Experiment at Bedside

: Harvey Cushing’s Neurophysiological Research*

Ock-Joo KIM**

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Often regarded as the founder of neurosurgery in America, Harvey Cushing developed neurosurgery as a specialty during the early twentieth century.\(^1\) A product of the reform of medical education during the late nineteenth century in America, he stood at the center of the twentieth-century transformation of American medicine. Born in Cleveland, Ohio in 1869, Cushing received his medical education at the Harvard Medical School, from 1891 to 1896.\(^2\) He then began a residency at

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** Department of History of Medicine and Medical Humanities, Seoul National University College of Medicine


2) John F. Fulton. Harvey Cushing: A Biography. Springfield Illinois: Charles C. Thomas, 1946; Elizabeth H. Thomson. Harvey Cushing: Surgeon, Author, Artist. New York: Neal Watson Academic Publications Inc.; 1981. Fulton was Cushing’s student and one of the founding members of the Harvey Cushing Society. He reconstructed Cushing’s life as much detail as possible, drawing upon voluminous primary sources such as Cushing’s and his
the Johns Hopkins Hospital under the noted
surgeon William Stewart Halsted. In 1900, his
residency completed, Cushing traveled to Europe to
spend fourteen months in experimental study with
Charles Sherrington and Theodor Kocher. After
returning to Johns Hopkins Hospital in 1901,
Cushing established a center for experimental
research in surgery, the Hunterian Laboratory of
Experimental Medicine in 1905. 3) Cushing had
become interested in neurosurgery during his
residency at Johns Hopkins, and began to develop
his neurosurgical skills. By 1908, he possessed a
national reputation as a "brain surgeon"; patients
came to him steadily from throughout the country.

In 1912, Harvey Cushing moved from Baltimore
to Boston, to become Moseley Professor of
Surgery at the Harvard Medical School and
Surgeon-in-Chief at the newly- built Peter Bent
Brigham Hospital. At the Brigham Hospital, he
established a resident system, laboratories, an
operating system, and post-mortem examinations.
At Harvard, Cushing established neurosurgery as a
medical specialty, educating medical students and
training surgical residents who came from all over
the world to work with him. By 1931, Cushing
had operated on more than 2,000 brain tumors,
steadily lowering his surgical mortality rate. He
was honored as a surgeon, a physiologist, and a
man of letters.4) On his retirement from Harvard
in 1932, he served as a professor of neurology at
Yale University until he died of myocardial
infarction in 1939.

During the period from 1896 to 1912 when Cushing
established himself as a neurosurgeon at Johns
Hopkins Hospital, he also pursued neurophysiology.
Along with William Stewart Halsted's experimental
studies on surgery, Cushing's neurophysiological
work has been praised as a breakthrough in modern
neurosurgery. 5) In pursuing physiological questions,
Cushing relied not only on laboratory experiments but
also on clinical observation and surgical experiments
upon his patients. As an elite academic surgeon at
a teaching hospital, Cushing played a dual role as a
scientist and a clinician and freely crossed over the
boundary between therapeutic and non-therapeutic
experiments. Cushing's case shows that a clear-cut
boundary between therapeutic and non-therapeutic
experiments, which was demarcated after the World
War II, did not exist in the early twentieth century
America. This paper seeks to analyze the context of

contemporaries' correspondence, papers and speeches. Thomson's biography of Cushing is less voluminous and more
interpretative than Fulton’s.

3) Harvey Cushing, Instruction in operative medicine. With the description of a course given in the Hunterian
Laboratory of Experimental Medicine. Johns Hopkins Hospital Bulletin 1906;17:123-34. For a short history of the
Hunterian Laboratory, see P. Sampath, D. M. Long, and H. Brem. The Hunterian Neurosurgical Laboratory: the
4) For example, see S. K. Pandya. Harvey Cushing: The man and his literary contributions. Neurology of Indiana
5) N. P. Christy. Harvey Cushing as Clinical Investigator and Laboratory Worker. American Journal of Medical
Sciences 1981;281:79-96; S. H. Greenblatt. The Crucial Decade: Modern Neurosurgery's Definitive Development in
Cushing’s experiment upon his patients. I will employ Cushing’s case to examine how the surgical experimentalism, surgical practice, and professional identity were interconnected in performing surgical research in early twentieth-century America.

