his tuition. Interestingly, his initial intent to pursue a career in law was changed after a customer commented that his appearance was more suited to someone in the medical profession.

Cooper completed a Bachelor of Arts degree at George Washington University in 1942. He continued his studies at George Washington University for his doctorate in medicine, which he completed in 1945 (Fig. 1). An internship at the United States Naval Hospital in 1946 was followed by neurosurgical training at the Mayo Clinic in Rochester, Minnesota. During this time, Cooper also earned a Masters degree followed by a doctorate in neurophysiology from the University of Minnesota. It was during this period that he developed an interest in physiology, which specifically fueled his interest in studying the neurophysiological mechanisms underlying movement disorders. Following his neurosurgical training at the Mayo Clinic, which lasted from 1948 to 1951, he accepted a faculty appointment at New York University (NYU). Early in his career he performed most of his clinical work at Bellevue Hospital in New York City. In 1954 he organized the Department of Neurosurgery at St. Barnabas Hospital in New York City, where he subsequently performed thousands of operations for the treatment of movement disorders. In 1977 Dr. Cooper left NYU and was appointed Director of the Center for Physiologic Neurosurgery at Westchester County Medical Center and Research Professor of Neuroanatomy at New York Medical College in Valhalla, New York, positions he held until his death in 1985.

FIG. 1. Photograph of Irving S. Cooper, circa 1947. Courtesy of John Hogle, photographer.

Foundations of Functional Neurosurgery

At the time Cooper completed his neurosurgical training, surgical management of movement disorders focused on the treatment of Parkinson's disease. In the 1930s and 1940s there were a large number of patients with postencephalitic Parkinson's disease.[84] Medical therapy was limited, leaving surgery as the sole method available to alleviate the patients' distressing tremor. During this period, operations had been devised to attack all levels of the nervous system, including the cerebral cortex,[10–12] cerebral peduncle,[8,95] and spinal cord[84] to the radicular level. Neurosurgical procedures for Parkinson's disease were initially aimed at the pyramidal tract and operations were devised to resect either the premotor or motor area itself for tremor ablation. In 1940 Klemme[74] described 100 resections of the premotor cortex; in 39 patients relief of tremor was achieved with no significant neurological deficit. In the series by Bucy[10] reported in 1942, both the premotor and motor cortex were resected; this initially produced plegia, but ultimately left the patient hemiparetic although without tremor. Subsequent to this, Putnam[85] devised the operation of pyramidotomy, which consisted of incising the pyramidal tract at the second cervical level of the spinal cord. Walker[95] introduced the pedunculotomy, which involved interrupting the pyramidal tract at the level of the midbrain; this was considered superior to cortical resection in that it avoided the convulsions associated with cortical resection. All of these procedures relieved tremor at the expense of motor function and did nothing to address the other cardinal manifestations of Parkinson's disease (rigidity and akinesia).

Major advances in the surgical therapy of Parkinson's disease occurred when the focus shifted to targets within the basal ganglia and thalamus. Meyers issued his pioneering reports[78,79] on a series of operations that revealed that sectioning of the pallidofugal fibers emerging from the medial globus pallidus resulted in improvement in both tremor and rigidity. Following these reports, other surgeons, including Spiegel and Wycis,[90,91] produced similar lesions in the pallidofugal fibers by using stereotactic localization. They reported reduction in tremor and rigidity without paralysis in four of six patients.[91] Fenelon and Thiebaut[69] devised a direct method for ansa lenticularis coagulation in which a transfrontal approach was used to pass an electrode transcortically to make a lesion. Using a subfrontal approach, Guiot and Brion directly coagulated the mesial globus pallidus; in this series[71] 42.5% of patients had an excellent outcome.

Cooper's Pioneering Work

Surgical Occlusion of the Anterior Choroidal Artery

During his career, Cooper developed several novel techniques for the surgical management of Parkinson's disease and other movement disorders. Perhaps none was more notable than the one inadvertently selected in October 1952, when Cooper was performing the approach to a pedunculotomy (as described by Walker) in a 39-year-old man who was incapacitated by postencephalitic tremor, right hemirigidity, and severe retrocollis. Using a subtemporal approach, the arachnoid just above the tentorium was opened with a sharp hook; an artery coursing in the region was torn, bled profusely, and was subsequently occluded with silver clips. The pedunculotomy was aborted. When the man emerged from anesthesia, much to Cooper's surprise the patient's tremor and rigidity were abolished although his motor and sensory function remained intact. The postoperative angiogram showed that the anterior choroidal artery had been occluded. Cooper concluded that the unintentional occlusion of the anterior choroidal artery resulted in a medial globus pallidal infarction that alleviated the patient's tremor and rigidity.[14] This hypothesis was consistent with anatomical work performed in animals by Alexander.[1] The next logical step Cooper pursued was to occlude the anterior choroidal artery purposefully in patients with advanced Parkinson's disease. Over the next 3 years, Cooper occluded the anterior choroidal artery in 50 patients (Fig. 2). He reported excellent results in 65% of cases, noting improvements in tremor, rigidity, bradykinesia, and gait disturbances.[14,43] A battery of tests performed by a team of independent observers including neurologists, physiatrists, and psycholgists was used to evaluate outcome in this series.[33,41] Patients underwent a thorough physical examination, neurological examination, psychological studies, speech evaluation, and electromyographic and cinematographic recordings. In addition, patients' subjective impressions and observations made by relatives, nurses, and referring medical doctors were made part of the permanent medical records. Complications included an operative mortality rate of 10%, three cases of hemiplegia, one case of moderate aphasia, and one case of quadrantic hemianopsia.[9,73,81]

