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William Stewart Halsted in the History of American Surgery

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The Johns Hopkins Hospital, founded in 1889 and the Johns Hopkins Medical School opened in 1893, provided young men and women with a unique environment for medical research. For the first time in America, a teaching hospital was established as an integral part of a medical school within a university.[1] The hospital staff and medical school faculty played an important role in introducing the institutions and ideals of scientific research to the United States from Europe. Under inspiring teachers, most of whom had research experience in European medical centers, medical students were trained as medical scientists both in laboratories and at the bedside. The influence of the Johns Hopkins Hospital and University on American medicine and medical education was far reaching.[2] The Johns Hopkins stimulated other universities and hospitals to adopt research – oriented medical education.[3] Many investigators trained at Johns Hopkins established similar

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1) The Johns Hopkins Hospital was unique, compared to other teaching hospitals in America. In successive papers, Kenneth Ludmerer has shown that teaching hospitals in America arose mainly from unions between voluntary hospitals founded in the nineteenth century and university medical schools in the 1910s and 1920s. He claims that the primary reason for the backwardness of clinical medicine, compared to the basic sciences, in early twentieth – century America was the lack of teaching hospitals. In the nineteenth century, hospitals had not been willing to be affiliated to universities for fear of losing their independence. See Kenneth M. Ludmerer. Reform of medical education at Washington University. Journal of the History of Medicine and Allied Sciences 1980;35:149 – 173; Ludmerer. Reform at Harvard Medical School: 1869 – 1909. Bulletin of the History of Medicine 1981;55:343 – 370; idem. The Rise of the teaching hospital in America. Journal of the History of Medicine and Allied Sciences 1983;38:389 – 414.

2) A. McGehee Harvey wrote several books on medical research at Johns Hopkins. Harvey. Adventures in Medical Research; idem, Research and Discovery in Medicine; idem. Science at the Bedside.

educational systems far and wide in America.

In 1870 Mr. Johns Hopkins signed his will, leaving his large fortune to found a hospital and a university.4) Born in 1795 of Quaker parents, Johns Hopkins prospered as a merchant in Baltimore. Possibly influenced by the Baltimore physician Patrick Macaulay, and by the London banker and philanthropist George Peabody, Hopkins had a clear idea of the kind of medical education required. At his death in 1873, he left seven million dollars to be divided equally between the university and the hospital, making it clear that the hospital should be part of the medical school of the university. In his letter to the trustees, Hopkins said,"In all your arrange－ments in relation to this hospital, you will bear constantly in mind that it is my wish and purpose that the institution should ultimately form a part of the medical school of that university for which I have made ample provision by my will.5)"

Two years later, the board of trustees chose Daniel Coit Gilman, then president of the Uni－versity of California, as leader of the new university. Gilman, who had experience in or－ganizing scientific education both at Yale and at the University of California, proved to be an excellent choice for Johns Hopkins. He played a crucial role in establishing both the hospital and the university. After observing the educational systems of the best universities in European countries, he adapted their systems to American needs and conditions.

1. Medical Organizers: John Shaw Billings, William Henry Welch, and William Osler

As their medical adviser, the trustees selected John Shaw Billings, who founded the Surgeon－Generals Library at Washington, and in 1880 began the Index Catalogue of that library. In planning the Johns Hopkins hospital and medical department, Billings traveled to Europe to study the organization and equipment of laboratories and methods of research and teaching. During his visit to Carl Ludwigs laboratory at Leipzig in 1876, Billings met a young American physician, William Henry Welch, who was studying physi－ology there. Welch had graduated from the College of Physicians and Surgeons of New York in 1875, and spent the following year as an intern at Bellevue Hospital. In April 1876 he went to Europe to study the sciences of pathology and physiology. On his return to New York in 1878, Welch found the conditions for research and teaching in America frustrating. He spent the next six years in studying and teaching pathology with inadequate facilities. In 1884 Billings visited Welchs laboratory to observe Welchs teaching and

3) In *Learning to Heal*, Ludmerer showed how the Johns Hopkins Hospital and the Johns Hopkins University influenced other American universities to adopt a similar program for medical education.

4) For the history of the Johns Hopkins Hospital and the Johns Hopkins University, see Chesney. History of the Johns Hopkins Hospital; Shryock, Unique Influence of the Johns Hopkins University; and Turner. Heritage of Excellence.

5) Johns Hopkins letter of March 10, 1873 to the trustees of the Johns Hopkins Hospital and the Johns Hopkins University, quoted in Chesney, History of the Johns Hopkins Hospital, p.16.

research. Impressed by what he saw, Billings recommended Welch to Gilman as a professor of pathology.6)

In September 1884, Welch again went to Germany to spend another year of study with Robert Koch on the relation of bacteria to disease and with Max von Pettenkofer on experimental hygiene. From that time forward, Welchs research became centered largely on bacteriology. On his return to Baltimore in 1885, Welch brought with him the new bacteriological techniques for the study of disease. The Johns Hopkins Hospital was not yet open, but the following year Welch established his laboratory in the new Pathology Building. He organized systematic courses and researches on pathology and bacteriology, and young men came to study with him. They included Walter Reed and James Carroll, who later discovered the mode of transmission of yellow fever, and Simon Flexner who was later to direct the Rockefeller Institute for Medical Research and organize clinical research on polio-myelitis. Lewellys F. Barker, William Thayer, John M. T. Finney, and T. S. Cullen studied in the Pathology Laboratory, and later became distinguished medical investigators. With William T. Councilman, Welch began studies on thrombosis, embolism, diphtheria, and hog cholera. In 1892 with George H. F. Nuttall, Welch published one of the most important discoveries made at the pathological laboratory-the identification of the gas gangrene bacillus, *Clostridium perfringens*, later renamed *Clostridium welchii*.

While the hospital was still under construction from 1886 to 1889, Welch selected the faculty for the medical school. President Gilman gave him the same freedom to choose medical faculty that the trustees had given Gilman to choose the university faculty. As professor of anatomy, Welch selected Franklin P. Mall, who had studied physiology and pathology in Germany after graduating from medical school and who worked with Welch as a fellow in pathology. As professor of medicine, Welch chose William Osler, then professor of clinical medicine in the University of Pennsylvania, and as professor of surgery, William Halsted. Through his own research, his training of young doctors in research, and his recruitment of key figures for the medical school, Welch played a crucial role in establishing medical research and teaching at Johns Hopkins.

William Osler was especially important to the development of clinical education in the hospital.7) Born in Canada in 1849, Osler studied medicine at McGill University in Montreal. After graduating in 1872, he spent two years in Europe, studying histology, physiology, experimental pathology, and clinical medicine. In 1878 he was appointed physician to the Montreal General Hospital. The same year he became a member of the Royal College of Physicians, and in 1884 a fellow.

6) For life and work of William Henry Welch, see Flexner and Flexner. William Henry Welch; Fleming. William H. Welch; Johns Hopkins Hospital, Welch Memorial: The centenary of the birth of Dr. William Henry Welch, held April 15, 1950, A special supplement to Johns Hopkins Hospital Bulletin 1950;87:1-54.

7) Useful biographies of William Osler are Cushing, Life of Sir William Osler; Reid, Great Physician.

Osler continued to visit Europe periodically to observe the clinical work of European physicians. He early recognized the importance of medical education on a university basis. In 1884 he became professor of clinical medicine in the University of Pennsylvania at Philadelphia. In addition to teaching at the medical school, he carried out clinical and pathological studies at Blockley Hospital.