1. Cushing and surgical experimentalism

With his education at Yale, Harvard, and Johns Hopkins, and European universities, and with his training both at the bedside and in the laboratory, Cushing helped to create a new profession in the United State, that of the clinical scientist. In the late nineteenth century, inspired by the successes of German scientific medicine, American physicians founded full-time appointments for basic medical sciences in the medical schools of major universities.\(^6\) The opening of the Johns Hopkins Hospital in 1889 and the Medical School in 1893 were part of a broad reformation in American medical education. Reformers advocated university-based medical education, with a strong emphasis on laboratory teaching and research. The professionalization of the basic medical sciences and the establishment of the laboratory medical teaching created young doctors skilled both in science and in clinical medicine. Scientifically oriented doctors established their own networks through journals and conferences, united by their strong advocacy of experiment. Cushing’s call for the specialization of neurosurgery in 1905 was based on an ideology of experimentation shared among elite medical scientists.

Like his teachers, preceptors, and colleagues, Cushing interpreted history of medicine as a progressive achievement enlightened by experimentation. Although they all placed a highly value on experimentation, the term “experiment” was used in different ways by various groups. First, basic medical scientists who underwent professionalization earlier than clinical scientists argued that experimentation in the laboratory should be the foundation of the modern medicine. William Henry Welch and Lewellys Barker, for example, believed that only laboratory-based medical education could make good physicians, among whom the highest noble minds would become experimenters to produce valuable knowledge of human kind.\(^7\) Second, while approving of laboratory experimentation as a historical necessity for medical progress, physician William Osler emphasized the importance of clinical observation on patients and of clinical studies that incorporated experimentation upon patients.\(^8\) Since disease was the very experiment of the Nature, meticulous clinical studies on patients would reveal the hidden secrets of the human body. To Osler, the bedside was the

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\(^7\) Lewellys Barker. Medical laboratories: their relation to medical practice and medical discovery. Science 1908.

laboratory of the physician. Neither an experimenter in the laboratory nor an ordinary practitioner could solve imminent problems posed at the bedside. As the historian Gerald Geison has pointed out, there was a creative tension that included elements of both cooperation and competition between basic scientists and clinical scientists in the early decades of the twentieth century.9) Third, the leading surgeons including William Stewart Halsted and William Williams Keen stressed contemporary surgery’s interdependence upon experimental sciences since the advent of elective surgery brought by antiseptics and anesthesia.10) With direct accessibility to the inside of the human body, these pioneering surgeons experimented upon their patients with new surgical techniques. From their surgical experiments, the surgeons tried to produce practicable knowledge for saving patients’ lives as well as physiological knowledge. They shared the surgical experimentalism: the surgeon’s moral obligation to perform experimentation. These three groups exerted a great influence on Cushing personally as well as academically while he was working at the Johns Hopkins Hospital. Trained in this interactive complexity, Cushing embodied these different meanings of experiments in his various activities while at Johns Hopkins.11)

2. Innovative experimental operation on the pituitary

Cushing’s well-known experimental studies on the pituitary gland characterized his mind-set as well as the experimental spirit dominant at Johns Hopkins in the early decades of the twentieth century. Since 1901 when he first saw a pituitary tumor patient, he became interested in pituitary diseases, puzzled by their various manifestations. Questions posed at the bedside about pituitary gland were moved to laboratories at the Hunterian Laboratory for Experimental Medicine, a place for pursuit of basic research with clinical relevance. With the help of John Homans and Samuel J, Crowe, Cushing removed the pituitary glands of one hundred dogs to understand the function of the