The main difficulties encountered with anterior choroidal artery occlusion were the inconsistent results that were obtained and the complications related to the variable territory of the basal ganglia that the artery irrigated.[44] In autopsy series and primate models, it was found that the anterior choroidal artery supplies medial and intermediate portions of the globus pallidus.[57] However, particularly in elderly patients with occlusive vascular disease, it can also supply the posterior portion of the internal capsule.[80] Cooper believed this was the reason why hemiparesis was more common in this latter group of patients. Given the results of his surgical experience,[51,52,66] he recommended

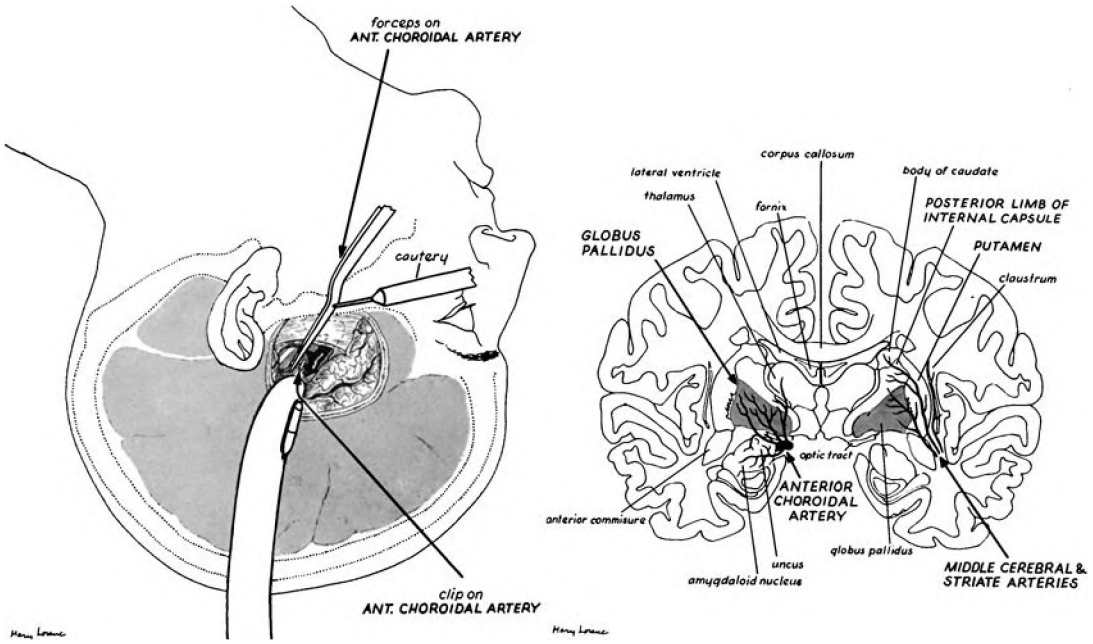

FIG. 2. *Left:* Diagram illustrating the surgical technique of occlusion of the anterior choroidal artery by vascular clips. The temporal craniectomy and subtemporal approach are shown. *Right:* Diagram showing the territory of irrigation of the anterior choroidal artery demonstrating the supply to the medial basal ganglia. Reproduced with permission from Cooper IS: **Parkinsonism: Its Medical and Surgical Therapy.** Springfield, Ill: Charles C Thomas, 1961.

that the procedure only be performed in patients younger than 55 years of age.

Chemopallidectomy and Chemothalamectomy

The experience with anterior artery occlusion had suggested that the motor symptoms of tremor, rigidity, and bradykinesia from Parkinson's disease could be improved by lesioning the basal ganglia. Through retrospective analysis, it was determined that patients with unilateral tremor, rigidity, and motor difficulties were ideal candidates for surgery. However, there was a need for a procedure that was safer and would provide more consistent results.

In September 1953 Cooper conceived the idea of chemopallidectomy as an alternative means of creating a lesion within the globus pallidus. For this surgery, patients first underwent preoperative pneumoencephalography for radiographic localization. Using the pallidectomy guide,[83] a cannula was then inserted through a small trephine so that the tip of the cannula could be placed in the medial globus pallidus (Fig. 3). After local anesthesia had been induced in the patient, a test lesion was created by procaine injection; if this resulted in alleviation of contralateral tremor and rigidity, a destructive lesion was created by an injection of absolute alcohol.[16,27]

As his experience using this technique increased, Cooper found that occasionally the procaine would reflux along the path of the cannula or would be diluted by extracellular fluid, making results unreliable. He therefore sought a more reliable method for producing a test lesion. By injecting air or liquid into the lumen of a small inflatable balloon, a test compressive lesion was produced. If successful, this would be followed by creation of the permanent destructive lesion (Fig. 4).[29] Cooper reported a mortality rate of less than 3% in his series of 70 patients who underwent chemopallidectomy that was performed using this technique.[14,20,35,36,59] Instances of morbidity consisted of only one case of hemiplegia and six cases of transient hemiparesis. This early experience, in which the coordinates developed at the time were used, also suggested that pallidotomy was best for treating rigidity but somewhat inconsistent for treating tremor.[5,6,16,17,21,37,49,56,57]

Hassler's seminal work in the early 1950s[72,73] helped determine that the main outflow of the medial globus pallidus was to the ventrolateral thalamus. Almost at once Cooper and Bravo and their colleagues[5,17,19,20,40,53,76,77] and Hassler and Reichert[72,73] started producing lesions by using stereotactic techniques in the ventrolateral thalamus. Thalamotomy proved to be more effective in alleviating tremor.[34,48,67,68,76,77] Along with interruption of the pallidal thalamic fibers in the subthalamus, thalamotomy rapidly became the operation of choice for the treatment of tremor caused by Parkinson's disease.[86–88] In 1960, Cooper[42] published the results of a series of 1000 consecutive operations on the basal ganglia and thalamus for Parkinson's disease with an impressive rate of success and a low rate of complications.

