

William Stewart Halsted: his life and contributions to surgery

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Lancet Oncol 2007; 8: 256–65

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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, acquired in the course of his research. Despite this, his legacy to medicine and human health is one of the greatest left by any individual surgeon in history and remains an inspiration today.

Background and early life

William Stewart Halsted (figure 1) was one of the most influential pioneers of surgery in the USA. His achievements varied widely and contributed to the many aspects of surgery he focused on throughout his career. Such achievements included formulating a new approach to breast cancer with the development of new operating procedures that became the basis of surgical technique; pioneering the use of local anaesthesia for general and dental surgery; improving the technique and safety of surgery; and changing the teaching methods for surgeons in the USA from disorganised self-teaching and apprenticeship to the coordinated training programmes of nowadays.^{1,2}

Halsted was born in New York City, NY, USA, in 1852, and was of English ancestry. His father, William Mills Halsted Jr, was a successful businessman and principal

partner of a highly exclusive dry goods company, Halsted, Haines and Company. The family was wealthy, with a magnificent house on Fifth Avenue in New York City and a country estate in Westchester County, NY, USA. Halsted's father was active in charitable works and also a governor of the New York Hospital and the Bloomingdale Asylum as well as a trustee of the College of the City of New York and of the College of Physicians and Surgeons at Columbia University, New York.

Halsted was first educated by a private tutor at home before being sent to boarding school at the age of 10 years (figure 2). Despite briefly running away, he graduated from Andover School, MA, USA, in 1869 at 17 years of age. His father did not consider him immediately ready for college, so Halsted spent the next year studying at home before entering Yale College, CT, USA, in 1870 to study Liberal Arts. Here, he was a below-average student and there is no record of him having ever borrowed a book from Yale library during his 4 years as an undergraduate. However, his poor academic achievements were made up for by his sporting prowess; he played short stop on the baseball team, rowed for the Yale crew, captained the football team, and scored the winning goal in a match against the Eton Graduates team. Halsted also belonged to many societies in addition to acting in comedies in amateur stage shows. He was interested in boxing and went to watch fights, but did not socialise much or drink alcohol.

The origin of his interest in medicine is unclear. As a child, Halsted captured and dissected frogs at the country estate, and during his senior year at Yale, purchased Gray's Anatomy and Dalton's Physiology and attended a few clinics at Yale Medical School. After graduation, Halsted enrolled at the College of Physicians and Surgeons (affiliated with Columbia College) in 1874, probably influenced by his father's involvement in medical institutions. Here, he became dedicated to the study of medicine and excelled; the impetus for his transformation from a poor student to a high achiever is unknown. Halsted's most relevant setback was in his senior year at Yale when he was denied membership to the Skull and Bones Society, a secret society to which his forbearers had belonged. Despite his athletic abilities and popularity he was known more for his caustic wit, which had led several students to block his election to the Society.

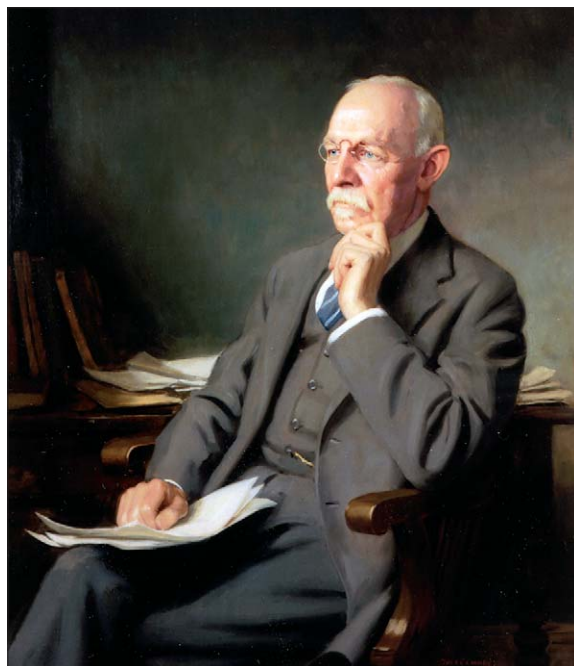


Figure 1: William Stewart Halsted

Portrait from last photograph taken in 1922. Reproduced with permission from Alan Mason Chesney Medical Archives of Johns Hopkins University Medical Institutions.

Early training

Halsted's tutor at medical school was Henry B Sands, a pre-eminent surgeon and Professor of Anatomy. Halsted also became first assistant to John C Dalton, a Professor of Physiology, and spent time on dissection and working in a pharmacy. Although Halsted had only completed 2 years at medical school, in 1876 he applied for an internship at Bellevue Hospital, New York, as House Surgeon. A new rule had just been implemented that did not allow the position to be taken unless the applicant had a medical degree; however, Halsted "took it as a lark". Appointment to this position was via a competitive exam, and the intense study coupled with the heat in New York that summer caused him to be "unable to memorize normally." Halsted therefore went to Block Island, RI, USA, where he studied in the morning and spent the afternoons sailing and fishing. He returned to New York in perfect health and with his memory recovered. Halsted stated that others taking the examination were pale and nervous, and some "...braced up on strychnine and quinine during the hot weather".³