William Osler came to Baltimore in September 1888. As a strong proponent of bedside teaching, when the Johns Hopkins Medical School opened in 1893 Osler established clinical teaching at the bedside. The Johns Hopkins Hospital was modeled upon a German university hospital with a graded resident staff. Using laboratory examinations to aid in the diagnosis of disease, Osler established clinical teaching along lines similar to those of British or French hospitals. Small groups of students served in the wards as clinical clerks or surgical dressers. They carried out practical work in the clinical laboratory, and worked in the outpatient department. During his sixteen years at Johns Hopkins, Osler studied typhoid fever, tuberculosis, malaria, pneumonia, amoebiasis, and many other diseases. In 1891, he published his *Principles and Practice of Medicine*. The book became so popular among medical practitioners and students that by 1930 it had reached its eleventh edition and had been translated into French, German, Spanish, and Chinese. Oslers most important contribution to medicine was his stimulation and encouragement of students and colleagues to carry out original research. Osler trained his pupils thoroughly, creating an American school of internal medicine.

After Harvey Cushing came to Johns Hopkins in 1897, Osler and Welch exerted a profound influence on him, both professionally and personally. When Cushing completed four－years of surgical training as Halsteds assistant in 1901, Osler and Welch advised him to go to Europe for further training. The trip proved crucial in Cushings development as a medical investigator. Although Cushing did not have a similarly close relationship with Halsted, he was greatly influenced by Halsteds surgical technique and his experimental approach.

2. William Stewart Halsted：His Early Career in New York

Halsted was one of the most influential surgeons of the twentieth century, contributing to the development of such fundamental aspects of modern surgery as anesthesia, hemostasis, and asepsis. He discovered the principle of local anesthesia. For hemostasis he introduced new methods including the transfixion of vessels. To aseptic technique he contributed the rubber glove, and the development of procedures for aseptic surgery, controlled by bacteriological tests. Halsted developed refined operative techniques, including the careful handling of tissues, meticulous methods of suturing, and techniques for gastro－intestinal anastomosis.

William Stewart Halsted was born at New York City in 1852, the son of a prosperous wholesale importer of dry food.[8] His grandfather and his father both had served on the Board of Governors of the New York Hospital. His father was a trustee of the College of Physicians and

Surgeons of New York. After six years at Phillips Academy, in Andover, Massachusetts, Halsted entered Yale College in 1870. Although not a brilliant student, Halsted was an outstanding athlete. He was captain of the Yale football team that in 1873 defeated Eton. As a senior at Yale, he became interested in medicine.

In 1874, Halsted entered the College of Physicians and Surgeons of New York. His preceptor was the professor of anatomy, Henry B. Sands, who was an active surgeon, later to become famous for his advocacy of early appendectomy for appendicitis. Halsted also became a student assistant to the professor of physiology, John Call Dalton. Dalton was the embodiment of scientific spirit and method, the first American physiologist to include demonstrations on living animals in his teaching. Halsted said later that he absorbed much of Daltons philosophy. After graduating in 1877, Halsted began an eighteen-month internship at Bellevue Hospital, completed in April 1878. During the following summer he served briefly as a house physician at the New York Hospital.

In the fall of 1878, Halsted went to Europe for further study. At Vienna he studied anatomy under Emil Zuckerkandl and Moritz Holl, and attended many clinical lectures, including Theodor Billroths surgical clinic. While studying embryology with Samuel Schenk, he became friends with Billroths assistants, Anton Woelfler and Johann von Mikulicz-Radecki. His friendship with Woelfler enabled Halsted to gain unlimited access to the surgical wards and Billroth's operating amphitheater. At Billroths clinic, Halsted observed German surgical techniques, including hemostasis. At Halle, Halsted observed surgical operations by Richard von Volkmann, who had played an important role in introducing antiseptic surgery into Germany. From Volkmann, Halsted learned antiseptic techniques. Halsted also studied with Baron Bernard von Langenbeck, professor of surgery at Berlin, Ernst von Bergmann, a neurosurgeon at Berlin, Victor von Bruns, professor of surgery at Tubingen, and Karl Tiersch, professor of surgery at Leipzig. Halsteds experience of German surgical clinics and laboratories would exert a great influence upon him as a teacher, researcher, and surgeon. At that time, German surgery was developing rapidly. German surgeons had eagerly accepted Listerian antisepsis, and were integrating the basic sciences into clinical surgery. Germany was also developing new sciences such as bacteriology, embryology, and pathology, and had become a mecca for medical students who sought the latest and best medical knowledge and training. Halsteds previous medical training at New York was narrow and practical. In Germany he experienced for the first time the scientific spirit. It stimulated him to

8) For accounts on Halsteds life and work by his pupils and friends, see Crowe. Halsted of Johns Hopkins; HarveyCushing. William Stewart Halsted, 1852-1922. Science 1922;56:461-464; Rudolph Matas. An appreciation. William Stewart Halsted:1852-1922. Johns Hopkins Hospital Bulletin 1925;36:2; George W. Heuer, Dr. Halsted. Johns Hopkins Hospital Bulletin 90 supplement 1952:1-105; W. G. MacCallum. William Stewart Halsted: Surgeon. For the several aspects of his life and work by historians of a later generation, see P.O. Olch. William Halsted's New York period, 1872-1886. Bulletin of History of Medicine 1966;40:495-590; idem. William S. Halsted and private practice; a reexamination. Surgery 1972;72:804-811.

become an experimental researcher, and would later influence his methods for training surgical residents at Johns Hopkins.[9] Later in life Halsted mentioned several times to his close friends what his studies at Vienna, Leipzig, and Berne had meant for his professional career.[10] I realize, "said Halsted, that I owe chiefly to Germany such success as I have had in my professional life.[11]

On his return to New York City in 1880, Halsted plunged into active surgical work. He also became a demonstrator in anatomy at the College of Physicians and Surgeons, and organized an extramural quiz for medical students. Within five years, he came to hold positions at the Charity Hospital, Bellevue Hospital, and the Presbyterian Hospital. At the Roosevelt Hospital, he was placed in charge of the out－patient clinic. He also carried on a private practice limited to surgery.

In 1884, a week or two after the arrival in America of a paper reporting the anesthetic effect of cocaine on the conjunctiva, Halsted began to perform experiments on nerve blocking with cocaine hydrochlorate.[12] With his assistants, Richard Hall, Frank Hartley, Frank Markoe, and George Brewer, Halsted injected cocaine into all accessible nerves in the body including the sciatic, the brachial plexus, and the inferior dental nerve. He found that injection of cocaine into a peripheral nerve produced local anesthesia of the area served by the nerve. The infiltration of a nerve by any analgesic substance including water, salt solution, or other fluid could also produce local anesthesia. In December 1884, after injecting cocaine into the supraorbital nerve at the supraorbital notch, he operated upon a patient with a lipoma of the supraorbital region. In 1885, he reported more than a thousand operations with cocaine anesthesia including operations for trige－

9) Several articles deal with how Halsteds early European trip influenced his development of the surgical training system at Johns Hopkins. Ira M. Rutkow. William Stewart Halsted and the Germanic influence on education and training programs in surgery. Surgery, Gynecology, and Obstetrics. 1978;147:602－606; Owen H. Wangensteen. The University of Glasgow and the Johns Hopkins Schools of Surgery. American Journal of Surgery 1980;139:870－875; Harvey. The influence of William Stewart Halsteds concepts of surgical training. Research and Discovery in Medicine, pp.49－70; Ira M. Rutkow and K. Hemple. An experiment in surgical education－ the first international exchange of residents. The letters of Halsted, Kuttner, Heur, and Landois. Archives of Surgery 1988;123:115－121.

10) Matas and Heuer discuss influence of Halsteds early European travel to his professional career based upon their personal conversation with Halsted. Rudolph Matas. An appreciation. William Stewart Halsted: 1852－ 1922,. Johns Hopkins Hospital Bulletin 1925;36:2; George W. Heuer. Dr. Halsted. Johns Hopkins Hospital Bulletin 90 supplement 1952:1－105, pp.11－13.