Cryothalamectomy

While at St. Barnabas Hospital, Cooper developed an alternative technique for creating lesions in the basal ganglia and thalamus. He conceived the idea after receiving a carbon dioxide wine bottle opener as a gift. While using the bottle opener, he noticed the carbon dioxide cooling his hand and how much the device looked like a brain cannula. In 1960, with the help of Robert Johnson, an engi-

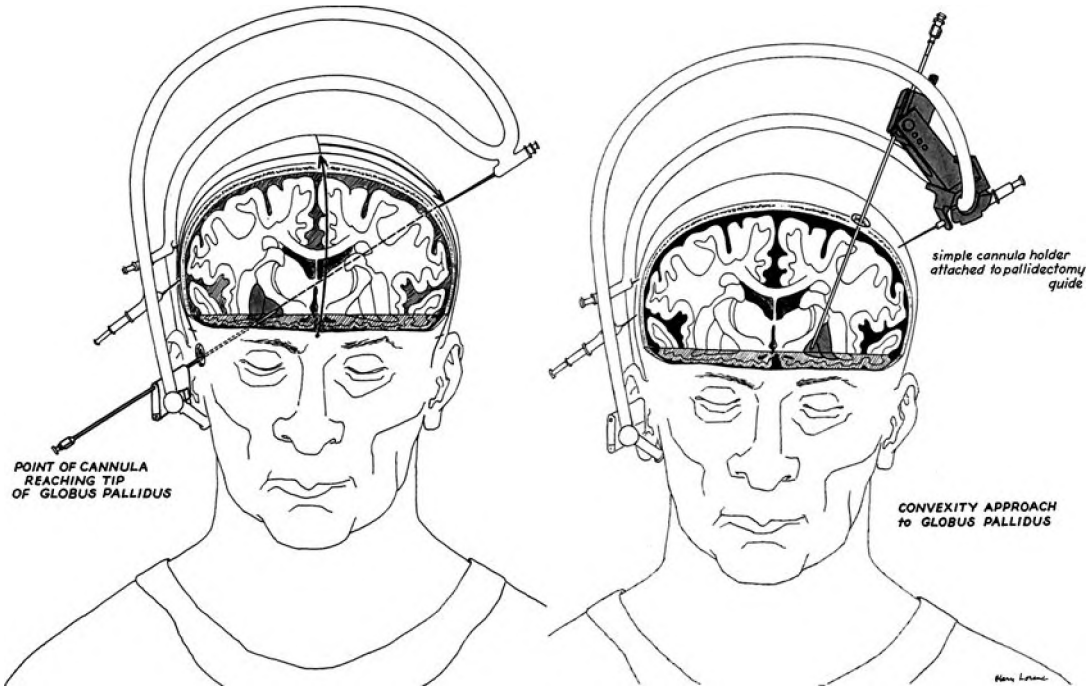

FIG. 3. *Left:* Diagram illustrating the subtemporal trajectory initially used for passing the cannula into the globus pallidus to perform chemopallidectomy in 1953. *Right:* Later, a frontal convexity approach was adopted to pass the cannula into the globus pallidus, similar to the approach utilized for performing contemporary pallidotomy. Reproduced with permission from Cooper IS: **Parkinsonism: Its Medical and Surgical Therapy.** Springfield, Ill: Charles C Thomas, 1961.

neer, and Arthur Rinfret, a cryobiologist, Cooper designed the first cryosurgical probe for use in the brain.[23,54,55] The instrument consisted of a cannula that was insulated on the sides but had an uninsulated tip so it could be cooled to produce a lesion. The first cryothalamectomy was performed in October 1962.[13,22] Using the same localizing techniques as those in his earlier operations, Cooper made a test lesion by cooling the area after the cannula was placed in the ventrolateral thalamus. If the patient's tremor and rigidity were successfully abolished, liquid nitrogen (-196°C) would be introduced into the cannula, freezing the tip of the cryoprobe and creating the ablative lesion (Fig. 5). Cryosurgery was also used to treat other movement disorders,[65] most notably lesioning of the posteroventrolateral area of the thalamus for the treatment of dystonia musculorum deformans.[26,30,50] Cooper treated numerous patients with Parkinson's disease by using this technique; he reported a mortality rate of less than 1.5%, a success rate of 90% in good-risk patients, and a success rate of 60% in poor-risk patients.[24,39,60,92,93]

Cooper has often been called the father of cryosurgery because of his development of cryosurgical equipment. Although others had preceded him in the use of freezing techniques to produce lesions in other organs, it is clear that Cooper's leadership in the development of cryosurgical instrumentation in neurosurgery was a major stimulus toward the development of cryosurgical apparatuses and techniques in many other areas of medicine.[64]

Cerebellar and Deep Brain Stimulation

In the early 1970s Cooper began work on cerebellar and deep brain stimulation for the treatment of intractable epilepsy and spasticity.[15,58] The foundation for this concept had been established in animal studies on cats that had demonstrated that stimulation of the anterior lobe of the cerebellum could ease decerebrate rigidity. While Cooper was a fellow at the Mayo Foundation, he discovered a report on the work of the Italian physiologist Giuseppe Moruzzi,[82] who had noted that electrical stimulation of the cerebellum could inhibit or facilitate motion depending on the frequency applied. With the help of engineers, Cooper designed a stimulator that consisted of electrodes that would be placed on the cerebellum or in the posterior portion of the ventrolateral nucleus of the thalamus adjacent to the internal capsule. The electrodes were then connected to wires that were tunneled under the skin to a generator embedded in the subcutaneous region of the chest. The work, which began in 1972, continued until Cooper's death in 1985. Cooper published results of series of patients treated with chronic cerebellar stimulation and deep brain stimulation for the treatment of spasticity and intractable seizures.[52,61] He reported that 55% of patients experienced useful improvements.[62] However, others who attempted controlled studies usually found negative or equivocal results when using these techniques.[47] It is interesting to note that recent work by Benabid and colleagues[2] and by others[3,75] has renewed interest in the use of stimu-