Halsted's exam was a success and he was appointed to Bellevue Hospital, where he remained for a year (figure 3).⁴ Here, two surgeons had adopted Joseph Lister's antiseptic technique, first described in 1867 before his visit to New York in 1877. Halsted noted the reduced incidence of infection in patients of the two surgeons who used antiseptics compared with the incidence in patients of surgeons who did not, "...you can only imagine the difference." This observation sparked Halsted's interest in antiseptics, and while at Bellevue he contributed to the treatment of infection. He also developed new devices for the treatment of fractures of the femur and patella.⁴ In 1877, he took an examination at the College of Physicians and Surgeons to gain his MD, and was ranked in the top ten honour students. These ten students competed for a prize of \$100 (equivalent to roughly US\$1750 nowadays)⁵ via a written examination, which Halsted won. He then competed for the position of House Physician at the New York Hospital, to which he was appointed in April, 1878, and stayed until October, 1878. During this time, Halsted changed the way vital signs were recorded in hospital records, using a method that was subsequently widely adopted.^{6,7} However, no formal training in surgery was provided at the New York Hospital, and so, once his internship ended, Halsted travelled to Europe and studied under many who subsequently became known as pioneers in their fields (panel 1).^{4,8} This experience had a profound affect on Halsted's future career.

Early career

In 1880, Halsted returned to New York, armed with the best knowledge of modern surgery Europe had to offer. The introduction of anaesthesia by William Morton at Massachusetts General Hospital in Boston, MA, USA,



Figure 2: William Stewart Halsted
Detail from a family portrait, aged 10 years. Reproduced with permission from Alan Mason Chesney Medical Archives of Johns Hopkins University Medical Institutions.

in 1846, and the development of new techniques using antiseptics, had greatly changed surgical practice in the USA, and Halsted seized the opportunities these changes had produced. From 1880 to 1886, he was appointed to several positions at six local hospitals, including Assistant Demonstrator in Anatomy at the College of Physicians and Surgeons, visiting physician to the Roosevelt, Bellevue, Presbyterian, and Charity Hospitals, and Surgeon-in-Chief to the Emigrant Hospital, all in New York. At Bellevue Hospital, he persuaded the Commissioners to erect a tent-like structure on the grounds of the hospital for the sole purpose of functioning as his operating room where he could practice antiseptic surgery. This venture cost \$10 000 (about \$180 000 nowadays),^{4,5} with some of the funding provided by his family. During this time, he undertook the first autotransfusion, gave the first successful person-to-person transfusion, treated carbon-monoxide poisoning caused by gas illumination on night boats, and did the first appendectomy in New York. In partnership with a pathologist named William Welch, who also worked at Bellevue, Halsted also contributed to surgical education by running private courses for medical students. Didactic teaching at medical schools was not thorough enough at this time, but Halsted's courses were different. They consisted of bedside clinical rounds, anatomy, and pathology

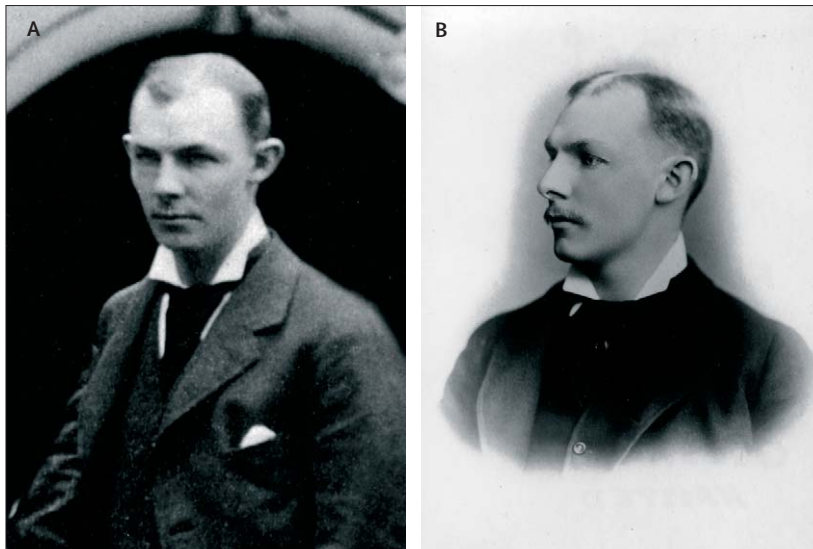


Figure 3: Halsted during surgical internship at Bellevue Hospital in New York City in 1877 (A) and at time of his appointment to Johns Hopkins University Hospital in 1889 (B)

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demonstrations, and, overall, covered the theory and practice of surgery. His students were consistently top of their class in medical school and he was recognised as an inspiring, charismatic teacher as well as a daring, skilled, and bold surgeon.