11) W. S. Halsted to Henry G. Beyer, M.D., February 11, 1915, quoted from Ira M. Rutkow, William Stewart Halsted and the Germanic influence on education and training programs in surgery. Surgery, Gynecology, and Obstetrics 1978;147:602－606, p.602.

12) Halsteds own recollection on his discovery of local anesthesia was recorded in his personal letter to Sir William Osler, dated August 23, 1918, published in Fulton, Cushing, pp.142－143; Halsted to C. Edmund Kells, March 29, 1920, published in Rudolph Matas. The story of the discovery of dental anesthesia by nerve blocking: Achievement of William Stewart Halsted. Surgery 1952;32:530－537, pp.534－536.

minal neuralgia.13) In 1884 Halsted also discovered that reducing the circulation to the anesthetized part prolonged the action of anesthetics. On the limbs and on the fingers he used a constricting rubber bandage and heavy rubber rings to intensify and prolong the anesthetic effect of the drug. He introduced spinal anesthesia by injecting cocaine into the lumbar meninges. Halsteds principle of nerve blocking became the foundation of regional anesthesia for surgical purposes. His discovery began to be used promptly in dental practice and oral surgery.

Fifteen years later in 1898, when Harvey Cushing rediscovered the principle of nerve blockage, and used it successfully for operations on hernia, he did not know that his chief had earlier carried out studies on local anesthesia with cocaine.14) Cushing devised local anesthetics for patients for whom ether anesthesia was unsuitable, such as patients with chronic pulmonary disease or with strangulated hernia, causing shock or vomiting. Furthermore, Cushing had difficulty in getting experienced anesthesiologists for prolonged operations, like those for breast cancer and intestinal strangulation. In 1925 Cushing recalled It was owing to this that I took up local anaesthesia without getting much moral support from the Professor. I little realized at the time the reasons for this.15) Halsted was extremely reticent about the use of cocaine for local anesthesia, and little interested in questions of priority.16) In April 1922, just six months before Dr. Halsteds death, the American National Dental Association recognized the significance of Halsteds discovery in local and regional anesthesia, presenting him with a gold medal and giving him full credit for the discovery of neuroregional anesthesia.17)

The cocaine experiments left an indelible mark on Halsted. At that time, physicians knew little of the addictive nature of cocaine. At the evening quizzes which Halsted ran at New York, twentyfive or thirty students of the College of Physicians and Surgeons, who registered with Halsted as their preceptor, injected into all accessible nerves in order to map out the areas of

13) William Stewart Halsted. Practical comments on the use and abuse of cocaine; suggested by its invariably successful employment in more than a thousand minor surgical operations. New York Medical Journal 1885; 43: 294–295.

14) Cushings well–known papers on cocaine anesthesia were: Harvey Cushing. Cocaine anesthesia in the treatment of certain cases of hernia and in operations for thyroid tumors. Johns Hopkins Hospital Bulletin 1898;9: 192–193; The employment of local anaesthesia in the radial cure of certain cases of hernia, with a note upon the nervous anatomy of the inguinal region. Annals of Surgery 1900;31:1–34; Observations upon the neural anatomy of the inguinal region relative to the performance of herniotomy under local anaesthesia, Johns Hopkins Hospital Bulletin 1900;11:58–64.

15) Harvey Cushings recollection, dictated in January 1925. Harvey Cushing Papers, Microfilm Reel 114.

16) Harvey Cushing,"William Stewart Halsted, 1852–1922, Science 1922;56:461–464, p.462.

17) Matas described how Halsted came to be recognized as the discoverer of local anesthesia in Rudolph Matas. The story of the discovery of dental anesthesia by nerve blocking: Achievement of William Stewart Halsted. Surgery 1952;32:530–537, pp.534–536. For the relationship between Halsted and Matas, see Ira M. Rutkow. William Halsted and Rudolph Matas; their unique alliance. Surgery 1980;87:524–538.

anesthesia. Unaware of the dangerous nature of the drug, Halsted and his assistants injected each other with cocaine into their peripheral nerves. All of his assistants became addicted to cocaine, and most did not recover from it. The only one who eventually overcame the addiction was Halsted. Richard Hall, a brilliant researcher second only to Halsted, finally gave up his academic career, and in 1892 moved to California to begin private practice. He did not recover from the addiction before his death in 1897, following appendectomy. Addiction threatened Halsted with professional extinction. For fifteen months in 1886 and 1887 he was hospitalized in the Butler Hospital at Providence, Rhode Island, an episode that ended Halsteds professional career in New York.18) In an effort to control the agitation produced by the drug, Halsted turned at one point to morphine, and later to alcohol. In December 1886, without having recovered fully from the addiction, Halsted moved to Baltimore at the invitation of William Henry Welch, to work in Welchs laboratory at Johns Hopkins. The laboratory was, in a sense, occupational therapy. With Welchs sustained support and friendship, Halsted regained his health. Three years later when the Johns Hopkins Hospital opened, he was appointed surgeon－in－chief and head of the outpatient department. On the opening of the medical school in 1892, he became professor of surgery. The question of whether Halsted ever completely overcame drug addiction has been discussed for many years. In his Inner History of the Johns Hopkins Hospital,"Sir William Osler wrote that as late as 1898 Halsted took 3 grains of morphine daily.19)

3. Halsted in Baltimore : A Scientific Inves－tigator of Surgery

In Baltimore, Halsteds life was quite different from that in New York, where his enthusiasm for experimental research had been suppressed. As a rapidly rising surgeon in New York City, his time had been consumed by clinical respon－sibilities. He was too busy and his schedule too crowded to use time－consuming techniques in surgical operations. During the years with Welch and Mall at Baltimore in the quiet, contemplative environment of the laboratory, Halsted changed from a busy, genial, energetic surgeon to an introverted, reflective scholar. He used the la－boratory to solve basic problems in surgery, including the problem of the optimal conditions for wound healing.

Halsteds first experiments performed at Johns Hopkins were on intestinal suture. On his arrival at Welchs laboratory, Halsted found that Franklin Mall was engaged in a detailed study of the blood supply and structure of the stomach and

18) Recently Rutkow suggested that financial improprieties of his family also affected his life in New York, and his decision to leave the city. Ira M. Rutkow. William Halsted, his family and 'queer business methods'. Archives of Surgery 1996;131:123－127.

19) William Osler. The inner history of the Johns Hopkins Hospital. Johns Hopkins Hospital Bulletin 125 1969: 184－194.

intestine of the dog. Interested in developing a new and safer technique for resection and anastomosis of the intestine, Halsted and Mall began an experimental investigation of intestinal suture. In April 1887, he presented the results of sixty-nine experiments. Surgeons then had only a vague knowledge of the structure of the intestinal coats. Among the various layers of the intestinal wall (i.e., the mucosa, submucosa, muscular coat, and peritoneum), Halsted found that the thin but tough submucosal layer was strong enough to hold the sutures in sewing together the two ends of a divided intestine, or in establishing an artificial opening between two parts of the gastro-intestinal system. He emphasized that in performing intestinal anastomoses a surgeon should pick up portions of the submucosal coat. He should take care not to penetrate the mucous lining of the intestine. Bacteria living in the intestinal canal might cause serious infection. For intestinal anastomosis, Halsted devised a special suture, called the Halsted mattress suture. It brought together the opposing peritoneal surfaces of the intestine so as to establish ideal conditions for healing.[20]