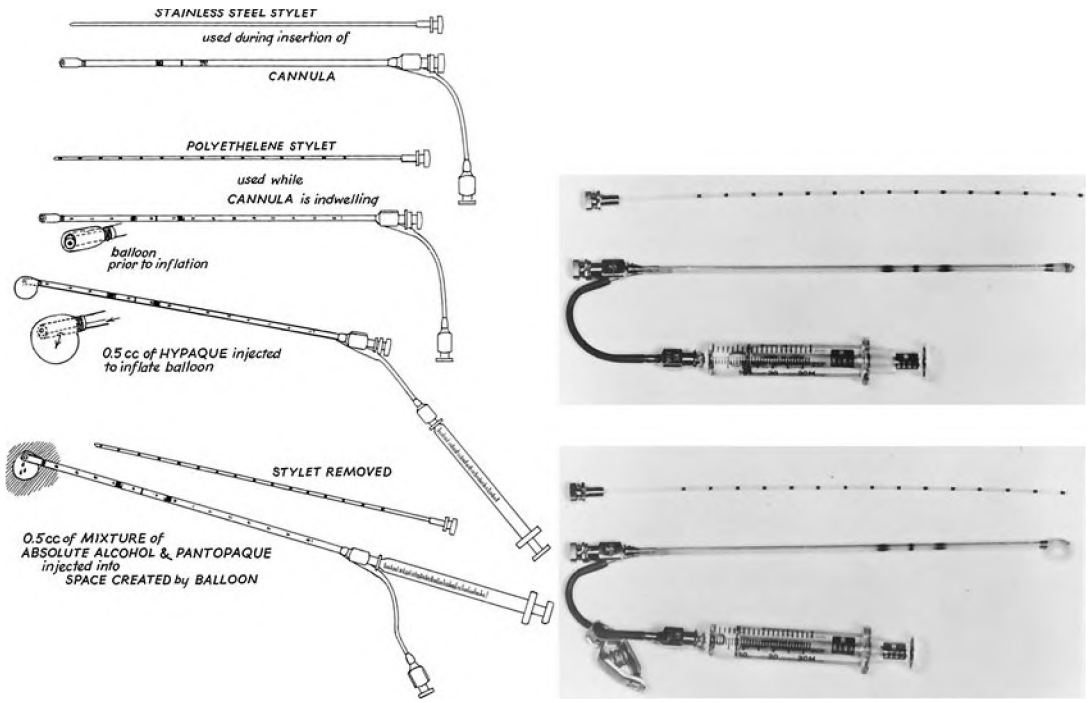

FIG. 4. *Left:* Diagram of the cannula with inflatable balloon used for chemopallidectomy. Reproduced with permission from Cooper IS: **Parkinsonism: Its Medical and Surgical Therapy.** Springfield, Ill: Charles C Thomas, 1961. *Right:* Photograph of the actual instrument. Once in place the balloon was inflated to make a test lesion before creating the permanent lesion by instilling absolute alcohol. Reproduced with permission from Bravo G, Cooper IS: Chemopallidectomy–two recent technical additions. **J Am Geriatr Soc 5:**653, 1957.

lators for the treatment of Parkinson's disease and other movement disorders.

A Controversial Academician

Cooper was a complex and charismatic man whose creativity, dedication to human welfare, and energy contributed to his many achievements. However, during the most productive portion of his career, many colleagues found his work controversial. One may wonder why he provoked such strong emotional, frequently irrational, and destructive responses from his peers. There are a number of possible explanations for the behavior of the prominent and influential doctors at that time; however, probably none are completely satisfactory. It should be recognized that 40 years ago medical discussions were confined to peer-reviewed journals and the appearance of a young, attractive surgeon in the lay press or, worse yet, on television was anathema to a large portion of the academic community. Also, Cooper's somewhat brash, nondeterred approach did not sit well with some of his colleagues. Much of this was a matter of style, but acrimony regarding the man and his methods occasionally reflected on his work. In the introduction to Cooper's autobiography *The Vital Probe: My Life as a Brain Surgeon*, Dr. Adrian Upton states "It is my view that a young physician could achieve a lifetime of negative results; such an individual would gain a reputation for honesty and integrity without the risk of jealousy or suspicion in his colleagues. However, a young physician can expect nothing but trouble from an important and original discovery made early in his career. Such an individual would be wise to attribute his discovery to luck rather than ability. An even more cynical thought is that a pioneer should develop some physical handicap (a limp, a stutter, or an eye patch) in order to offset jealousy with sympathy."[47]

To be sure, Dr. Cooper was in his early 30s when he reported his original observations about the basal ganglia and movement disorders. He believed that surgical treatment would benefit patients afflicted with these crippling disorders. His attempts to widen the use of these procedures were seen by many as self-promotion. Many persons in the medical community criticized Cooper because he subjected patients to procedures that had not been confirmed in animal models or in controlled studies. In addition to this, his results often could not be reproduced by other surgeons. Cooper responded by saying that there were no suitable models for this disease: "I had the ultimate responsibility to be right. I'm treating desperate patients who come to me for help, not an experiment."[22]