This boldness was clearly shown when he did the first ever emergency blood transfusion on his own sister.⁹ She had developed a postpartum haemorrhage leaving her in a critical condition. Halsted transfused his own blood into her and she made an immediate recovery. Additionally, in 1882 he was called to see his mother urgently because she was jaundiced with right upper-quadrant abdominal tenderness. She had been treated in New York for some time for abdominal symptoms. In the early morning at his mother's house, Halsted did the first successful cholecystostomy, removing pus and seven gallstones, which also resulted in his mother's complete recovery.²

Local anaesthesia and Halsted's addiction to cocaine

Indigenous South Americans were already known to chew coca leaves, which reportedly led to dependence and loss of sensation in the oral cavity. In September, 1884, at the meeting of the German Ophthalmological Society in Heidelberg, Germany, a paper reporting the anaesthetic properties of a solution of hydrochlorate of cocaine on the conjunctiva and cornea was presented on behalf of Carl Koller of Vienna (who did not have sufficient funds to travel to Heidelberg himself).¹⁰ Koller's discovery resulted in the birth of modern ophthalmological surgery. Furthermore, cocaine had been purified by Nieman in 1860.¹¹ Henry D Noyes from New

York was present at the meeting in Heidelberg and reported Koller's findings in a letter to *The New York Medical Record*,¹² which resulted in a widespread demand for the cocaine solution in the USA and other countries. Cocaine, at that time, was widely used as a tonic, especially in Coca Cola and a wine called Vin Mariani, and in the treatment of morphine addiction and alcoholism. By November, 1884, Edward Squibb (founder of the Squibb Pharmaceutical Company, now Bristol Myer Squibb) had received over 300 letters requesting cocaine for medical use. Within a month the price rose from \$2·50 to \$7·50 (equivalent to about \$140 nowadays).⁵ Cocaine would subsequently be recommended by Sigmund Freud,¹³ who published a paper on the topic in 1887; Freud reportedly became addicted.

In December, 1884, George F Shradly wrote an editorial in *The New York Medical Record* describing a group of surgeons and medical students studying the effect of cocaine on sensory cutaneous nerves.¹⁴ He was referring to Halsted and his colleagues at Roosevelt Hospital. The month before, a letter to the editor of the *New York Medical Journal* had been published, written by Halsted's colleague Richard J Hall, describing the experiments Halsted's group had done on each other and how they were using cocaine hydrochlorate to block sensory nerves.¹⁵ Unfortunately, Halsted and his colleagues became addicted to cocaine during these experiments. A contemporary narrative by Halsted of his experience in more than 1000 minor surgical procedures provides insight.¹⁶ The first paragraph reads:

"Neither indifferent as to which of how many possibilities may best explain, nor yet at a loss to comprehend, why surgeons have, and that so many, quite without discredit, could have exhibited scarcely any interest in what, as a local anesthetic, have been supposed, if not declared, by most so very sure to prove, especially to them, attractive, still I do not think that this circumstance, or some sense of obligation to rescue fragmentary reputation for surgeons rather than the belief that an opportunity existed for assisting others to an appreciable extent, induced me, several months ago, to write on the subject in hand the greater part of a somewhat comprehensive paper, which poor health disinclined me to complete."

The paper is rambling and incoherent, consistent with a cocaine-induced psychosis, as diagnosed by a psychiatrist at the Payne-Whitney Clinic of the New York Hospital who assessed the paper.¹⁷ Several unpublished manuscripts, detailing experience using cocaine local anaesthesia in nearly 2000 minor surgical procedures, were later found among Halsted's papers. During this time, his contributions to the prestigious New York Surgical Society declined and he was unable to deliver the lectures needed for entering the competition for the Chair of Surgery at his alma mater, the College of Physicians and Surgeons. By early 1886, Halsted was so incapacitated that he took a break from work and went

Panel 1: William Halsted's training in Europe (1878–1880)**Anatomy**

Zuckerkindl (Vienna, Austria)

Dermatology

Kaposi (Vienna, Austria)

Embryology

Schenck (Vienna, Austria)

Kölliker (Würzburg, Germany)

Gynaecology

Pawlik (Vienna, Austria)

Histology

Exner (Vienna, Austria)

Stoehr (Würzburg, Germany)

Ophthalmology

Fuchs (Vienna, Austria)

Arit (Vienna, Austria)

Otology

Pollitzer (Vienna, Austria)

Gruber (Vienna, Austria)

Pathology

Neumann (Vienna, Austria)

Chiari (Vienna, Austria)

Huber (Leipzig, Germany)

Surgery

Theodore Billroth (Vienna, Austria)

Braun (Vienna, Austria)

Mikulicz (Vienna, Austria)

Von Bergmann (Würzburg, Germany)

Von Bruns (Tübingen, Germany)

Wagner (Leipzig, Germany)

Volkman (Halle, Germany)

Schede (Hamburg, Germany)

Esmarch (Kiel, Germany)

Thiersch (Leipzig, Germany)

on a cruise to the Windward Islands with the hope of beating his addiction. However, on his return Halsted was admitted to the Butler Hospital in Providence, RI, USA, where he was treated for cocaine addiction with morphine.¹⁸ After 7 months he was discharged, but realising his career in New York was over, he went to join William Welch in Baltimore, MA, USA, who held the position of founding Chair of Pathology at Johns Hopkins University, Baltimore, MA, USA.