11) While working at the Johns Hopkins Hospital, Cushing, with the experimentalist’s spirit, performed various activities in relation to experimentation, medical practice and medical education. His bacteriological and physiological experiments at the laboratory were published as Harvey Cushing. A comparative study of some members of a pathogenic group of bacilli of the Hog Cholera or Bac. Enteritidis (Gartner) Type, Intermediate between the typhoid and colon groups. With the report of a case resembling typhoid, in which there occurred a post-febrile osteomyelitis due to such an intermediate bacillus. Johns Hopkins Hospital Bulletin. 1900;11:156-70; Concerning a definite regulatory mechanism of the vasomotor centre which controls blood pressure during cerebral compression. The Johns Hopkins Hospital Bulletin 1901;12:1-8; Concerning the poisonous effect of pure sodium chloride solutions upon the nerve-muscle preparation. American Journal of Physiology 1901;6:77-90. He also made Oslerian clinical observation at the bedside and produced clinical knowledge. For example, see Harvey Cushing. Perineal zoster, with notes upon cutaneous segmentation post-axial to the lower limb. American Journal of Medical Sciences 1904;37:375-91. For an example of surgical experiment, see Harvey Cushing, Samuel Crowe, and John Homans. Experimental hypophysectomy. Johns Hopkins Hospital Bulletin. 1910;21:127-69.
gland. The stark similarities in appearance between animals with a partially removed pituitary gland and his patients with pituitary diseases spurred Cushing to further studies on the pituitary gland clinically and experimentally. Inventing new operative techniques, Cushing attempted surgical cure of pituitary diseases. His pituitary operations served two-folded experiments: therapeutic experiments of the pituitary diseases and pathophysiological experiments on the effect of surgical extirpation of the gland. His innovative operations upon patients with pituitary diseases were experimental in nature because no proven therapy had been established yet.

At the same time, the surgical extirpation of the gland granted Cushing to observe the symptoms of depletion of the gland. From the integration of meticulous pre- and post-operative observations of patients and animal experimentation, Cushing produced comprehensive knowledge on pituitary endocrinology. This work was often regarded as the culmination of his Johns Hopkins years.

3. Experiment inseparable from treatment: trigeminal nerve experiment

While physiologists worked with animals most of the time, Cushing studied physiology also from the bedside and the operating table. As a surgeon with legitimate access to the inside of the human body, Cushing was well aware that he had a better opportunity than physiologists in the laboratory to produce physiological knowledge. Cushing attacked the questions which neurophysiologists working with animals could not easily solve - the sensory function of the nervous system. While operating upon twenty patients suffering from trigeminal neuralgia from 1899 to 1905, Cushing concurrently performed physiological experiments, in order to elucidate the sensory function of the nerve. Treatment and experiment were interdependent and inseparable.

A typical trigeminal neuralgia patient whom Cushing operated on had the following history. In August 1899, a sixty-three-year-old man, formerly a prosperous sea captain, came to Cushing for surgical treatment. Suffering from trigeminal neuralgia for nine years, the patient spent all his life savings to obtain relief from the constant, unbearable pain in his face that frequently intensified into paroxysms. The areas of the face and mouth cavity, supplied by the three branches of the trigeminal nerve, were very sensitive to stimulation. Unable to speak or to swallow food, the patient weighed only ninety pounds. The intractable pain deprived him of sleep. He had undergone extraction of all of his teeth and three operations of peripheral neurectomy, which had given him only temporary relief. When he came to the hospital, he was so desperate that, without relief from the pain, he was considering suicide, something not uncommon among this kind of patient. Such patients sometimes looked insane: screaming loudly and constantly, with emaciated,

12) Harvey Cushing. The surgical aspects of major neuralgia of the trigeminal nerve. A report of twenty cases of operation on the Gasserian ganglion, with anatomic and physiologic notes on the consequences of its removal. the Journal of the American Medical Association (JAMA) 1905;44:773-778; 860-865; 920-929; 1002-1008; 1088-1093.
dirty, and hairy faces that they could not bear to touch even lightly, for fear of exacerbating the pain. After Cushing succeeded in excising the ganglion and sensory root of the patient’s trigeminal nerve, the patient slept eight hours without interruption. The next morning, he said that it was his “first long sleep in nine years.” Nine months after the operation, he had gained forty pounds, to restore his usual weight. Four years later, the patient reported to Cushing that he remained free from symptoms: “My face has not given me any trouble whatever since the operation was performed... My general health is good and I have a splendid appetite.”