In this early Baltimore years, Halsted tackled problems of fundamental principles in surgery. He believed that surgery could not advance greatly without clarifying basic concepts and techniques that might be applied to any surgical operation. Such concepts included how to perfect wound healing, and how to prevent wound infections. At New York in the early 1880s, Halsted eagerly accepted antiseptic surgery. Antiseptic surgery was based upon the concept that bacteria in the air caused the infection of clean wounds through contact with the open wound, or by contact with the instruments, the dressings, or the hands of the surgeon or nurses. By killing bacteria with anti-septic solutions, wound infection might be reduced or eliminated. In the late 1880s, Halsted and other American surgeons pursued the concept of aseptic surgery. They found that bacteria in the air were not an important cause of surgical infection. Infection was caused instead by bacteria introduced into the wound from the skin of the patient, from the hands and clothes of the surgeon and his assistants, or from instruments and dressings. Halsted performed experiments on the sterilization of the skin of the patients and the hands of the surgeon.[21] In some cases, he disinfected the skin of the patient rigorously for four days, and then inoculated test-tubes with scrapings of the patients skin. In every case, Halsted found at least three or four bacterial colonies in each of the inoculated tubes. One of the most prevalent microorganisms was *Staphy-lococcus aureus*. He also performed many expe-

20) George W. Heuer. Dr. Halsted. Johns Hopkins Hospital Bulletin 90 supplement 1952:1-105, pp.88-89. William Stewart Halsted. Circular suture of the intestine-an experimental study, Delivered at the Harvard Medical School, Boston, Mass., April 5, 1887. Surgical Papers, Vol. I, pp.185-211.

21) Halsteds experiments were reported in William Stewart Halsted. The treatment of wounds with especial reference to the value of the blood clot in the management of dead spaces. Johns Hopkins Hospital Reports 2 1897:255-314; Surgical Papers, Vol. I, pp.71-113.

riments on the disinfection of the hands. Even after immersion of the hands for an hour in antiseptic solutions, many colonies appeared in test tubes inoculated with scrapings from the hands. Halsted concluded that neither the patients skin nor the hands could be sterilized with soap and water or with chemicals. Faced with the inevitable introduction of some bacteria into any wound, Halsted turned his attention to the natural resistance of the tissues to infection. In a series of experiments with forty-five dogs, he injected 1 cc. of a bouillon culture of *Staphylococcus aureus* into the normal peritoneal cavity. Peritonitis did not develop in a single case. The same injections made after ligating a small piece of omentum with sterile technique usually caused fatal peritonitis. In another series of fifteen animals, similar injections of *Staphylococcus aureus* into the muscles of the legs did not produce abscesses. From his experiments, Halsted drew important conclusions. (1) Normal, uninjured tissues have a natural resistance to infection. (2) Wounds of parts rich in blood vessels usually heal well, even without antiseptic precautions. (3) If tissues are crushed with clamps, or otherwise traumatized, or their blood supply is impaired, they lose their resistance to infection. The problem, then, became how to conduct an operation with minimal injury to the tissues, and maximum preservation of the blood supply.

To meet these needs, Halsted introduced a number of significant surgical techniques. He invented a clamp with a sharp point, called the Halsted artery forceps, to stop bleeding while crushing no more than a minimum of tissue. As his experiments showed him that sutures and ligatures were frequent sources of infection, Halsted made every effort to develop ideal sutures and ligatures. He came to believe that obstruction of the circulation by sutures and ligatures was often the immediate cause of suppuration in infected wounds. The larger the masses of tissue constricted and the tighter the strangulation the greater the danger of suppuration. To avoid strangulation, he used the finest black silk thread to tie bleeding vessels. Silk could be completely sterilized by boiling and caused less inflammatory reaction in tissue than catgut. Halsted stopped virtually all bleeding in an operative field, so that blood could not collect in tissue spaces. He always transfixed the bleeding point. It allowed the ligature to be drawn just tight enough to stop bleeding, without unnecessary strangulation of tissue and without danger of the ligatures slipping off. He closed an incision layer by layer, without stretching the tissue, so as not to impede the blood supply. To avoid infection, he devised a subcutaneous suture, which he called a buried skin suture."These sutures were taken from the under-surface of the skin, without perforating the skin, which harbored pathogenic organisms. He opposed the drainage of clean wounds, because infection could be introduced along the drainage pathway. To avoid injury to delicate granulation tissue, Halsted devised a filmlike gutta-percha tissue, which did not adhere to the wound surface. He usually interposed strips of gutta-percha between the wounds and the dressings to protect granulation tissue. Halsted wrote that the tearing off of a dressing into which the granulations have grown is a barbarous act which insults both the wound and the patient.[22]"

Halsted was a slow, careful, and painstaking operator. Using fine instruments and silk sutures, he handled tissues very carefully to minimize injury and bleeding. At the time Halsteds surgical concepts and techniques were unique. Speed of operation was still considered a mark of surgical brilliance. Many of his contemporaries sought dramatic rapidity in their operations. A common scene in operating rooms was a surgeon poised with a knife, looking at the large clock in the operating room before he began.[23] He then made an incision, and worked at top speed. After completion of the operation, the surgeon looked again the clock, and announced to an admiring audience,"a minute and a half,"or"five minutes, or whatever time he had spent in the surgery. By contrast, Halsteds meticulous surgery took several hours. An operation for breast cancer, in which Halsted usually clamped almost two hundred bleeding points, might require three hours. Visiting surgeons often expressed their astonishment at his prolonged, meticulous procedures. George Heuer told a story about a visit to Halsteds operating rooms by Charles Mayo. As Halsteds assistant, Heuer took part in an operation which lasted four hours. On leaving the operating room afterward, Dr. Mayo took Heuer by the arm and asked,"Whats your name?"Well, Heuer, said Mayo, I have had a new experience. I have seen the upper half of an incision healed before the lower half was closed.[24]"

Halsted recommended thorough disinfection of the hands and the skin. He found that the best results in disinfection were obtained when the water was as hot as could be endured. He recommended 117 F to 120 F (47 C to 49 C) water to be employed in all of the steps of the disinfection. The procedures were as follows: 1. Scrub the hands and forearms for about ten minutes with the official green soap in water as hot as possible. 2. Wash off the soap in three or four basins of water as hot as possible. 3. Clean the nails most scrupulously with a sharp steel instrument. 4. Soak the hands and forearms for ten minutes in a hot corrosive sublimate solution, 1-1000.[25]"These procedures were too severe to be employed everyday. Thus, Halsted advised the surgeon to collect surgical cases, and operate upon them only two days in the week. The preparation of the patients was also so thorough that sometimes they were subjected to disinfection for three days before an operation.

4. Halsted's Development of Surgical Gloves

Halsteds other important contribution to aseptic surgery also came early in the Baltimore period. In 1889, Halsted introduced rubber gloves in the operating room for his head nurse, Caroline Hampton.[26] The mercuric chloride solution, used

22) Halsted, Surgical Papers, Vol. I, pp.106-107.
23) George Heuer depicted his experiences of visiting other surgical clinics as a young surgeon. George W. Heuer. Dr. Halsted. Johns Hopkins Hospital Bulletin 90 supplement 1952:1-105, p.80.
24) George W. Heuer. Dr. Halsted. Johns Hopkins Hospital Bulletin 90 supplement 1952:1-105, pp.80-82.
25) Halsted. Surgical Papers, Vol. I, p.107.