During his time in Welch's Hunterian laboratory, Halsted worked on intestinal anastomosis using submucosal suturing, which became a basis for gastrointestinal surgery. In April, 1887, he presented a paper at Harvard Medical School, Boston, MA, USA, but was soon after readmitted to the Butler Hospital.¹⁸ After 9 months as an inpatient he returned to Baltimore.

Reports from Butler Hospital to the board during 1887 indicate that patients with an opium habit, which probably included Halsted, were cured. There is little evidence, however, to suggest that Halsted's collaborating colleagues in New York recovered from their addiction. Richard Hall, who died at an early age of appendicitis after moving to California, had written to Halsted with reference to "a long period of misery, the causes of which I do not need to describe". Furthermore, Halsted himself wrote to William Osler, the founding Chief of Medicine, at Oxford University, Oxford, UK, in August, 1918, describing his work on cocaine for local anaesthesia, stating that all three of his colleagues died never having recovered from the habit.¹⁹ During his career, subsequent to his work at Roosevelt Hospital, Halsted rarely used or referred to his work on local and spinal anaesthesia; however, shortly before he died, the National Dental Association (subsequently the American Dental Association) awarded him a gold medal in recognition of his development of dental local anaesthesia.

Later career at Johns Hopkins University Hospital and Medical School

The Johns Hopkins University Hospital was opened in 1889 and the Medical School in 1893. The initial choice for Surgeon-in-Chief for the hospital was Sir William Macewen, Professor of Surgery in Glasgow, UK. However, his requirements for bringing his team to the hospital could not be met. In 1889, Welch recommended that Halsted be appointed head of the outpatient department, acting Surgeon to the Hospital, and Associate Professor of Surgery (figure 3). The fact that Halsted was initially appointed to these positions, rather than Surgeon-in-Chief, indicated the concerns of Welch and the trustees about his addiction to cocaine. The next year William Osler, who was also affiliated with the hospital at the time, suggested to the President of Johns Hopkins University that Halsted be appointed Surgeon-in-Chief of the hospital. He stated, "Halsted is doing remarkable work in surgery, and I feel his appointment to the University and Hospital would be safe".¹⁹ After his appointment to this position in 1890, Halsted became the first Professor of Surgery at the Medical School in 1892.

Contributions to surgery

Development of radical mastectomy for breast cancer

During his years in Baltimore, Halsted made an unprecedented number of contributions to general surgery, including his development of radical mastectomy as a treatment for breast cancer.

In England, Charles Hewitt Moore described an operation which removed the skin, breast, pectoral muscles, and axillary lymph nodes. Moore's approach was based on a clinical rather than pathological idea of poor local control.²⁰ He stated that anything less was

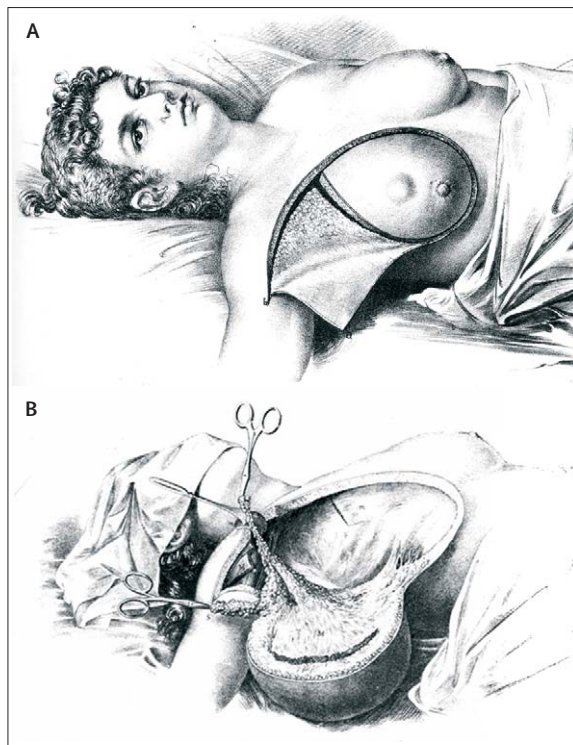


Figure 4: Incision for radical mastectomy (A) and extent of dissection of breast, pectoral muscles, and axillary lymph nodes in a radical mastectomy (B)

Reproduced with permission from ref 47.

“a mistaken kindness to the patient”, because the cancer was likely to return in a more aggressive form. The cellular basis of pathology was established by Rudolf Virchow (1821–1902) in Berlin, Germany, and a detailed study of breast pathology and the spread of cancer was done by Lothar Heidenhain, also in Berlin.²¹ Heidenhain carefully documented the spread of cancer from within the breast to the pectoralis major muscle and the lymphatics. Cancer cells were identified in the lymphatics and were believed to be progressive and contiguous with each other. Heidenhain noted that “...occasionally isolated embolic or a few free cancer cells are present in the lymph...”.²¹ The hypothesis of local and regional spread of breast cancer was influenced by William Sampson Handley, who worked at the Middlesex Hospital, London, UK, and was the Hunterian Professor of Surgery at the Royal College of Surgeons, London, UK. He stated that there was “continuous growth of cancer along the lymphatics...” which he termed lymphatic permeation.²² He also wrote: “Embolic invasion of the axillary glands almost invariably occurs in an early stage of breast cancer” and that “there can be no doubt in certain rare cases of carcinoma, embolism by the way of the blood stream does occur as a process effective in causing metastases”.