The twenty patients with this desperate neuralgia were the subjects of Cushing’s physiological inquiries. With a clear design for research, Cushing made thorough pre-operative tests of sensations of touch, temperature, pain, and taste with various stimuli in order to establish the patient’s equation. A few elderly patients had already lost their sense of taste before the operation. The pre-operative tests also trained patients to identify different stimuli promptly. For more than two to three weeks after extirpation of the Gasserian ganglion, the root of the trigeminal nerve, he examined the changes in the four sensations in the tongue, the skin of the face, and the mucous membrane of the mouth and throat everyday. Cushing was able to demarcate the sensory fields in the skin and mucous membrane, governed by the trigeminal nerve. In his papers, Cushing included post-operative photographs of his patients with the anesthetized areas marked with black lines on their faces. Accompanied by detailed and vivid case histories of the patients, the photographs illustrated the areas of sensation innervated by the trigeminal nerve. Cushing found that the sensory distribution of the trigeminal nerve possessed a distinct shape. The anterior line of the area anesthetized after Gasserian ganglion extirpation was the median-longitudinal line of the scalp and face, where all sensations of touch, temperature, and pain disappeared. The posterior line was irregular and varied among individuals. Invariably, however, the posterior line of tactile and thermal anesthesia enclosed the tragus, and upper and anterior wall of the external auditory canal.

Cushing took full advantage of being a surgeon, when he drew a final conclusion about the relationship between the trigeminal nerve and the sensation of taste. The anatomist and the physiologist failed to elucidate the route of the taste fiber. The clinical observations and interpretations were so contradictory that some concluded that the route of taste fibers showed considerable individual variation. Confused by the intricate phenomena of disturbance in taste sensation caused by an intracranial lesion, for example, one physician said to Cushing: “One feels inclined to think that there may

14) Harvey Cushing. The surgical aspects of major neuralgia of the trigeminal nerve. A report of twenty cases of operation on the Gasserian ganglion, with anatomic and physiologic notes on the consequences of its removal. the Journal of the American Medical Association (JAMA) 1905;44:773-778; 860-865; 920-929; 1002-1008; 1088-1093. For the citation, see p.864.
be individual variations in the proportion of taste fibres present in the nervus intermedius and glossopharyngeal on the one hand, and in the fifth [the trigeminal nerve] on the other."17) Cushing thought that such individual anatomical variations were improbable.

After an operation, Cushing made regular examinations to see whether his patient had preserved or lost the sense of taste. For about ten days after an operation, patients could not recognize taste with the anterior two-thirds of the tongue on the operated side. After a transient period of one or two weeks, patients recovered their entire sense of taste. General sensation of the anterior two-thirds of the tongue on the same side as the operation remained anesthetized permanently after the operation. Most previous papers, which had reported post-operative loss of taste sensation, had relied upon tests executed during the first two or three weeks while the patient was hospitalized.

From his systematic clinical observation of thirteen patients who had undergone Gasserian ganglion extirpation, Cushing concluded that the trigeminal nerve “in all probability does not convey taste fibres to the brain either from the anterior or posterior portion of the tongue.”18) In April 1903, soon after publication of his paper on the independence of taste fibers from the trigeminal nerve, Cushing sent a copy to the distinguished British neurophysiologist Charles Sherrington at Liverpool with whom he studied three years ago. In 1898 from an experiment with monkeys, Sherrington had concluded that section of the trigeminal nerve caused loss of the sensation of taste as well as general sensation.19) In May 1903, in a rather apologetic tone Sherrington replied that the surgeon was in an incomparably better position for the study of sensation than the physiologist.