The slightest rumor about exaggeration, hiding of adverse results, personality problems, financial advantage, or harm to patients caused widespread criticism of Cooper's entire body of work. Much smaller series of results were accepted without question, particularly if the conclusions disagreed with the work of Cooper and his associates.[47] He was occasionally subject to illogical, unscientific, and emotional attacks, and even the results obtained

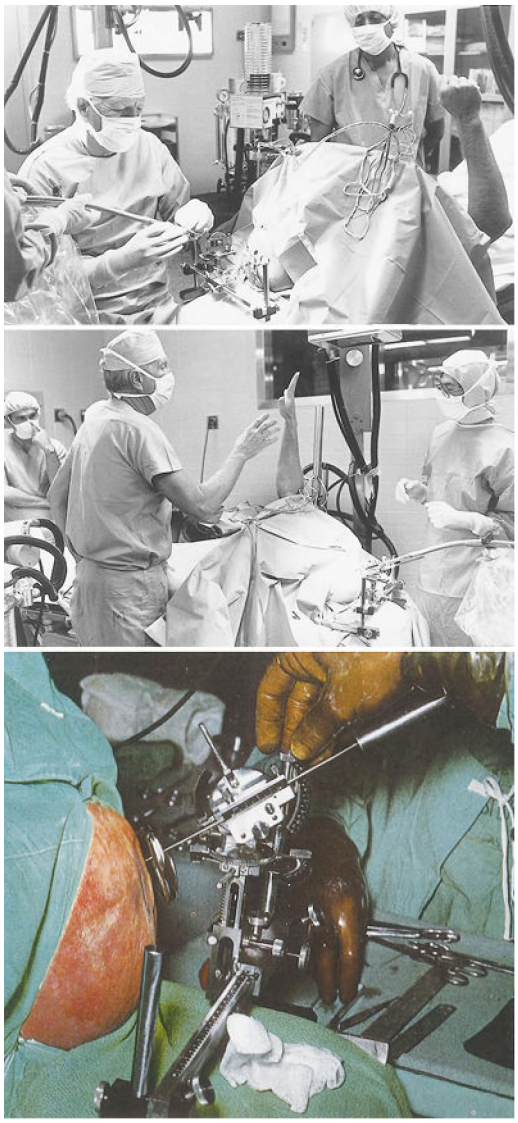

FIG. 5. *Upper:* Photograph showing a cryosurgical probe being inserted while the patient is receiving localized anesthesia. After the probe is placed in position, a test lesion is made by cooling the probe to 0°C, followed by creation of a permanent lesion as the probe is cooled to −196°C using liquid nitrogen. *Center:* As the test lesion is made, the patient is asked to open and close his hand to confirm accurate placement of the cryosurgical probe by assessing rigidity, bradykinesia, and strength before creating the permanent lesion. *Lower:* Photograph of the stereotactic apparatus used to perform cryothalamectomy, displaying the mechanical microdrive that is used to make fine adjustments to the probe position. Photographs courtesy of John Hogle, photographer.

from a single monkey experiment were used to negate results he reported from the surgical treatment of hundreds of patients.[47]

Once, during a meeting, after presenting results of his surgery, Cooper was criticized by persons in the audience who said his work was not performed scientifically and

FIG. 6. Photograph of Cooper speaking with the family of a girl with dystonia musculorum deformans prior to her surgery. Photograph courtesy of John Hogle, photographer.

questioned its validity. Cooper responded by bringing patients out on the stage, one by one, after having shown films of their preoperative disabilities. Displays such as this were not looked on favorably by the medical community at the time, and Cooper was viewed as a showman rather than a scientist. Dr. Cooper's youth and enthusiasm continued to jar the academic community. He traveled the world speaking about his results, frequently to lay audiences. His work was received more favorably outside the United States,[18] especially in Europe where he was made a member of many prestigious neurosurgical societies. During his illustrious career he authored nearly 300 journal articles and several books about parkinsonism, other involuntary movement disorders, and surgical techniques.

To his credit, after learning about levodopa from the work of Dr. George Cotzias (Brookhaven National Laboratory, Upton, New York), Cooper immediately deferred 700 patients who were scheduled for surgery and enrolled them in one of the first clinical trials for the use of levodopa for Parkinson's disease at St. Barnabas Hospital.

Dr. Cooper was praised by many, such as British scientist and author C.P. Snow[89] who described Cooper as "professionally one of the great brain surgeons of the world" and regarded him as a true innovator. Others saw Cooper as someone who publicized his results through his novels and by other means before going through the usual forum of peer review.

Irving S. Cooper, Author and Humanist

Cooper will always be remembered for his humanistic attitude in caring for patients (Fig. 6). He was the author of novels about the lives of patients afflicted with crippling neurological diseases. He once stated "the patient is never free, because he is imprisoned by his disease."[46] In one of his novels, *The Victim is Always the Same*,[46] Cooper describes the moral and ethical dilemma he encountered before surgically treating a young girl with dystonia musculorum deformans[25] whose case was deemed hopeless by other doctors:

> How does one decide to place for the first time an instrument deep in a child's brain and destroy part of it? It's not just

> a question of overcoming the technical difficulties, which can always be worked out in the laboratory. It's a more profound moral question than that, because only human beings have this disease.[32]

Cooper stated that modern medicine has forced us to witness human suffering analytically and become detached.

