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Walter E. Dandy: his contributions to pituitary surgery in the context of the overall Johns Hopkins Hospital experience

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Abstract

Background—Walter E. Dandy (1886–1946) was an outstanding neurosurgeon who spent his entire career at the Johns Hopkins Hospital. After graduating from medical school in 1910, he completed a research fellowship in the Hunterian laboratory with Harvey Cushing and then joined the Department of Surgery as resident, rising to the rank professor in 1931. Dandy made several contributions that helped building the neurosurgical specialty, most famously the introduction of pneumo-ventriculography to image brain lesions for which he received a Nobel prize nomination. He also performed many pituitary surgeries, although his role in this area is less known and overshadowed by that of Cushing’s.

Purpose—This retrospective cohort study was designed to unveil Dandy’s pituitary work and place it in the context of the overall pituitary surgeries performed at the Johns Hopkins Hospital.

Methods—Pituitary surgery data were obtained by screening the paper and electronic surgical pathology records of the Department of Pathology, as well as the general operating room log books of the Johns Hopkins Hospital housed in the Chesney Medical Archives.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Results—A total of 3211 pituitary surgeries associated with a pathological specimen were performed between February 1902 and July 2017 in 2847 patients. Most of the surgeries (2875 of 3211 89%) were done by 21 neurosurgeons. Dandy ranks 4th as number of surgeries, with 287 pituitary operations in 35 years of activity. He averaged 8 pituitary surgeries per year, a rate that positions him 6th among all Hopkins neurosurgeons. With the exception of his first operation done in July 1912 while Cushing was still at Hopkins, Dandy approached the pituitary gland transcranially, rather than transphenoidally. The majority of Dandy's pituitary patients had a pathological diagnosis of pituitary adenomas, followed by craniopharyngiomas and sellar cysts. In the decades Dandy operated, pituitary surgeries represented 0.56% of the total Johns Hopkins surgeries, a percentage significantly greater ($p < 0.001$) than the 0.1% observed in modern days. Dandy's pituitary clinical work was matched by important experimental studies done in the early stages of his career.

Conclusions—This study highlights the role of Dandy as an important contributor to advance our understanding of pathophysiology and treatment of pituitary diseases.

Keywords

Walter E. Dandy; Harvey W. Cushing; Pituitary surgery; History of endocrinology

Historical prelude

Walter E. Dandy (1886–1946) of Johns Hopkins was one of the outmost neurosurgical figures of the twentieth century, with contributions including the diagnosis and treatment of hydrocephalus, the introduction of pneumo-encephalography, the unilateral approach and total excision of acoustic tumors, the sectioning of the sensory root of the 5th nerve at the pons for relieving tic douloureux, and the treatment of intracranial aneurysms [1]. Less known is Dandy's work on the pituitary gland, in part because overshadowed by that of his Hopkins predecessor, Harvey Cushing. This study focuses on Dandy's pituitary work. It will begin with an historical prelude to summarize what was then known about the pituitary gland and its surgical approach, the Hopkins environment and culture, and Cushing's pioneering efforts.

The first pituitary surgeries in Europe

Endocrinology as we know it today emerged in the mid nineteenth century from the watershed year of 1855. In that year, Claude Bernard promoted the concept of “sécrétion interne” to indicate that endocrine glands release their secretion directly into the blood stream; Thomas Addison published his masterpiece “On the constitutional and local effects of disease of the suprarenal capsules”; and Charles Brown Séquard introduced the classic method of learning about the function of a gland by examining the consequence of its removal, concluding that adrenal glands are “absolutely essential to life”. Three decades later Pierre Marie coined the term acromegaly and published the first two complete cases [2]. Physicians began recognizing the association of acromegaly with enlarged pituitary gland, while surgeons sought ways of approaching this secluded gland for treatment, something that was then considered like “tempting Providence” [3]. The first pituitary surgery, that is a surgery specifically directed towards the pituitary gland, is credited to

Richard Caton and Frank T. Paul of the Royal Liverpool Infirmary. On February 2, 1893, they performed a temporal decompression in an acromegalic patient who complained of chronic headaches [4]. They noted the enlarged pituitary but did not resect it, providing only temporary symptom relief that was followed by death 3 months later. The authors learned this transcranial temporal approach from Sir Victor Horsley, an eclectic researcher, experienced surgeon, and social activist in London. Horsley had been doing craniotomies for a few years to treat several conditions [5], including ten surgeries directed at the pituitary gland, but had not published full details on these cases. He mentioned them during his 1906 address at the 74th annual meeting of the British surgical association entitled “On the technique of operations of the central nervous system” [6]. Only one additional case of pituitary surgery was published in the decade following the original Caton and Paul’s report, when Fedor Krause in Berlin performed a transcranial operation approaching the pituitary gland from the frontal bone [7].