The “trigeminus” observations interest me particularly. We have as physiologists much to hope from these observations by the surgeons, for “interrogation” is the only means of communication that can deal adequately with the subtleties of sensation: & this means of communication is barred to the physiologist even in dealing with his nearer ancestry, the apes or even his grandmotherly anthropoids … Sensation can only be adequately judged of as between man & man.20)

While studying the sense of taste in animal experiments, Sherrington said that he had not realized that he had pushed animal physiology “beyond its legitimate capability.”21)

Cushing’s research on trigeminal function embraced the tension of playing double roles both as a scientist and as a healer. Given that previous studies employing occasional, short-term tests led to confusion about the path of taste sense, Cushing made special efforts to perform rigorous

19) Charles Sherrington. Examination of the peripheral distribution of the fibres of the posterior roots of some spinal nerves. Philosophical Transactions of the Royal Society, Series B. 1898;190:45-186.
21) Ibid.
examinations upon patients. The patients were subjected to tedious and time-consuming daily examinations for several weeks. The examination of sensation took much time, requiring great patience on the part of subject, who after an operation easily became tired from the tests. In these experiments, however, patients’ cooperation was essential. Obviously those examinations gave no benefit to patients; rather it gave them discomfort. Judging by his description of patients’ records, Cushing did not always get permission from his patients for their participation in research. To quote the historian Susan Lederer, “What physicians understood by the words ‘full consent and understanding’ is less clear than the circumstances in which they solicited patient permission.”

22) When admitted to the Johns Hopkins Hospital, a teaching hospital with plenty of free beds, patients were considered as “clinical material” for education and research. Some of his patients, whom Cushing described as “intelligent patients,” understood Cushing’s purpose and helped him. In general patients participated in his experiments, because they believed that the tests were part of the procedure for their treatment. Most of all, the environment of the experiments compelled the patients to take part in them. After the operation, the patient, relieved from the severe pain that had afflicted them for many years, felt obliged to accept his surgeon’s solicitation. One patient resisted the test, claiming that Cushing had experimented on him with routine daily examination of his palate, sensation, and taste. Cushing described the patient in a negative tone: the patient was a farmer, thereby implying an “unintelligent patient” compared to a cooperative intelligent patient. He was a “habitual opium-eater,” who tried “to extort money from the hospital.” Despite the uncooperativeness of this patient, Cushing reproduced a picture of him in his paper. While handling difficult patients was not easy, Cushing still managed to collect data from them.

24) Harvey Cushing. The surgical aspects of major neuralgia of the trigeminal nerve. A report of twenty cases of operation on the Gasserian ganglion, with anatomic and physiologic notes on the consequences of its removal. the Journal of the American Medical Association (JAMA) 1905;44:773-778; 860-865; 920-929; 1002-1008; 1088-1093.

4. Experiment on the operating table
— localization of the sensory cortex

Trained himself as a surgeon-physiologist, Cushing capitalized on access to the human brain for his experiment on the localization of the human cortex. While performing brain surgery, he developed the technique of electrical stimulation of the human cortex. After becoming familiar with the methods of electrical stimulation of the brain at Sherrington’s laboratory in 1901, Cushing systematically stimulated the motor cortex of more than fifty anesthetized patients during operations. Sherrington’s experiment in which Cushing
participated was to delineate functional areas in the motor cortex of chimpanzees and gorillas by means of electrical stimulation. After returning to Baltimore, Cushing tried to verify the motor cortex of the brain in man: “… for the past five years I have invariably put into practice whenever stimulation of the cerebral hemisphere, exposed by operation or injury, has been needed for purposes of localization, or has seemed justified in the interests of physiological investigation.” While “the interest of physiological investigation” and “the purpose of localization” for treatment did not always come together, Cushing did not mention whether he received permission from patients to electrical stimulation for “the interest of physiological investigation.”

Questions of the cerebral localization in man intrigued neuroscientists for several decades in the late nineteenth century. Such British scholars as John Hughlings Jackson, David Ferrier, and later Charles Sherrington as well as Germans such as Edward Hitzig and Gustav Fritsch ardently pursued the topic, mainly employing clinical observation and animal experimentation. To neurosurgeons and neurologists, animal experimentation hardly resolved anatomical and physiological differences among species. Most of all, approach of animal experiments were lacking verbal communication between experimenter and subject, which was the most important method for obtaining reliable data. Illustrious as Hughlings and Broca’s cerebral localization, clinical observation with its concomitant postmortem findings needed first-hand knowledge on the physiology of the human brain. What would happen if the human brain were electrically stimulated directly? Would the results be similar to those from animal experiment?