The hypothesis of lymphatic permeation was used to explain the spread of cancer, in a centrifugal manner, to

Surgeon	Years	n	Local recurrence (%)
Bergmann	1882–1887	114	51–60
Billroth	1867–1876	170	82
Czerny	1877–1886	102	62
Fischer	1871–1878	147	75
Gussenbauer	1878–1886	151	64
König	1875–1885	152	58–62
Küster	1871–1885	228	59
Lücke	1881–1890	110	60
Volkman	1874–1878	131	59
Halsted	1890–1895	50	6

Table 1: Results of mastectomies for breast cancer by surgeon 1867–1890

more distant sites such as the lung, liver, and skeleton.²³ The notion of centrifugal spread led Halsted to devise a radical procedure for breast cancer, which he undertook in 1894. This procedure involved removal of the breast, the pectoral muscle, and the regional lymph nodes en bloc to ensure that no cancer was incised, which would have allowed contamination of the operative site or resulted in residual disease (figure 4).²⁴ An identical procedure was also reported by Willie Meyer at the same time.²⁵ Between 1894 and 1895, Halsted reported on 50 cases of breast cancer treated by radical mastectomy with only three (6%) local recurrences.³ Analyses of the results of other series at that time showed local recurrence rates that varied from 51% to 82% (table 1).

In 1898, Halsted published the results of a radical mastectomy done by his assistants, John Finney, Joseph Bloodgood, and Harvey Cushing (figure 5).²⁴ 130 operations were reported, with local recurrences in 9% of cases and regional recurrence in 16%. Halsted also reported on the removal of supraclavicular lymph nodes in 101 patients,²⁶ but he subsequently abandoned the procedure for reasons unknown.

Halsted was aware that the internal mammary lymph nodes could also be a site of spread and asked his assistant Harvey Cushing to study this. However, this work was never completed, perhaps because of Cushing’s increasing interest in neurosurgery. Instead, William Sampson Handley described the technique for exploring the anterior mediastinum and removing the internal mammary lymph nodes from the first, second, and third intercostal spaces.^{22,27} More detailed studies were done by his son, Richard Sampson Handley.²⁸

The most radical form of mastectomy was attempted by Olaf Wangensteen in the 1940s, which involved the additional removal of the supraclavicular lymph nodes, internal mammary lymph nodes, and the mediastinal lymph nodes. However, poor results because of high mortality prevented further development of this technique.^{29,30} In 1952 Jerome Urban, at Memorial Hospital in New York, described an extended radical mastectomy, which included en bloc resection of the

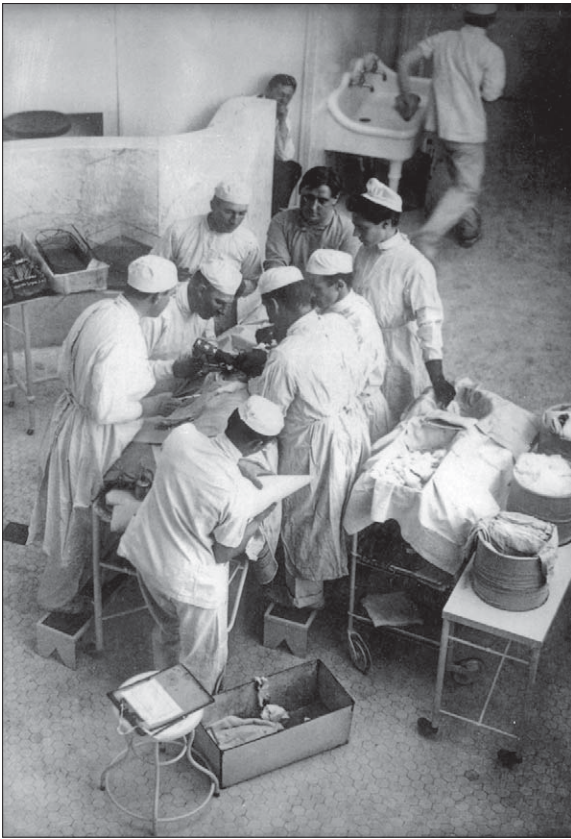


Figure 5: "All Star Operation"

Halsted with Harvey Cushing and John Finney. Reproduced with permission from Alan Mason Chesney Medical Archives of Johns Hopkins University Medical Institutions.

chest wall and internal mammary lymph nodes; the chest wall was reconstructed with fascia lata.^{31,32}

Eventually, radical mastectomy was challenged by David Patey in the 1940s, at the Middlesex Hospital in London, who modified Halsted's operation to preserve the pectoralis major muscle. This modified technique subsequently became the gold standard procedure in the USA in the 1970s.³³ In a highly controversial approach, McWhirter (a radiation therapist in Scotland) proposed radiotherapy of the chest wall and regional nodes after total mastectomy as an alternative to radical mastectomy.³⁴