> In my view when this occurs, the goal of medicine—to make sick people well, or failing that to relieve pain and suffering—becomes obscured.[45]

He believed that understanding how illness affects patients and their entire families is something that is often overlooked and deemphasized in physician training. In his autobiographical novel *The Vital Probe: My Life as a Brain Surgeon*,[47] Cooper highlighted some of the achievements of his remarkable career through vivid descriptions of surgery and the lives of the people he affected. He also expressed his rage at the blindness, arrogance, and pettiness of some established doctors of the time, who Cooper believed saw new discoveries as threats to their careers rather than hope for their patients. Cooper died of cancer in 1985. He is survived by his wife, five sons, and one daughter. Toward the end of his career, he founded the Cooper Institute for Advanced Studies in Medicine and the Humanities in Naples, Florida, which is now managed by his wife, Sissel Cooper.

Conclusions

Irving S. Cooper was a fascinating, complex, and controversial man whose work constitutes an invaluable contribution to the field of functional neurosurgery. Although he was criticized for the forum he used to convey his surgical results, the significance of his contributions should not be overlooked. Those who knew him personally remember him as a charismatic, energetic, and innovative neurosurgeon who fostered a humanistic approach to treating patients afflicted with crippling neurological diseases.

Acknowledgments

The authors thank Mrs. Jane Beers (personal research assistant) and John Hogle (photographer) of Westchester County Medical Center in Valhalla, New York, and Mrs. Sissel Cooper of Naples, Florida, wife of the late Dr. Cooper, for providing much of the personal biographical information contained herein.

References

1. Alexander L: Vascular supply of strio-pallidum. **Res Nerv Mental Dis Proc 21:**77–132, 1942
2. Benabid AL, Pollak P, Louveau A, et al: Combined (thalamotomy and stimulation) stereotactic surgery of the VIM thalamic nucleus for bilateral Parkinson disease. **Appl Neurophysiol 50:**344–346, 1987
3. Blond S, Caparros-Lefebvre D, Parker F, et al: Control of tremor and involuntary movement disorders by chronic stereotactic stimulation of the ventral intermediate thalamic nucleus. **J Neurosurg 77:**62–68, 1992
4. Bravo G, Cooper IS: Chemopallidectomy–two recent technical additions. **J Am Geriatr Soc 5:**651–655, 1957
5. Bravo GJ, Cooper IS: A clinical and radiological correlation of the lesions produced by chemopallidectomy and thalamectomy. **J Neurol Neurosurg Psychiatry 22:**1–10, 1959
6. Bravo GJ, Cooper IS: Early electroencephalographic observations following chemopallidectomy. **J Am Geriatr Soc 4:** 1275–1279, 1956
7. Brock S, Constable K, Cooper IS, et al: Parkinson's disease: medical and surgical management. Transcription of a panel meeting on therapeutics. **Bull NY Acad Med 32:**202–235, 1956
8. Browder J: Section of the fibers of the anterior limb of the internal capsule in Parkinsonism. **Am J Surg 75:**264–268, 1948
9. Bucks JF, Cooper IS: Speech problems in parkinsonian patients undergoing anterior choroidal artery occlusion of chemopallidectomy. **J Am Geriatr Soc 4:**1285–1290, 1956
10. Bucy PC: Cortical extirpation in the treatment of involuntary movements. **Res Nerv Ment Dis Proc 21:**551–595, 1942
11. Bucy PC, Buchanan DN: Athetosis. **Brain 55:**479–492, 1932
12. Bucy PC, Case TJ: Tremor. Physiologic mechanism and abolition by surgical means. **Arch Neurol Psychiatry 41:**721–746, 1939
13. Caracalos A, Levita E, Cooper IS: A study of rotengenoanatomic lesion location and results in cryosurgery of the basal ganglia. **St Barnabas Hosp Med Bull 1:**24–32, 1962
14. Cooper IS: Anterior choroidal artery ligation for involuntary movements. **Science 118:**193, 1953 (Letter)
15. Cooper IS (ed): **Cerebellar Stimulation in Man.** New York: Raven Press, 1978
16. Cooper IS: Chemopallidectomy: an investigative technique in geriatric parkinsonians. **Science 121:**217–218, 1955 (Letter)
17. Cooper IS: Chemopallidectomy and chemothalamectomy for parkinsonism and dystonia. **Proc Roy Soc Med 52:**47–60, 1959
18. Cooper IS: Chemopallidectomy for parkinsonism and juvenile extrapyramidal hyperkinesis, in Van Bogaert L, Radermecker J (eds): **International Congress of Neuroscience.** London: Pergamon Press, 1959, pp 108–115
19. Cooper IS: Chemopallidectomy in parkinsonism and juvenile extra-pyramidal hyperkinesia. **Problem Neurosurg 3:**3–8, 1958 [Reference unverified]
20. Cooper IS: Chemosurgery for parkinsonism. **Med Sci 3:** 524–527, 1958
21. Cooper IS: Clinical results and follow-up studies in a personal series of 300 operations for parkinsonism. **J Am Geriatr Soc 4:**1171–1181, 1956
22. Cooper IS: A cryogenic method for physiologic inhibition and production of lesions in the brain. **J Neurosurg 19:**853–858, 1962
23. Cooper IS: Cryogenic surgery: a new method of destruction or extirpation of benign or malignant tissues. **N Engl J Med 268:** 743–749, 1963
24. Cooper IS: Cryogenic surgery of the basal ganglia. **JAMA 181:**600–604, 1962
25. Cooper IS: Dystonia musculorum deformans, alleviated by chemopallidectomy and chemopallidothalamectomy. **Arch Neurol Psychiatry 81:**5–19, 1959
26. Cooper IS: Dystonia reversal by operation on basal ganglia. **Arch Neurol 7:**132–145, 1962
27. Cooper IS: Etopalin: a new substance useful for production of focal intracerebral lesions in human subjects. **J Am Geriatr Soc 4:**1033–1034, 1956 (Letter)
28. Cooper IS: Heredofamilial tremor. Abolition by chemothalamectomy. **Arch Neurol 7:**129–131, 1962
29. Cooper IS: Intracerebral injection of procaine into the globus pallidus in hyperkinetic disorders. **Science 119:**417–418, 1954
30. Cooper IS: An investigation of neurosurgical alleviation of parkinsonism, chorea, athetosis, and dystonia. **Ann Intern Med 45:**381–392, 1956
31. Cooper IS: **Involuntary Movement Disorders.** New York: Harper & Row, 1969