for the disinfection of instruments and hands had caused a marked dermatitis on Miss Hamptons hands and arms. Halsted, therefore, asked the Goodyear Rubber Company to make two pairs of thin rubber gloves with gauntlets. The gloves could be sterilized by boiling, and were the first rubber gloves ever used in a surgical operation. The trial was so satisfactory that Halsted ordered additional gloves, and required the assistants who passed instruments to wear the gloves. The purpose of wearing the gloves was to prevent dermatitis caused by the antiseptics. At first the operator wore gloves only when he made an incision into joint cavity. After a while, the assistants became so accustomed to working in gloves that they began to wear them while working as operators. Joseph C. Bloodgood, Halsteds house surgeon, was the first surgeon who wore gloves invariably when operating. In his report on hernia in 1899, Bloodgood said that since wearing gloves, cases of post-operative wound infection had markedly decreased.[27] In 1894, in a book on aseptic technique, Hunter Robb, resident gynecologist of the Johns Hopkins Hospital, also recommended that the operator wear rubber gloves.[28] Dr. Robb had frequent opportunities to observe the technique of the surgical clinic. Before he recognized fully the importance of wearing gloves, Halsted himself used rubber gloves only occasionally. He thought that gloves might diminish the sense of touch of the fingers. Thus, in the early years of using rubber gloves in the operating room, Halsted would take off the glove from one hand to palpate the common bile duct, searching for gall stones. Halsted recalled later in 1913, "the operating in gloves was an evolution rather than an inspiration or happy thought, and it is remarkable that during the four or five years when as operator I wore them only occasionally, we could have been so blind as not to have perceived the necessity for wearing them invariably at the operating table.[29]" Visiting surgeons also had failed to recognize the need to eliminate contact between the surgeons skin and the surgical wound by wearing gloves. Surgeons at Harvard ridiculed their colleagues at Johns Hopkins for operating in surgical gloves. In 1925, Harvey Cushing recalled:

> the Boston school of operating surgeons … were most scornful of the Hopkins and its

26) Caroline Hampton was the daughter of Colonel Frank Hampton, who was killed in the Civil War, and a niece of General Wade Hampton, who was a member of General Robert E. Lees staff and later a senator from South Carolina. Although wealthy before the Civil war, the war had left the Hampton family impoverished, and Caroline Hampton decided to become a nurse. After graduating at the New York Hospital, she was appointed head nurse of the surgical department in 1889 when the Johns Hopkins Hospital opened.

27) Joseph C. Bloodgood. Operations on 459 cases of hernia in the Johns Hopkins Hospital from June, 1889, to January 1899; the special consideration of 268 cases operated on by the Halsted method, and the transplantation of the rectus muscle in certain cases of inguinal hernia in which the conjoined tendon is obliterated. Johns Hopkins Hospital Report 7 1898-1899:223-562.

28) Robb. Aseptic Surgical Technique.

29) Halsted. Employment of Fine Silk. pp.21-22.

inartistic rubber-gloved methods of operating. However, to one who was familiar with the postoperative care of cases under each system, there could be no question which was superior, at least from the standpoint of end results.30)

5. Halsted's Development of Surgical Techniques for Breast Cancer, and Hernia

Halsted developed new operations for several important diseases. From 1895 to 1908, he worked on the problem of breast cancer, a disease recognized from antiquity.31) In the eighteenth century, the French surgeon Jean Louis Petit (1674-1750) made an epoch in the history of its surgical treatment. Petit thought that the axillary lymph nodes might contain the roots of breast cancer, and should be removed together with the breast tumor. Two centuries later, Joseph Lister, the founder of antiseptic surgery, exposed the axilla by division of the pectoral muscle. Lister was the first surgeon to perform adequate axillary dissection for cancer of the breast. As microscopic pathology developed in the nineteenth century, Richard Volkmann in 1875 advocated the complete removal of the breast, axillary dissection, and excision of the pectoral fascia. He observed the fascia frequently invaded by cancer cells even when the naked eye could not see them. Volkmanns method was widely accepted. Rudolf Heidenhain confirmed Volkmanns observations, and recommended the extension of Volkmanns method to include the removal of the superficial layer of the pectoral muscle. In cases in which the cancer was attached to the pectoral muscle, Heidenhain advocated removal of the entire muscle. When Halsted became interested in breast cancer surgery in 1895, the outcomes of operations for breast cancer were not good. When the breast alone was removed, 5 per cent of patients were free of disease three years after operation, but 95 per cent died of recurrent cancer. When an axillary dissection was carried out with complete removal of the breast, 18 per cent of the patients were free of the disease three years after operation, and 82 per cent died of recurrence. With the additional removal of the pectoral fascia and sometimes parts of the major pectoral muscle, 20 per cent were free of disease three years after operation, but 80 per cent suffered from recurrence.

Aiming at the complete cure of breast cancer, Halsted developed a radical operation. He made a wider removal of the skin over the involved area, and a more extensive reflection of the skin flaps to secure a more complete exposure of the underlying structures. He removed routinely the entire *pectoralis major* muscle, and made a wider exposure and more meticulous dissection of the axilla by division of the minor pectoral muscle. He also emphasized that the whole mass-skin, breast, surrounding fat, pectoral muscle, and axillary glands and fat-be removed in one piece or block. To avoid dissemination of the disease,

30) Harvey Cushings recollection, dictated in January 1925. Harvey Cushing Papers, Microfilm Reel 114.
31) For a short history of breast cancer and of its surgical treatment, see Moulin. A Short History of Breast Cancer.

he never cut across any known extension of the cancer. At every step of the operation, he employed extraordinary care and time-consuming exactness. The statistics for Halsteds operations on breast cancer proved the effectiveness of his new surgical technique.[32] In 1907, with the help of Joseph Bloodgood, Halsted presented the results of his operations for breast cancer.[33] Among 210 patients, 42 per cent were free of disease three years after the operation. Among patients with no metastasis, microscopically demonstrated (60 in number), 85 percent had a three-year cure. When the patients had axillary metastasis (110 in number), 30 percent were free of disease three years after operation. In those who had neck metastasis (40 cases), only 10 per cent were free of disease three years after operation. Halsteds radical operation for breast cancer was a significant contribution. It brought hope for the treatment of a disease that had been regarded as almost hopeless. The traditional saying, Cancer of the breast is operated upon, but not cured," was no longer true. In 1913 A. Baumgartner, the French surgeon, evaluated Halsteds work on breast cancer.

> By combining and selecting the best suggestions offered by the most advanced operators (and adding many new and important details of his own) the American surgeon, Halsted, elaborated a surgical technique which gave a powerful impulse to a more radical and extensive extirpation of cancer of the breast. The operation he devised was quickly adopted, wholly or with variations, by the majority of surgeons the world over … Halsteds operation or any other that approaches it, which is based upon the principles that govern it, is amply justified by its (superior) results, as shown by all published statistics.[34]

Halsted also developed surgical treatments for other diseases, including operations for various kinds of vascular aneurysm, surgical treatments for inguinal hernia, and operations for a primary carcinoma of the ampulla of Vater. Halsteds development of surgical technique for inguinal hernia was regarded as one of his most important contributions to surgery.[35] Previously, operations seldom cured hernia effectively and were followed

32) The early results of breast cancer surgery were reported in 1894. William Stewart Halsted. The results of operations for the cure of cancer of the breast performed at the Johns Hopkins Hospital from June, 1889, to January, 1894. The Johns Hopkins Hospital Report 4 (1894-1895): 297-350. Also idem. Surgical Papers. Vol. II, pp.3-50.

33) William Stewart Halsted. The results of radical operations for the cure of carcinoma of the breast. Annals of Surgery 1907;46:1-19. Also Surgical Papers, Vol. II, pp.66-81.

34) A. Baumgartner. Maladies de la mamelle. Nouveau Trait de Chirugie, (Le Dentu-Delbet, 1913), xxlii, p. 270, cited in Rudolph Matas. An appreciation. William Stewart Halsted: 1852-1922. Johns Hopkins Hospital Bulletin 1925;36:2. Also Halsted, Surgical Papers, Vol. I, p. xxxi.