The lack of access to the human brain caused physicians enthusiastic about stimulating the human brain directly. In 1874 American physician Robert Bartholow electrically stimulated an Irish housemaid’s brain that had been exposed by cancer erosion. The patient, Mary Rafferty, suffered from pain and convulsions, and eventually died. Although severely condemned both by the medical profession and public, Bartholow’s experiment was acknowledged as important for having demonstrated the relevance of cerebral localization in human already performed upon animals. Even in an article critical of the cruelty of Bartholow’s experiment, the author mentioned that the results of the experiment with human brain corresponded to those of animal experiments. All the criticisms against the Bartholow experiment never stopped physicians from trying to stimulate the human brain electrically. After 1882

26) Bartholow’s experiments were reported in Roberts Bartholow. Experimental Investigations into the Functions of the human brain. American Journal of Medical Sciences 1874;76:305-13. For a historical study on Bartholow’s experiment, see James P. Morgan. The first electrical stimulation on the human brain. Journal of the History of Medicine and Allied Sciences 1982;37:51-64.  
when Victor Horsley electrically stimulated the brain of an epileptic patient, more physicians followed his example. In 1893, John S. Pyle emphasized the importance of access to a living human brain for the development of neurosurgery and suggested that condemned criminals be used for the study of brain localization.29) His proposal was rejected on ethical grounds, but scientific doctors kept seeking access to the human brain, especially to solve the question of localization of the human cortex. Most neuroscientists agreed upon the location of the motor cortex located in the precentral gyrus, anterior to the central fissure. The question of the location of the sensory cortex, however, divided experimentalists as well as clinical neurologists into opposing camps. Some thought that the precentral and postcentral gyri were sensori-motor areas, while others regarded the postcentral gyrus, located posterior to the central fissure, as the motor area. Experimental studies on sensory function in animals had serious limitations because the experimenter could not communicate verbally with animals. In Osler’s textbook in 1905, and again in Cushing’s neurosurgical treatise in 1908, the location of the sensory cortex remained vague.30)

For delineation of the sensory cortex, Cushing stimulated electrically the cortex of conscious patients after opening their skulls and dura mater. From electrical stimulation of the sensory cortex in two patients suffering from epilepsy, he was able to map out the localization of the sensory cortex.31) In 1907, Cushing operated upon a patient suffering from a cystic tumor. Because the patient suffered from pulmonary tuberculosis, Cushing had difficulties in administrating anesthesia to the patient. During the fifth operation the patient, the patient became unanesthetized and conscious, and chatted with operators and explained what he sensed.32) After the operation, Cushing greatly regretted that he had not electrically stimulated the postcentral gyrus of the conscious patient. Through experience with the patient, however, Cushing saw the possibility to perform a surgical experiment upon unanesthetized patients with electrical stimuli upon the cerebral cortex. From then on, he looked for patients upon whom he could perform surgical experiments on the sensory cortex. His first experience of this kind came soon. On a patient operated upon for decompression with temporal opening, Cushing performed an experiment: “without an anesthetic, and the exposed temporal lobe was stimulated, giving the patient certain definite auditory impression[s] which he clearly distinguished from the “buzz” of the vibrator.”33) Only the temporal lobe was involved; this case did not satisfy

Cushing.

An opportunity for a better experiment came on June 16, 1908, when Dr. H. M. Thomas, professor of neurology at the Johns Hopkins Hospital referred to Cushing a fifteen-year-old epileptic boy. The first operation was performed on that day, since it was “the looked-for opportunity of making further observations upon the sensory field.” At the first operation, he stimulated the motor area electrically, but failed to find the lesion. Twenty days after the first operation, Cushing performed a second operation. At this time, Cushing intended to stimulate the brain cortex after the patient recovered from the light anesthesia. After receiving morphine and chloroform, the boy promptly regained consciousness. With mild current electricity, Cushing stimulated the sensory cortex. When Cushing stimulated the postcentral gyrus, the patient, unaware of the application of the electrode, reported sensing touch in the hand, the arm, the tongue, and the fingers.