32. Cooper IS: **It's Hard to Leave While the Music's Playing.** New York: Popular Press, 1977
33. Cooper IS: Ligation of the anterior choroidal artery for involuntary movements—Parkinsonism. **Psychiatric Q 27:**317–319, 1953
34. Cooper IS: Neurosurgical alleviation of intention tremor of multiple sclerosis and cerebellar disease. **N Engl J Med 263:** 441–444, 1960
35. Cooper IS: Neurosurgical alleviation of parkinsonism. **Am Surg 22:**1070–1075, 1956
36. Cooper IS: Neurosurgical alleviation of parkinsonism. **Bull NY Acad Med 32:**713–724, 1956
37. Cooper IS: **The Neurosurgical Alleviation of Parkinsonism.** Springfield, Ill: Charles C Thomas, 1956
38. Cooper IS: **Parkinsonism: Its Medical and Surgical Therapy.** Springfield, Ill: Charles C Thomas, 1961
39. Cooper IS: Principles and rationale of cryogenic surgery. **St Barnabas Hosp Med Bull 1:**5–10, 1962
40. Cooper IS: Relief of juvenile involuntary movement disorders by chemopallidectomy. **JAMA 164:**1297–1301, 1957
41. Cooper IS: Results of anterior choroidal artery occlusion in parkinsonism. **Arch Neurol Psychiatry 73:**578–579, 1955 (Abstract)
42. Cooper IS: Results of 1,000 consecutive basal ganglia operations for parkinsonism. **Ann Intern Med 52:**483–499, 1960
43. Cooper IS: Surgical alleviation of parkinsonism: effects of occlusion of the anterior choroidal artery. **J Am Geriatr Soc 11:**691–718, 1954
44. Cooper IS: Surgical occlusion of the anterior choroidal artery in Parkinsonism. **Surg Gynecol Obstet 99:**207–219, 1954
45. Cooper IS: Surgical treatment of parkinsonism. **BMJ 1:** 1248–1249, 1961 (Letter)
46. Cooper IS: **The Victim is Always the Same.** New York: Harper & Row, 1973
47. Cooper IS: **The Vital Probe: My Life as a Brain Surgeon.** New York: WW Norton, 1981
48. Cooper IS, Bravo G: Chemopallidectomy and chemothalamectomy. **J Neurosurg 15:**244–250, 1958
49. Cooper IS, Bravo GJ: Alleviation of dystonia musculorum deformans and other involuntary movement disorders of childhood by chemopallidectomy and chemopallido-thalamectomy. **Clin Neurosurg 5:**127–149, 1957
50. Cooper IS, Bravo GJ: Anterior choroidal artery occlusion, chemopallidectomy and chemothalamectomy in parkinsonism: a consecutive series of 700 operations, in Fields WS (ed): **Pathogenesis and Treatment of Parkinsonism. Sixth Annual Scientific Meeting of the Houston Neurological Society.** Springfield, Ill: Charles C Thomas, 1958, pp 325–352
51. Cooper IS, Bravo GJ: Implications of a five-year study of 700 basal ganglia operations. **Neurology 8:**701–707, 1958
52. Cooper IS, Bravo GJ: Production of basal ganglia lesions by chemopallidectomy. **Neurology 8:**344–346, 1958
53. Cooper IS, Bravo GJ, Riklan M, et al: Chemopallidectomy and chemothalamectomy for parkinsonism. **Geriatrics 13:** 127–144, 1958
54. Cooper IS, Lee AS: Cryostatic congelation: a system for producing a limited controlled region of cooling or freezing of biologic tissues. **J Nerv Ment Dis 133:**259–263, 1961
55. Cooper IS, Lee AS: Cryothalamectomy–hypothermic congelation: a technical advance in basal ganglia surgery. Preliminary report. **J Am Geriatr Soc 9:**714–718, 1961
56. Cooper IS, Poloukhine N: Chemopallidectomy: a neurosurgical technique useful in geriatric parkinsonians. **J Am Geriatr Soc 3:**839–859, 1955
57. Cooper IS, Poloukhine N: The globus pallidus as a surgical target. **J Am Geriatr Soc 4:**1182–1207, 1956
58. Cooper IS, Poloukhine N: Neurosurgical relief of intention (cerebellar) tremor: a preliminary report. **J Am Geriatr Soc 7:** 443–445, 1959
59. Cooper IS, Poloukhine N, Morello A: Surgical alleviation of parkinsonism. **JAMA 160:**1444–1447, 1956
60. Cooper IS, Riklan M: Cryothalamectomy for abnormal movement disorders. **St Barnabas Hosp Med Bull 1:**17–23, 1962
61. Cooper IS, Upton ARM: Therapeutic implications of modulation of metabolism and functional activity of cerebral cortex by chronic stimulation of cerebellum and thalamus. **Biol Psychiatry 20:**811–813, 1985
62. Cooper IS, Upton ARM: Use of chronic cerebellar stimulation for disorders of disinhibition. **Lancet 1:**595–599, 1978
63. Cooper IS, Upton ARM, Amin I: Chronic cerebellar stimulation (CCS) and deep brain stimulation (DBS) in involuntary movement disorders. **Appl Neurophysiol 45:**209–217, 1982
64. Cooper IS, Waltz JM: Cryogenic applications in neurosurgery. **J Cryosurg 1:**15–30, 1968
65. Dierssen G, Gioino GG, Cooper IS: Participation of ipsilateral hemisphere lesions in the pathology of hemichorea in hemiballismus. **Neurology 11:**894–898, 1961
66. Diller L, Riklan M, Cooper IS: Preoperative response to stress as a criterion of the response to neurosurgery in Parkinson's disease. **J Am Geriatr Soc 4:**1301–1308, 1956
67. Fairman D, Cooper IS: Criteria in the selection of parkinsonian patients for chemopallidectomy. **J Am Geriatr Soc 4:** 1214–1218, 1956
68. Fairman D, Diller L, Riklan M, et al: Preoperative studies in selection of parkinsonism patients for surgery. **J Am Geriatr Soc 4:**1233–1239, 1956
69. Fenelon F, Thiebaut F: Résultats du traitement neurochirurgical d'une rigidité parkinsonienne par intervention striopallidale unilatérale. **Rev Neurol 83:**280, 1950
70. Figurelli V, Cooper IS: Twelve-foot radiography for cryothalamectomy. **St Barnabas Hosp Med Bull 1:**37–46, 1962
71. Guiot G, Brion S: Traitement des mouvements anormaux par la coagulation pallidale. Technique et résultats. **Rev Neurol 89:** 578–580, 1953
72. Hassler R, Reichert T: Indikationen und Lokalisationsmethode der gezielten Hirnoperationen. **Nervenarzt 25:**441–447, 1954
73. Hassler R, Reichert T: Über die Symptomatik und operative Behandling der extrapyramidalen Bewegungsstörungen. **Med Klin 53:**817–824, 1958
74. Klemme RM: Surgical treatment of dystonia, paralysis agitans and athetosis. **Arch Neurol Psychiatry 44:**926, 1940 (Abstract)
75. Lenz FA, Dostrovsky JO, Kwan HC, et al: Methods for microstimulation and recording of single neurons and evoked potentials in the human central nervous system. **J Neurosurg 68:** 630–634, 1988
76. Lin TH, Cooper IS: Results of chemopallidectomy and chemothalamectomy. A study of one hundred cases of parkinsonism with ages over sixty. **Arch Neurol 2:**188–193, 1960
77. Lin TH, Dierssen, G, Mingrino S, et al: Relationship between candidacy and outcome in surgery for parkinsonism. **Arch Neurol 3:**267–278, 1960
78. Meyers HR: The modification of alternating tremors, rigidity and festination by surgery of the basal ganglia. **Nerv Ment Dis 21:**602–665, 1942
79. Meyers HR: Surgical procedure for postencephalitic tremor, with notes on the physiology of the premotor fibers. **Arch Neurol Psychiatry 44:**455–457, 1940
80. Morello A, Cooper IS: Arteriographic anatomy of the anterior choroidal artery. **AJR 73:**748–751, 1955
81. Morello A, Cooper IS: Visual field studies following occlusion of the anterior choroidal artery. **Am J Ophthalmol 40:** 796–801, 1955
82. Moruzzi G: **Problems in Cerebellar Physiology.** Springfield, Ill: Charles C Thomas, 1950
83. Parera C, Cooper IS: A modification of the chemopallidectomy guide. **J Neurosurg 17:**547–550, 1960