35) For a historical assessment and brief accounts of Halsted development of hernia operation, see George W. Heuer. Dr. Halsted. Johns Hopkins Hospital Bulletin 90 supplement 1952:1-105, pp.95-99; William F. Rienhoff, Jr. The impact of Halsted upon surgical technique of today with particular reference to his operation for hernia. Surgery 1952;32:493-497.

by frequent recurrence. For example, William F. Bull, a distinguished surgeon and a contemporary of Halsted, reported that only 4 patients, out of 136 upon whom he had operated, remained without recurrence four years after surgery. Hernia was a challenge to surgeons. It was very prevalent and often accompanied by serious complications, including fatal strangulation. While teaching anatomy at New York, Halsted became interested in hernia. With his students he dissected the inguinal region carefully. His prolonged and rigorous study of anatomy helped him to develop new operative techniques for hernia. From 1889 to 1895, he made eight presentations about hernia at meetings of the Johns Hopkins Hospital staff. After performing experiments on surgical wound healing and surgical treatment of hernia with dogs, Halsted developed the principles of radical curative surgery for hernia.36) After exposing the inguinal canal along its whole length, Halsted made a careful dissection, high ligation, and excision of the hernial sac. He then isolated the vas deferens and the vessels of the spermatic cord, and transplanted them to the upper outer angle of the wound to avoid placing them in a weaker area of the abdominal wall. With interrupted strong silk sutures, passed to include everything between the skin and the peritoneum, he closed and repaired the anatomically weak area of the abdominal wall, approximating abdominal muscles and fascia to Pouparts ligament. Later he devised a method to use the fascia of the rectus abdominis muscle to strengthen the weak abdominal wall in more difficult cases.37) He also took every precaution to avoid infection, including aseptic techniques and hemostasis. In 1899 Joseph Bloodgood published the statistics of the results of operations upon hernia at the Johns Hopkins Hospital.38) The recurrence rate for those who had been operated upon by Halsteds method was 6.2 percent. In 1920, Adrian S. Taylor reported the results at the Johns Hopkins Hospital of operations upon 2,486 patients with hernia from 1889 to 1918.39) They included a 94.4 percent cure rate for patients with indirect hernia, and 82 percent with direct hernia, which was more difficult to correct. Although different operators used the same procedure, the results of operations varied from one operator to another. After a series of modifications of the surgical procedure, Halsted himself was able to operate upon hernia patients without a single

36) On November 4, 1889 at the Johns Hopkins Hospital Medical Society, Halsted reported his operative method upon patients with hernia for the first time. William Stewart Halsted. Radical cure of hernia. Johns Hopkins Hospital Bulletin 1 1890:12－13. Also idem. Surgical Papers, Vol. I, pp.261－262.

37) William Stewart Halsted. The cure of the more difficult as well as the simpler inguinal ruptures. Johns Hopkins Hospital Bulletin 14 1903:208－214. Also idem. Surgical Papers. Vol. I, pp.292－305.

38) Joseph C. Bloodgood. Operations on 459 cases of hernia in the Johns Hopkins Hospital from June, 1889, to January 1899; the special consideration of 268 cases operated on by the Halsted method, and the transplantation of the rectus muscle in certain cases of inguinal hernia in which the conjoined tendon is obliterated. Johns Hopkins Hospital Report 7 1898－1899:223－562.

39) Adrian S. Taylor. The results of operations for inguinal hernia performed in the Johns Hopkins Hospital from Jan. 1, 1899 to Jan. 1, 1918. Archives of Surgery 1 1920:382－406.

recurrence.[40]

Halsted regarded each patient as a problem for study and reflection. He was not interested in doing many operations for the same disease. As a serious student of disease, he reflected deeply upon a few examples of a disease, rather than providing operative treatment for the largest possible number. The diseases that Halsted selected for study were not only significant in themselves, but diseases for which the surgical treatment could be applied widely in other kinds of surgery. Halsteds principles of hernia operation came to be applied to other kinds of hernia in various parts of the body, just as his breast cancer surgery provided principles for the surgical treatment of other kinds of cancers. Halsteds thyroid and parathyroid studies became models for the study of endocrine glands, influencing Harvey Cushings research on the pituitary gland.

6. Halsted's Studies on the Thyroid and Parathyroid Glands

Halsted became interested in the thyroid gland in the laboratory of Anton Woelfler at Vienna in 1879, while studying the development and structure of the thyroid gland in fish. Eight years later in William Welchs laboratory at Baltimore, Halsted began to study problems connected with the surgery of the thyroid. Seeking the cause of death after operations upon the thyroid gland, he studied the effect of partial removal of the gland in dogs. To his surprise, Halsted found that the remaining thyroid increased in size and underwent marked histological change. The microscopic appearance of the hypertrophied tissue was so different from that of the normal gland that no pathologist in America or abroad, to whom Halsted had showed the specimens, could identify it. The hypertrophied thyroid tissue resembled that found in Graves disease (exophthalmic goiter), and reflected a hyperactive state of the thyroid gland.[41] In his experiments, Halsted tried to determine what part, and how much of the thyroid gland should be left after surgical treatment for Graves disease.

Diseases of the thyroid gland were a constant challenge to surgeons, often ending in fatal, or devastating conditions. Surgeons recognized two types of thyroid disease. The more conspicuous was the larger, colloid goiter, which often caused great disfigurement. It might also cause distressing symptoms by exerting pressure on the trachea and providing insufficient thyroid secretion. The other type was exophthalmic goiter, associated with symptoms of thyroid hyperactivity. In goiters the blood vessels were so enlarged and so numerous that fatal hemorrhage was a frequent complication of thyroid surgery. Many eminent surgeons at the time declared that operations on the thyroid were not justified. Along with Theodor Billroth at Vienna, Theodor Kocher of Bern pioneered

40) William Stewart Halsted. An additional note on the operation for inguinal hernia. prepared by Halsted on August 26, 1922, Surgical Papers. Vol. I, pp.306－308, p.307.

41) William Stewart Halsted. An experimental study of the thyroid gland of dogs, with especial consideration of hypertrophy of this gland. Johns Hopkins Hospital Reports 1897;1:372－408.

thyroid surgery in the 1870s. When Halsted visited Kocher, and attended his clinical lecture and operations, he watched Kochers operative procedures upon thyroid patients.[42] By 1883, Kocher had performed one hundred thyroid-ectomies. Halsted examined and occasionally operated upon Kochers patients. Operations upon the thyroid often caused body changes and tetany. Kocher reported that thirty patients out of one hundred who had undergone thyroidectomy showed symptoms of hypothyroidism, such as mental dullness, coarse and dry skin, anemia, hypo-thermia, and edematous changes in soft tissue. In 1889 Kocher named the train of symptoms caused by hypothyroidism cachexia strumipriva. Patients who had undergone thyroidectomy also frequently developed tetany. In 1890, Anton von Eiselsberg, the Viennese surgeon, reported 30 cases of tetany following thyroidectomy. Tetany after thyroidectomy also puzzled Halsted in his 1887-1888 experiments on thyroidectomy on dogs. Although animals with chronic tetany survived several months, at autopsy the remaining thyroid was found hyperplastic.

Until 1891 tetany and cachexia strumipriva were regarded simply as different phases of hypothyroidism. Then the French physiologist, Marcel Eugene Emile Gley (1857-1930) found that the cause of tetany after thyroid operations was the inadvertent destruction of the parathyroid glands. These tiny glands lying alongside or embedded in the lateral borders of the thyroid lobes had been recognized anatomically, but until Gleys work, their physiological importance to the maintenance of life remained unknown. Physi-cians found it difficult to believe that the loss of bodies so small could cause such disastrous results as fatal tetany.