A second patient, aged forty-four, also came to Cushing, complaining of epilepsy. At the second operation, the patient recovered promptly from the temporary narcotic effects of chloroform, and regained consciousness. Since this patient was cooperative, Cushing made a full electrical navigation over the exposed area: “the outlying convolutions were “coursed” in order to see whether any subjective sensations occurred from stimulation of other than the postcentral gyrus from which the sensory impressions had first been obtained. Thus the crests of all of the exposed convolutions ⋯ were stimulated, with the elicitation of no sensory.” To Cushing’s questions after electrical stimulation, he replied that he felt, “as though someone had touched or stroked the fingers.” By repetitions of the stimulus, Cushing was able to confirm that the postcentral gyrus was the sensory area, and to map out the area of its function.

Cushing’s study on human sensory cortex drew wide professional attention. It was lauded as a scientific accomplishment proving the existence in man of a sensory cortex comparable to the motor cortex. The author of a review of Cushing’s work in Lancet wrote that his paper had a “modest title” and “may well prove to be epoch-making, both from the physiological and the surgical point of view.” Cushing’s electrical stimulation of the motor cortex in more than fifty anaesthetized patients was “of the deepest significance.” “By experiment on the human cortex,” according to the same author, “the motor area has been exactly delimited and found to correspond strictly to the excitable motor area of the anthropoid ape.” While the need for experimentation on animals was obvious, human experiment was more satisfactory and easier. Using human subjects, Cushing overcame the shortcomings of animal experimentation. In his Linacre Lecture, Victor Horsley also proclaimed Cushing’s experiment as a breakthrough in neurophysiology. With Horsley

34) Ibid.:46.
and Fedor Krause, Cushing came to belong among pioneers of electrical stimulation of the human cortex.  


However praiseworthy his work was on scientific grounds, Cushing’s human experimentation needed to be justified. The same author of the article in *Lancet* tried to defend the experiments based upon several reasons. First, there was no harm; under Cushing’s skillful hands, there was an “entire absence of any sort of pain or even of discomfort on the part of the patient.” 39) Second, the purpose of the experiment was to benefit the patients: “It must be emphasized that Professor Cushing applied his electrode for the particular purpose of determining the localisation of the area of excitability producing his patient’s attacks, and for that purpose alone. The experiments were conducted from the patient’s standpoint.” Third, Cushing received cooperation from his patients.

Although Cushing was not clear for the case of the fifteen-year-old boy, he emphasized that he had informed the second epileptic patient and received his cooperation. What is not clear in his description was the content of information given to the patient. Did Cushing fully reveal that the electrical stimulation had multiple purposes, therapeutic as well as non-therapeutic? Again, Cushing highlighted that the cooperative patient was “intelligent.” Did the intelligent man understand why all of the exposed area had been stimulated, and how he developed unexpected convulsions, cyanosis, and protrusion of the cerebral cortex after repeated stimulation? Cushing gave up stimulation on this patient, resumed anesthesia, enlarged the skull opening, and finally found the hidden irremovable lesion.

5. Identity, ethos, and human experimentation

Was the human experiment compatible with Cushing’s identity and ethical standards as a neurosurgeon? Of course, yes. Cushing, following examples of his preceptor Halsted, believed that nobody could be a good surgeon without the experimentalists’ ethos. Philadelphia surgeon William Williams Keen held the same view, saying, “The Age of Experiment is the Age of Progress,” and “Stop experiment and you stop progress.” 40) The network of elite medical scientists in leading universities influenced Cushing’s enthusiasm of experiment. Sherrington, Kocher, Osler, Welch, Halsted, and Keen were all ardent proponents for experimental research, legitimating human experimentation in cases in which only a human could serve as a meaningful subject for the experiment. Varied in their specialties and foci of emphases, they shared a common ethos and spirit: imperatives for medical experimentation.

Cushing’s identity as a neurosurgeon was closely interconnected with this experimentalists’ ethos. In his writing titled “Human Experimentation,” Cushing said, “As a matter of fact every surgical operation is vivisection,” and “most forms of treatment are experimental in the full sense that...
antivivisectionist asks and not surgical treatment alone but most medical care.” His surgical practice included not only therapeutic experiments but also non-therapeutic ones. To Cushing armed with incomparable neurosurgical skill of his time, desperate patients came from all over the country to seek his care. Cushing made experiments upon the patients brought under his therapeutic umbrella. Dedicated to alleviating his patients’ suffering, he freely experimented with physiological questions as well as with surgical techniques. Cushing’s willingness and capability to cross over the boundary between therapeutic and non-therapeutic experiments were the essential characteristics of his identity as an academic surgeon.