Between 1931 and 1932, Geoffrey Keynes at St Bartholomew's Hospital in London, UK, proposed breast irradiation using radium needles.³⁵ This procedure was then compared with mastectomy by randomised trials that began in the 1970s in the wake of earlier diagnosis of breast cancer, and continued for the next 20 years. In 2002 the results of the studies became available, showing that radical mastectomy was no longer necessary because breast-conserving surgery seemed to be equally effective in most patients.^{36,37} In the meantime, pressure from women's groups and the earlier results of clinical trials, which compared breast-



Figure 6: Founding physicians of Johns Hopkins University Hospital painted by John Singer Sargeant in 1905

Left to right: William Welch, William Halsted, William Osler and Howard Kelly. Reproduced with permission from the Alan Mason Chesney Medical Archives of Johns Hopkins University Medical Institutions.

conserving surgery with mastectomy, led to a National Cancer Institute Consensus Statement in 1990 that breast conserving surgery was appropriate for most women.^{38,39} Although Halsted's radical mastectomy was rejected by many women, the procedure was, in fact, developed for the treatment of stage III breast cancer, which was prevalent before the 20th century. The advent of mammography and the early detection of cancer paved the way for breast-conserving surgery. Nowadays, non-radical mastectomy is needed in around a third of cases of breast cancer.

Other contributions

Halsted's work with the founders of pathology, medicine, and gynaecology proved to be a valuable experience (figure 6), and his contributions to thyroid, gastrointestinal, biliary, and vascular surgery were crucial developments within these fields (panel 2). Other pioneering work included parathyroid transplantation, and the use of plate and screws for large bone fractures.

Halsted is also credited with the introduction of rubber glove use during surgery.⁴⁰ However, even though he was on a quest for combating surgical infection, his introduction of rubber gloves was solely meant for protecting the hands of his scrub nurse, Caroline Hampton, whom he later married. Caroline was trained at the New York Hospital and graduated in 1888. She was appointed head nurse of the surgical division of John Hopkins Hospital in 1889. The scrub-up process was lengthy and rigorous, with initial scrubbing of the hands, arms, and nails with green soap. Afterwards, the hands and arms were immersed in a saturated solution of potassium permanganate followed by a hot oxalic acid solution to decolonise any

Panel 2: Halsted's contributions to surgery at Johns Hopkins University (partial list from 180 papers from Johns Hopkins University Hospital medical archives; *Medical Archives JHMI* 2000)

1881	First person-to-person blood transfusion
1882	First cholecystostomy
1887	Submucosal intestinal suture
1888	Hypertrophy of the contralateral lobe of the thyroid after lobectomy (concurrent with Sir Victor Horsley)
1889	Introduced rubber gloves into surgery
1889	Conceived radical mastectomy for breast cancer
1890	Operation for cure of inguinal hernia
1891	First successful ligation of the subclavian artery and excision of subclavian aneurysm
1893	First three choledochotomies in the USA
1894	Described the operation for radical surgery for breast cancer
1896	First successful excision of cancer of the Ampulla of Vater transplanting the common bile duct into the duodenum
1903	Described the use of the cremaster muscle for repair of oblique inguinal hernia and rectus abdominis for direct inguinal hernia
1905	Devised method for partial, progressive, and complete occlusion of the aorta and other large arteries for aneurysms using metal bands
1906	Experimental demonstration of parathyroid transplantation
1910	Innovated new method for end-to-end intestinal anastomosis
1912	Showed in an experimental model that removal of transplanted parathyroid gland resulted in tetany
1912	Cured iliofemoral aneurysm with partial occlusion
1915	Developed a new, safer method of draining the common bile duct
1913	Partial occlusion of thoracic and abdominal aortic aneurysm
1920	Devised blind-end anastomosis of large intestine with per rectal opening of the anastomosis with a guarded knife

bacteria. Soaking in corrosive sublimate of mercury (1:1000 mercuric bichloride) was the final step. Halsted recognised that this process was taking its toll on Caroline's hands. He later stated, "...she was an unusually efficient woman, I gave the matter my consideration, and one day in New York requested the Goodyear Rubber Company to make, as an experiment, two pairs of thin rubber gloves with gauntlets".⁴ The use of these gloves not only saved Caroline's hands from further damage, but also became a fundamental barrier against infection during surgery.

In addition to rubber gloves, Halsted also used fine, small, straight mosquito clamps that he designed himself, and was recorded to have applied 250 artery forceps during the course of a radical mastectomy at a time when most operating rooms had no more than six available.

In his quest for safe surgery, Halsted became known for his gentle tissue handling, careful haemostasis, meticulous tissue plane re-approximation, and the use of fine silk sutures and ligatures rather than the heavy catgut favoured at the time. Halsted commented, in his sometimes cryptic way, "Silk should not be used that does not break easily". These tenets seem obvious nowadays but were unknown to surgeons practicing at that time.