84. Parkinson J: **An Essay on the Shaking Palsy.** London: Whittingham & Rowland, 1817
85. Putnam TJ: Relief from unilateral paralysis agitans by section of the lateral pyramidal tract. **Arch Neurol Psychiatry 40:** 1049–1050, 1938 (Abstract)
86. Riklan M, Cooper IS: Chemosurgery and multidiscipline rehabilitation in Parkinson's disease. **Rehabil Rec 1:**26–31, 1960
87. Riklan M, Diller L, Laszewski Z, et al: Vocational status following chemopallidectomy and thalamectomy for parkinsonism. I. The problem and initial findings. **Arch Phys Med Rehabil 39:**634–641, 1958
88. Schacter JM, Bravo CJ, Cooper IS: Involuntary movement disorders following basal ganglia surgery in man. **Neuropathology 19:**228–237, 1960
89. Snow CP: Book reveiw: "The Victim Is Always the Same." **NY Times Book Review,**. August 12, 1973, Sect 7, p 3
90. Spiegel EA, Wycis HT: Ansotomy in paralysis agitans. **Arch Neurol Psychiatry 71:**598–614, 1954
91. Spiegel EA, Wycis HT, Thur C: The stereoencephalotome. **J Neurosurg 8:**452–453, 1951
92. Stellar S, Cooper IS: Basal ganglia surgery for abnormal movement disorders. Experience with 2,250 cases. **S Dakota J Med Pharm 16:**19–22, 1963
93. Stellar S, Cooper IS: Morbidity and mortality studies in 2,868 consecutive cases of parkinsonism treated by cryothalamectomy. **Acta Neurol Scand 44:**258, 1968 (Abstract)
94. Torres M, Cooper IS, Poloukhine N: Effects of lesions in the putamen on involuntary movements and rigidity in Parkinson's disease. **J Am Geriatr Soc 4:**1309–1319, 1956
95. Walker AE: Cerebral pedunculotomy for the relief of involuntary movements. II. Parkinsonian tremor. **J Nerv Ment Dis 116:**766–775, 1952

Manuscript received December 29, 1997.
Accepted in final form April 6, 1998.
Address reprint requests to: William T. Couldwell, M.D., Ph.D, Department of Neurological Surgery, New York Medical College, Munger Pavilion, Valhalla, New York 10595. email: william_couldwell@nymc.edu.