The Johns Hopkins Hospital

The year 1893 is also when the Johns Hopkins Hospital, which had opened to patients in 1889, launched its medical school, featuring 9 full professors (including William Welch, pathology, William Osler, medicine, and William Halsted, surgery), 6 assistants, and 18 medical students, 3 of whom were women. Mary Elizabeth Garrett (the philanthropist who donated over \$350,000 to make up the \$500,000 endowment that the Board of Trustees deemed necessary for the school opening), had in fact attached strings to her gift. The first one was that women should be admitted on the same terms as men and enjoy the same prizes, dignities, or honors awarded by competition, examination, or merit. Another revolutionary clause was that the school of medicine be a graduate program of 4 years, rather than the 2 or 3 years used at the time, and that students be admitted only if they had completed college courses in chemistry, biology, and natural science, and were fluent in modern languages other than English. These high admission standards prompted the famous remark of Osler to Welch “we are lucky we got in as professors, for I am sure that neither you nor I could ever got in as students”. Ms. Garrett’s vision dovetailed perfectly with the “scientific method” Welch was using to shape Hopkins medicine, a method he had brought back to America from his fellowship in Germany where hypotheses, experimentations, and data analyses drove the advancement of knowledge. Another Hopkins innovation was the establishment of a residency training program. The idea, also adopted from Germany, was to allow graduating physicians to spend a number of years in the hospital to complete a specialized training. As Osler wrote to the Board of Trustees in January 1890 “Perhaps the one special advantage which the large German hospitals have over corresponding American Institutions is the presence of highly training men who remain, in some cases 3, 5, or even 8 years, and who, under the Professor, have control of the clinical material”.

Dr. Harvey W. Cushing

After graduating from Yale in 1891, Cushing entered Harvard Medical School, showing from the start a keen interest in surgery and unsurpassed manual dexterity. He graduated cum laude in 1895, worked for a year at the Massachusetts General Hospital, and then joined the Johns Hopkins staff as an assistant resident in surgery in October 1896. In those days, the place to be was the bacteriology research lab that Welch had established in “The

Pathological". In that building, Cushing spent his first Baltimore months, looking at specimens alone at night with a German textbook at hand. Welch's influence led him to focus on surgical complications of bacterial diseases, as shown in his first publication entitled "Typhoidal Cholecystitis and Cholelithiasis". Cushing quickly built a reputation in the operating room and was made chief resident in 1897, instructor in 1898, and associate in 1899. He became interested in neurological diseases from taking care of patients suffering from trigeminal neuralgia. After deeply reviewing the literature and practicing on 30 fresh cadavers, he performed his own version of the Gasserian ganglion dissection in August 1899, a second one in December, and a third one in January 1900, all with spectacular results, publishing his findings in the April 1900 issue of JAMA.

Shortly thereafter, he left for Europe for a 1-year fellowship. He spent most of his time in Berne, in the laboratory of future Nobel prize winner Theodore Kocher, who assigned him the study of how intracranial circulation responds to increased pressure. In London, on his way back to America, Cushing met Horsley who offered him to do some work in his lab. He decided instead to work with the neurophysiologist Charles Sherrington, also a future Nobel prize winner. Back in Baltimore in August 1901, Cushing was eventually allowed to focus on developing the new field of neurosurgery.

Very few surgeons attempted to operate on the brain in those days because of blood loss, infection complications, and herniation. Cushing practiced extensively with dogs in the newly established Hunterian laboratory, adopted the use of gloves pioneered by Halsted, and with his superior skills showed to America that operating on the brain was indeed possible. Through his experimental work, he became interested in the pituitary gland and performed his first human "pituitary surgery" on February 21, 1902. The patient was a 16-year-old girl with a few years history of headache and 1 month history of vision loss, nausea, vomiting, and constipation. He correctly thought she had a mass in or around the pituitary gland and brought her to the operating room to release the compressive symptoms, performing first a left subtemporal decompression, then a suboccipital decompression on March 8, and then a right subtemporal decompression on March 21. The patient died 41 days later. The autopsy showed a large suprasellar tumor interpreted macroscopically by Welch as a teratoma. No histological study was performed. Cushing featured this patient as case 3 in his 1912 monograph "The Pituitary body and its disorders", writing that he performed "three futile operations disclosing only an internal hydrocephalus" [8]. The second "pituitary" surgery was done on July 17, 1908. He operated on a 26-year old woman with primary amenorrhea and a decade long history of headache and blindness in the left eye for 4 years. He thought the patient had an "uncertified hypophyseal struma with primary optic atrophy" and performed a bilateral subtemporal decompression "in the hope of relieving the intracranial discomforts". The diagnosis of this patient, featured as case 14 of the monograph, remains unclear to us (see Supplemental Table 1) although Cushing indicates she was operated a second time in 1912 via the transphenoidal route, listing then a diagnosis of "chromophobe struma with adiposo-genital dystrophy".