Halsted's most enduring contribution to surgery was the development of an organised system for surgical training in the USA.⁴¹ The residency training programme he introduced has remained fundamentally unchanged during the past 100 years. Most surgeons in the 19th and early 20th century preferred private practice, thereby avoiding commitment to teaching and research. Furthermore, they were often reluctant to train surgeons because of the ensuing competition they would face from these physicians. Unlike the European system of lengthy training in University hospitals, so-called the dead men's shoes system because of the poor prospects for eventual academic promotion, Halsted's residency training programme produced surgeons with immediate career opportunities. His chief residents (those in charge of the assistant residents) trained for 8 years and his assistant residents for 1 year or more. After this time, many of them went on to become leaders in US surgery. Of 17 chief residents, seven became Professors of Surgery (Harvard, Yale, Stanford, Cornell, Virginia, Pittsburgh, and Cincinnati), one became Surgeon-in-Chief in Detroit, and only four went into private practice. One chief resident, George Heuer, became the first chairman of the Department of Surgery at the New York Hospital, Cornell Medical College in 1930. Of 55 assistant residents, 20 became Professors, eight assistant professors, and 14 went into private practice. His trainees included Harvey Cushing, John Finney, George Heuer, Mont Reid, and Joseph Bloodgood.

Halsted's training programme has ensured the continued development of the science and practice of surgery, resulting in the high standards we have nowadays.^{41,42} However, his recognition by the medical and scientific community at the time was much less than might have been expected considering his enormous contributions (panel 3).

Personal life

During his early years in New York he shared a home with an internist called Thomas McBride and they frequently entertained, hosting concerts with a male quartet on Sunday afternoons in the winter. He also played bowls at the nearby University club, a commonly played sport among many senior physicians. After moving to Baltimore he met Caroline Hampton, and they married on June 4, 1890. They lived in a large house in Baltimore where they occupied different floors; him on the second and her on the third. However, they remained close, although they never had children. Initially, Halsted entertained with elaborate dinner parties for which he personally oversaw the details. He was also noted for his fine taste in antiques and clothes; his suits were tailored in London and his shirts and shoes made in Paris, with shirts being sent back to Paris for laundering. He was a heavy cigarette smoker, disliked being photographed, and his hobbies were growing dahlias and astronomy. Halsted also owned an estate in

North Carolina, USA, which he had purchased from his wife's family. It was named High Hampton after his ancestral origin in High Halsted in Yorkshire, UK, and after the Hampton Bays, named for his wife's family.

Halsted and his wife usually left Baltimore from May to September and spent some of the summer at High Hampton. He also often visited Europe, sometimes with the intention of visiting professional colleagues and other times to spend time alone. In 1911, Sir William Osler wrote, "I have not seen the Professor; when over here he keeps in seclusion in a very funny way".¹⁹ William Welch also noted that Halsted delighted in those brief periods of seclusion and that he went to small places in Brittany, Paris, or England. In Paris he spent long periods at the Hotel Continental, avoiding all acquaintances and using an unobtrusive side door. On visits to the UK, he escaped to a hotel in Brighton or Folkestone where he largely stayed in his room and read undisturbed when he could.¹ On one visit, when he stayed in the Metropole Hotel in Folkestone, he wrote to his secretary:

"This is an ideal spot. En route for Bonn, I have been here for a week, unable to tear myself away. Go to bed at ten punctually and sleep usually until six. My corner room on the fifth floor has an unobstructed view of the ocean front, and of the downs on the side. At night I can see vividly the flashlights of two lighthouses on the coast of France, 27 miles away. On a clear day one can see the French coast, and steamers and fishing boats are constantly in sight. I have a soft coal fire constantly, much the amusement, I fancy, of the servants, who do not quite approve of the combination of open windows and a fire, when the thermometer registers perhaps 60°. And they are complaining it is 'ot."²¹

Thus, he seems to have enjoyed spending time alone, pondering surgical problems, and reading and writing. In Baltimore, he usually went home after work in the late afternoon and secluded himself in his study where he could not be disturbed until dinner. Osler noted that Halsted had the signs of morphine withdrawal in 1898.^{19,43} This suggests that the trips to Europe Halsted so often took might have been an attempt at withdrawal in the comfort of seclusion and thus out of sight of family, friends, and colleagues. The Board of Trustees of Johns Hopkins University Hospital became concerned about his absences and made him aware of their concerns, but there is no evidence that Halsted changed his habits.¹⁹

The fact that Halsted did not receive the recognition he deserved during his lifetime could have been related to his dramatic personality change that took place between his time in New York and his time in Baltimore.² In New York he was charismatic, energetic, highly sociable, a good teacher, and a bold and daring surgeon. In Baltimore he was reclusive, reticent, a poor teacher of medical students, and a slow, meticulous surgeon. Halsted's dramatic change is consistent with his

Panel 3: Medical and scientific recognition

1900	Honorary Fellow, Royal College of Surgeons, UK
1904	Honorary Doctor of Law, Yale University, USA Honorary Doctor of Science, Columbia College, USA
1905	Honorary Doctor of Law, Edinburgh University, UK
1913	Honorary Fellow, American College of Surgeons Member, Royal Academy of Medicine, Belgium
1914	Honorary Member, Surgical Society, Germany Honorary Member, Association of Surgery, France
1917	Foreign Member, Royal Academy of Science, Sweden Member, National Academy of Science, USA
1920	Honorary Foreign Member, Royal Academy of Medicine, Belgium
1922	Gold Medal, American Dental Association

addiction. His health after his appointment to Johns Hopkins Hospital is largely unknown; the few that did know kept it secret, and he was generally believed to be cured. After Halsted's death in 1922, his two closest friends, Welch and Osler (Osler also being his personal physician) revealed that he remained addicted to morphine until at least the age of 60 years.