As a scientist at the bedside, Cushing played double roles as a healer and as an experimenter. For their part, Cushing’s patients became his subjects as well. Communicating between the laboratory and bedside, he belonged to two domains: the sphere of suffering and sphere of knowledge. In the sphere of suffering, he stood between patient and disease, commanding therapeutics to his patients; his patients and their families relied heavily upon his surgical judgment and techniques. In the sphere of knowledge, he belonged to the network of clinical scientists, highly insulated and trained to exercise “doubling” as healer and scientist. Conflicts of interests scarcely became a problem to him. His ambition as a scientist was supported by the conviction that only the progress of medical knowledge could eventually bring benefits to the suffering patients. Cushing’s success as a clinical scientist resulted from his ability to mobilize his patients as human subjects. Yet, Cushing’s case was just the beginning of the story. Until 1979 when the Belmont Report was published to distinguish research from practice as one of the key features of ethical guidelines for human experimentation, the line between patient care and research had often been blurred. Throughout the twentieth century, clinical research conducted upon the patients increased rapidly. Cushing’s case signified the beginning of the emergence of clinical scientists who performed experiment at bedside in the twentieth century.

Key Words: Harvey Cushing, Human experimentation, Neurosurgery, Neurophysiology, History of Research Ethics.

41) Harvey Cushing Paper. Reel 152 Box 190 Folder 314. Yale University.
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이 논문은 하비 쿠싱(Harvey Cushing, 1869-1939)이 그의 환자들 대상으로 수행한 비치료적인 실험 (non-therapeutic experiments)을 다룬다. 하비 쿠싱은 1896년부터 1912년까지 존스홉킨스 병원에서 신경외과학 분야를 개척하는 동안 신경생리학 연구를 병행하였다. 쿠싱의 신경생리학 연구는 주로 그의 환자들에게 대한 임상관찰과 외과적인 실험이에 의존하였다. 자신이 신경외과 의사로서 동물 대상으로 연구하는 신경생리학자들보다 더 유리한 위치에 있다는 것을 알고 있는 쿠싱은 신경생리학자들이 쉽게 풀지 못하는 문제인 신경계의 감각 기능에 대해 연구하였다. 그의 연구방법은 수술을 하는 도중 다양한 자극을 신경계에 주고 환자의 반응을 보는 것이었다. 대뇌의 운동 피질을 확인하기 위해 쿠싱은 수술 도중 50명 이상의 환자의 운동 피질에 체계적으로 전기자극을 주었다. 감각 피질을 구분하기 위해서는 두개골과 경질막(dura mater)을 없애 의식이 있는 환자의 대뇌 피질을 전기로 자극하며 감각에 대해 질문하여 감각피질 지도를 완성하였다. 이 논문은 쿠싱의 연구를 20세기 초반 미국의 임상연구의 맥락에서 살펴보았다. 쿠싱의 학자들은 치료적 이익이 없는 쿠싱의 생리학 연구에 참여하였다. 쿠싱의 연구방법은 수술을 하는 도중 다양한 자극을 신경계에 주고 환자의 반응을 보는 방법이었다. 대뇌의 운동 피질을 확인하기 위해서는 두개골과 경질막(dura mater)을 없애 의식이 있는 환자의 대뇌 피질을 전기로 자극하여 감각에 대해 질문하여 감각피질 지도를 완성하였다. 이 논문은 쿠싱의 연구를 20세기 초반 미국의 임상연구의 맥락에서 살펴보았다. 쿠싱의 학자들은 치료적 이익이 없는 쿠싱의 생리학 연구에 참여하였다. 쿠싱의 연구방법은 수술을 하는 도중 다양한 자극을 신경계에 주고 환자의 반응을 보는 방법이었다. 쿠싱의 연구방법은 수술을 하는 도중 다양한 자극을 신경계에 주고 환자의 반응을 보는 방법이었다.