In 1904 Halsted studies on the thyroid and parathyroids were stimulated by his experience with a woman patient suffering from a large and rapidly growing goiter. It was one of his early experiences of full-blown symptoms of hypo-parathyroidism.[43] In May 1904, Halsted removed the left lobe of the patients thyroid, taking great care to leave both parathyroids of that side *in situ*. The excised thyroid tissue revealed no evidence of removal of the parathyroids. In March 1906, the patient returned, complaining of asphyxia caused by the remaining lobe. The thyroid had grown rapidly since the previous operation. Halsted determined to remove as much of the thyroid as he thought could be done safely. After operation, he watched the patient carefully during the convalescent period. From the outset, the recovery was different from that of the first operation. Her temperature and pulse were normal, but she was abnormally flushed and very

42) Ira M. Rutkow. William Halsted and Theodor Kocher: an exquisite friendship. Annals of Surgery 188 1978: 630-637.

43) William Stewart Halsted. Hypoparathyreosis, status parathyreoprivus, and transplantation of the parathyroid glands. American Journal of Medical Sciences 1907;134:1-12. Reprinted in Halsted. Surgical Papers. Vol. II, pp.150-163. Another case report on hypoparathyroidism in the same year is Eugene H. Pool. Tetany parathyreopriva. Annals of Surgery 1907;46:507-540. In this paper, Pool summarized the history of research on the parathyroid glands.

restless, sleeping poorly. On the seventh day, she began to complain of attacks of a queer feeling. The next day when Halsted visited the patient, he saw her in one of such attacks. He realized immediately that her symptoms were severe and were caused by parathyroid deficiency. Halsted asked MacCallum, who had been collecting bovine parathyroids for the purpose of research, to give the patient dried parathyroids. The patient took six dried parathyroids by mouth every three hours. The result was almost instantaneous and to Halsted most marvelous. The symptoms improved greatly. Hoping to stimulate any remaining parathyroids glands, Halsted decreased the amount of bovine parathyroids to one gland three times a day. As prepared glands were used up, the patient took parathyroids fresh from the slaughter house. They proved to be even more effective than the dried glands. In January 1907, when the patient was still invalid, Halsted began to give her the parathyroid nucleotide hypodermically. S. P. Beebe of Cornell, New York, who began to make the nucleotide preparation, sent it to Halsted at his request. The effect was prompt and complete. The pains and twitching in the joints and depression disappeared immediately after treatment.

Complete as it was, the effect of nucleotide treatments was transient. Feeling deeply that he was responsible for the patients miserable condition, Halsted began experimental research on the parathyroids along two lines. One was to devise a safe method of operation upon the thyroid to prevent removal of, or injury to, the parathyroid glands. The other was on transplantation of the parathyroids for patients who had been deprived accidentally of parathyroid secretion as a result of thyroid surgery.

At the time, surgery for exophthalmic goiter was directed toward removal of the greater portion of the thyroid gland without sacrifice of the parathyroids. The toxic symptoms of exophthalmic goiter were so serious that almost total thyroidectomy was required. Realizing that the surgeon should be aware of the variations in the size and position of the parathyroids, Halsted asked MacCallum, who had already published two papers on the parathyroid glands, to search at every autopsy for the parathyroids. From six-tyseven dissections, MacCallum concluded that the position and size of the parathyroids varied greatly. Two on each side of the thyroid, the parathyroid glands could exist at any level from the superior to the inferior pole on the posterointernal surface of the thyroid. Most frequently they were near the terminal branches of the inferior thyroid artery.[44] If the thyroid gland were lobulated, as was commonly the case, a parathyroid might be concealed in a cleft between the lobules.

Halsted also found that tetany following thyroidectomy at the hands of a skilled operator resulted from interference with the blood supply of the parathyroid by the cutting or clamping of arteries, rather than from inadvertent removal of the glands. Halsted suggested to Herbert M.

44) Halsted. Surgical Papers. Vol. II, pp.163-164.

Evans that he should study the exact source and position of the blood supply to the parathyroid glands in man. Few studies had been made on human parathyroids, most previous studies having been done on dogs. Evans secured human specimens a few hours after death, removing the entire neck organs *en masse*. He dissected the upper and lower poles of each lateral lobe, and injected the arteries and veins with mercury sulphides and ultramarine blue. After making a simple sketch, Evans put the specimen into formalin, and performed a careful dissection. He described variations in the blood supply of the parathyroid glands. The parathyroid arteries, superior and inferior, usually arose from the inferior thyroid artery.45) On the basis of Evans studies, Halsted suggested three ways to save the parathyroid glands.

> 1. Slice through the thyroid gland in such manner as to leave in situ and with intact blood supply the area in which the parathyroids usually lie. This procedure is, probably not applicable to cases which are very ill. 2. At a preliminary operation ligate the superior and inferior thyroid arteries with the expectation that the parathyroids will receive a peripheral (extrinsic) blood supply; a week or two later perform the subscapular operation. 3. Search for the parathyroids before ligating any vessels of the thyroid glands; demonstrate the precise origin of each parathyroid artery; continue in such manner as not to imperil the circulation of the para-thyroid. For this procedure much practice on the cadaver is essential.46)

Finally, Halsted studies led him to decide upon a method for operation upon the thyroid gland, safe not only from the viewpoint of avoiding hemorrhage but of protecting the patient against removal of, or injury to, the parathyroid glands and recurrent laryngeal nerves. With beautiful illustrations by Max Brodel, Halsted presented his method of operation for exophthalmic or hyperplastic goiter in The Operative Story of Goitre; the Author's Operation.47) This book contained a history of thyroid surgery with an exhaustive review of thyroid literature. It became a classic in the field.

From 1906 to 1908 Halsted performed experiments on transplantation of the parathyroids, searching for treatment for patients with deficient parathyroid secretion as a result of thyroid surgery. Using the same operative technique as for humans in the hospital, Halsted performed 130 transplantations in 60 dogs. As the sites for transplantation, he chose the thyroid gland, the spleen, and the rectus abdominis muscle. He reported a 61 percent success rate of auto-

45) William Stewart Halsted, and Herbert Evans. The parathyroid glandules. Their blood supply, and their preservation in operation upon the thyroid gland. Annals of Surgery 1907;46:489-506.

46) William Stewart Halsted. Hypoparathyreosis, status parathyreoprivus, and transplantation of the parathyroid glands. American Journal of Medical Sciences 1907;134:1-12. Reprinted in Halsted. Surgical Papers. Vol. II, pp.150-163. Also see, idem, Preservation of the parathyroid during thyroidectomy,"Halsted, Surgical Papers, Vol. II, pp.146-167.

47) Halsted, Operative Story of Goitre. Halsted, Surgical Papers, Vol. II, pp.257-423.

transplantation of parathyroid glands, among cases in which a deficiency had been created. One of Halsteds important discoveries in transplantation was the principle that the creation of deficiency of parathyroid secretion was necessary to sustain the transplanted parathyroid tissue. Halsted reported that the life of a dog might be maintained by a particle of parathyroid tissue only a quarter of a millimeter in diameter and might be extinguished by tetany on its removal.[48] From his experiments, Halsted advised surgeons that when the parathyroid glands of patients were excised or deprived of their blood supply in the course of surgical operation, "parathyroid glands should, in the present state of our knowledge, be grafted, and probably into the thyroid gland.[49]"

Throughout his studies on the thyroid and the parathyroids, Halsted used the various techniques of surgery, physiology, and pathology. He was well aware of the importance of interconnected approaches. Halsted said, There is a most intimate interdependence of physiology, pathology and surgery. Without progress in physiology and pathology, surgery could advance but little, and surgery has paid this debt by contributing much to the knowledge of the pathologist and physiologist, never more than at the present time.[50] "

7. Conclusion : Halsted in the History of American Surgery

As a professor, Halsted was unapproachable, detached, and reserved. He avoided social gatherings whenever possible. To a few intimate friends, however, he was warm, witty, and hospitable, displaying a rich sense of humor.[51] Halsteds marriage to Caroline Hampton was one of complete mutual devotion. They had no children. Each summer they spent at "High Hampton," an estate at Cashiers in the North Carolina mountains. In 1919 Halsted began to have gallstone colic. A few weeks later, he underwent cholecystectomy for gallstones. In 1922, Halsted had another attack of jaundice,

48) William Stewart Halsted. Report of a dog maintained in good health by a parathyroid autograft approximately one-fourth of a millimeter in diameter, and comments on the development of the operation for Graves disease as influenced by the results of experiments on animals. Journal of Experimental Medicine 1909;11:175.