Osler wrote a secret inner history of the Johns Hopkins Hospital in about 1893, which he bequeathed to his alma mater McGill University, Montreal, Quebec, Canada, under the condition that it should not be disclosed until 1989 at the time of the 100th anniversary of the hospital's opening. However, the contents were published 20 years early.^{19,43} Osler wrote that Halsted was a remarkable man but that his attempts to cure himself were ineffectual. Osler also recognised Halsted's outstanding surgical skills and said that Halsted was the most conscientious surgeon he knew. In his written history, Osler commented on Halsted's fees, quoting a particular fee of \$10 500 (about \$200 000 nowadays)^{4,5} that Halsted had charged for a gallstone operation he had done that had been fraught with complications. This operation had, therefore, needed redoing, from which the woman (who was from a wealthy family that collected valuable fine art) completely recovered. Osler had referred the patient to Halsted, and when questioned by the family about Halsted's small fee, he justified it by explaining that Halsted should be considered as an artist; at which point the family was grateful the fee was so small. Halsted's highest recorded fee was for surgery he did on a wealthy individual from Washington DC, USA, in 1893. The total fee of \$13 825 (about \$281 702 nowadays) covered two preoperative consultations, a femoral amputation for thrombosis of the popliteal artery, and six daily postoperative visits with dressing changes.^{5,44}

In his history of the hospital, Osler goes on to comment on his belief, shared with Welch in 1912, that Halsted was cured of addiction—the basis for his recommendation of Halsted for the position of Surgeon-in-Chief at the

Search strategy and selection criteria

Information for this Review was found by searching Medline using the following key words: "William Stewart Halsted". Only papers published in English up until 2006 were reviewed.

John Hopkins Hospital in 1890. However, Osler notes, that 6 months after Halsted's appointment to this position, Halsted had come to see him, as a patient, with a severe chill, which was "the first intimation that he was still taking morphia". Osler subsequently gained Halsted's full confidence and learned that "he had not been able to reduce the amount to less than three grains (180 mg) daily and that no one suspected it". During Osler's years as Regius Professor of Medicine at Oxford University, he noted in his diary sometime between 1912 and 1919 that "subsequently, 10 January 1898, he got the amount down to one and a half grains" and "of late years (1912) has possibly got on without it".¹⁹

Although Halsted was considered a reclusive person by his contemporaries, the discovery of correspondence between Halsted at 60 years of age with a woman 40 years younger revealed that he was a much warmer and personable individual in private.⁴⁵ Halsted continued working until the spring of 1922. While at his country estate in August 1918, he developed gallstone colic and was forced to return to Baltimore earlier than usual. He underwent a cholecystectomy with exploration and drainage of the common bile duct, undertaken by Follis (one of Halsted's trainees on staff at the John Hopkins Hospital), but then developed a bile fistula. This fistula eventually closed and he recovered. However, in 1921, Halsted developed acute cholangitis, which recurred with increasing frequency. In August, 1922, he returned to Baltimore, summoning Heuer and Reid to operate on him for a retained stone in the common bile duct. Postoperative pneumonia led to Halsted's death on Sept 7, 1922, aged 69 years.

Conclusion

William Stewart Halsted was one of the great pioneers in the history of surgery.⁴⁶ In the pursuit of science, he inadvertently became addicted to a prototype local-anaesthetic drug, cocaine, while attempting to develop local anaesthesia. During a lifetime struggle with addiction, Halsted had the will power and stamina to overcome the problem and to change the face of surgery. Alfred Blalock wrote, "I think it is all to Dr Halsted's credit that he was able to overcome this habit, and it is probably very fortunate for American surgery that he acquired it".¹ As Welch stated in his introduction to MacCallum's biography, Halsted showed "...a strength of will and tenacity of purpose and a triumphant issue of a hard struggle rarely exemplified in similar circumstances".¹ Halsted converted a personal tragedy into professional triumph and left a legacy that has substantially benefited people ever since.

Conflicts of interest

I declare no conflicts of interest.

Acknowledgments

I wish to thank: Syed Hoda and Vinod Malhotra for their help and review of the manuscript, Nancy McCall and Gerard Shorb of the Alan Mason Chesney Medical Archives of Johns Hopkins University Medical Institutions for illustrations, and James Gehrlach of the Medical Center Archives of New York-Presbyterian/Weill Cornell for assistance with research for this article. Funding was provided by The Iris Cantor Clinical Research Fund at Strang Cancer Prevention Center.

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