49) William Stewart Halsted. Auto- and isotransplantation, in dogs, of the parathyroid glandules. Surgical Papers. Vol. II, pp.178-199.

50) William Stewart Halsted. The training of the surgeon, 1904 Surgical Papers, Vol. II, p.513.

51) In successive papers, Ira M. Rutkow had examined Halsteds friendships based upon correspondence. Ira M. Rutkow. William Halsted and Theodor Kocher: an exquisite friendship. Annals of Surgery 1978;188:630-637; Ira M. Rutkow, B. G. Rutkow and C. B. Ernst. Letters of William Halsted and Rene Leriche: Our friendship seems so deep. Surgery 1980;88:806-25; Ira M. Rutkow. The letters of William Halsted and Alexis Carrel. Archives of Surgery 1980;115:993-1001; idem. William Halsted and Rudolph Matas; their unique alliance. Surgery 1980;87:524-538; idem. The letters of William Halsted and Erwin Payr. Surgery, Gynecology, and Obstetrics 1985;161: 75-87; idem. The letters of William Stewart Halsted and William Williams Keen. Surgery 1986;100:550-561; idem. The letters of William Stewart Halsted and John Chalmers DaCosta. American Journal of Surgery 1987;154:320-332.

and was operated upon. He died the day after the surgery.

William Halsteds most far-reaching contribution to American medicine was his system of surgical training and education. In 1904, in an address on the "Training of the Surgeon," he stated: We need a system, and we shall surely have it, which will produce not only surgeons, but surgeons of the highest type, men who will stimulate the first youths of our country to study surgery and to devote their energies and their lives to raising the standard of surgical science.[52]" As soon as patients became available in the wards of the Johns Hopkins Hospital, Halsted introduced the residency system. He carefully selected men, who spent seven years or more in residence in the hospital. During these years, they trained in surgical pathology, experimental surgery, and in the diagnosis, operation, and pre- and post-operative care of patients. Halsted gave them complete responsibility for patients. Halsteds system of surgical residency training was a major contribution of the Johns Hopkins Hospital to American medicine.

Johns Hopkins was the first school of surgery in America that embodied all the developments that Halsted pioneered, including surgical asepsis, control of hemorrhage, and careful handling of tissue. Among seventeen surgical residents trained by Halsted, eleven became professors of surgery. In their new posts they set up similar residency training programs. These eleven centers produced 166 resident surgeons, of whom 85 became teachers in university medical schools. Altogether the first two generations of the Halsted tradition trained 238 surgeons. Among them were 139 surgeons in full time teaching positions at universities, and 99 surgeons in private practice.[53] Through the influence of Halsteds former residents on surgical education, Halsteds imprint on American surgery continues today.

Keyword : William Stewart Halsted, History of Surgery, Medical Education in Early 20th Century America

52) Halsted. Surgical Papers. Vol. II p.527.

53) B. N. Carter. The fruition of Halsted concept of surgical training. Surgery 1952;32:518-527. Crowe. Halsted of Johns Hopkins. pp.54-56.

= 초록 =

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윌리엄 스튜어트 할스테드는 19세기 말 20세기 초에 이루어진 미국 의과대학의 의학교육 개혁을 배경으로 미국 외과학의 기초를 세우게 되었다. 미국 최초의 교육병원으로 1889년에 설립된 존스홉킨스 병원과 1893년에 설립된 존스홉킨스 의과대학에서는 윌리엄 헨리 웰치나 윌리엄 오슬러 등의 젊은 의학자들이 의학연구와 임상교육에 기초하여 학생과 전공의들을 교육시키는 개혁적 분위기가 형성되었다. 다른 의과대학에 모델을 제시함으로써 미국 의학교육사에서 큰 역할을 한 존스홉킨스의 초대 외과학 교수로 임명된 할스테드는 재직기간 동안 근대 외과학의 발전에 큰 공헌을 하였다. 전통적으로 외과의사의 3대 적이었던 통증, 출혈, 감염을 방지하기 위한 외과 술기 및 이론들을 정립시켰던 것이다. 일련의 실험을 통해 국소마취법을 개발했으며, 동물실험으로 조직의 괴사와 감염간의 상관관계를 밝히고 조직 괴사를 최소화하는 혈관의 결찰법을 개발하였다. 그는 또한 무균 수술법을 개발하여 수술 시에 고무장갑을 착용하도록 하였고, 세균학적 검사를 통해 무균적 상태를 확인하도록 하였다. 이전의 외과수술이 빠른 속도에 의존한 데 비해, 할스테드의 수술법은 꼼꼼한 결찰 및 지혈, 정교한 수술기법, 섬세하고 조심스러운 시술 등을 통해 부작용을 최소화하고 회복을 빠르게 하는 현대화된 수술법이었다. 할스테드는 외과병리, 실험외과학, 진단, 수술법, 수술전후 처치 등을 체계적으로 교육하는 외과전공의제도를 도입함으로써 외과의의 수련 및 교육에 관한 체계를 확립하였다. 그가 훈련시킨 17명의 외과의 중 11명이 교수가 되어 각 대학병원에서 전공의 수련을 확립시킨 이래, 2대에 걸쳐 양성된 238명의 외과의 중 139명이 의과대학 외과학교수가 되어 미국 전역에서 할스테드의 외과학 전통을 오늘날까지 이어오고 있다.

색인어 : 윌리엄 스튜어트 할스테드, 외과학의 역사, 20세기 초 미국의학교육

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Learn about the history of plastic surgery, from its beginnings in ancient India to the very sophisticated surgical specialty that it is today.Â However, it was not until the early 20th century that modern plastic surgery was to be recognized as its own medical specialty. In 1907, Dr. Charles Miller penned the first text specifically written on cosmetic surgery, entitled The Correction of Featural Imperfections.Â It was there that Dr. William Stewart Halsted created the first general surgery training program in the United States.ï»¿ï»¿ In 1904, he published The Training of a Surgeon, which laid the foundation for what was to become the prototype for all modern surgical training programs. With this, the U.S. could finally claim a level of surgical sophistication on par with Europe. William Stewart Halsted was a pioneer of surgery in the USA and made many wide-ranging contributions, including the surgical treatment of breast cancer. He changed the training of surgeons from a disorganised apprenticeship to the residency training programmes used today. Halsted's research developed a better understanding of surgically amenable disease and a multitude of new techniques and operations. Over a 40-year career, beginning in New York and continuing at Johns Hopkins University Hospital in Baltimore, he endured a terrible struggle resulting from an accidental addiction, acquire Dr. John Thackery (partially based on historical figure, William Stewart Halsted[2]), the newly appointed leader of the surgery staff, battles his cocaine and opium addictions with his ambition for medical discovery and reputation among his peers. Vintage Nurse Vintage Medical Medical Humor Nurse Humor Rn Humor Nurse Ratchet Ob Nursing Maternity Nursing Tea Reading.Â Surgical photo, early 20th century. The Burns Archives. William Harvey Writing A Biography Cushing Disease Philosophy Of Science Johns Hopkins Medical History Problem And Solution Psychiatry Ernest. Harvey Williams Cushing 1938 - Father of Neurosurgery. Vintage Nurse Vintage Medical Cold Rolled Medical History World War One Nursing Students Light In The Dark Surgery Photo Wall.