In the period between Cushing's first two "pituitary" surgeries, Walter E. Dandy entered medical school at Johns Hopkins and Hermann Schloffer performed the first transphenoidal surgery in Innsbruck, Austria. On March 16, 1907, Schloffer operated on a 30-year old man

with a long history of worsening headaches and vision loss [9]. The approach was esthetically disfiguring, since it involved a large incision along the side of the nose and up to the front, but nevertheless revolutionary and groundbreaking. Schloffer was able to reach the pituitary gland, remove a significant portion of the tumor, and relieve initially the symptoms, although the patient died 2 months later.

Cushing performed his first real pituitary surgery on March 25, 1909 (close to his 40th birthday) on a 38-year old Dakotan farmer with “outspoken acromegaly” [10] (case 26 of his monograph, Supplemental Table 1). He modified Schloffer transphenoidal operation by making a skin incision in the shape of an omega, flanking both sides of the nose and up onto the forehead. After opening the frontal and sphenoidal sinuses, he reached the pituitary gland with great difficulty and removed small fragments of tissue that were sent to pathology. At the end of his very detailed operative notes, Cushing wrote that it was impossible with the instruments at hand to satisfactorily enlarge the opening and curette out the gland itself, concluding “my first case: a very unnecessary procedure”. The patient had no post-operative complications and initially improved, but two years later symptoms returned.

From March 1909 to the time he moved to Boston in August 1912, Cushing performed 66 pituitary surgeries in 46 patients (summarized in Supplemental Table 1), modifying the procedure and rapidly moving to the sublabial transphenoidal approach [11] to eliminate the esthetic consequences of the omega incision. In this 3-year interval, Cushing performed 512 additional surgeries, ranging from Gasserian ganglion dissections to craniotomies, with a few non-neurosurgical operations such meniscectomy, laparotomy, thyroidectomy, and tooth removal (Supplemental Table 2). It is during this period of intense activity that Walter Dandy, who had graduated from the Johns Hopkins medical school on June 14, 1910, met Cushing.

Walter Dandy's early life

Walter Edward Dandy was born in Sedalia, Missouri, on April 6 1886. His parents had emigrated from England to work in the booming train industry where Walter's father became a locomotive engineer [12]. Walter loved trains and recalled often taking rides to allow time for himself and write [13]. As the only child, he was pushed to competitiveness and excellence since the very early school years. He graduated from Sedalia High School as valedictorian and then entered the University of Missouri in 1903. He became interested in biology and medicine and worked in the laboratory of Winterton C. Curtis, a Ph.D. graduate from the Johns Hopkins University [14]. Walter wrote to Sir William Osler, who by that time had become Professor Regius of Medicine in Oxford, about the prospect of studying medicine in England. Osler replied that “it would be much better to finish at Hopkins, and then come abroad for postgraduate work”. And so Walter finished college and entered Johns Hopkins medical school in 1907 as a second-year student, in recognition of the courses he had taken at the University of Missouri [12].

Walter showed strong interest in anatomy and was accepted in the prestigious laboratory of Franklin P. Mall, the professor of Anatomy who founded the field of embryology. Mall

noticed Walter's skills in dissecting and drawing and assigned him the task of representing the youngest human embryo he had in his collection. Walter's work became to be known as the "Dandy Embryo", was published before completion of medical school, and earned him a Master degree [13, 15]. In this first paper, Dandy already showed his fascination with the nervous system. After medical school graduation, Halsted assigned Dandy to work in the Hunterian Laboratory as an assistant for the Hopkins star Harvey Cushing [14]. After a period of an initial devotion for the master, a palpable competition between the gifted master and the equally or even more gifted apprentice developed, a competition that extended from the research laboratory, to the operating room, and the tennis court. Within a few months, in December 1910, Walter was able to boast to his parents he had "stumped" the master himself in reaching the aqueducts of Silvius without killing the dog, a procedure Cushing had considered impossible. Under Cushing's supervision, Dandy investigated the blood and nerve supply of the dog and cat pituitary gland, experiments that formed the basis of his second and third publications [16, 17], publications that also reiterate Dandy's talent and passion for drawing.

On March 3, 1912 Dandy performed his first surgery on a young English sailor who had developed severe epileptic seizures after a fall. Cushing considered the case inoperable but allowed Dandy to try it. Dandy performed a decompression and spent 2 h to remove all the adhesions he could find clinging to the brain. The sailor recovered and words of Dandy's triumph spread quickly around the hospital. The following June, Cushing left for Europe for a 6-week vacation and still had not communicated to Dandy whether he would take him with him to Boston. Dandy took advantage of Cushing's absence and performed in this time frame 11 brain surgeries, including his first pituitary surgery on July 13, 1912. As indicated in the letter he wrote to his parents the following day he "had a bully week as far as operations are concerned, and did also one hypophysis, Cushing's hardest and most delicate operation. Imagine Cushing looking at me in resentment and disdain when he finds I have done a hypophysis operation and got away with it. The men looked at me in amazement when I posted the operation. That was something none but almighty Cushing would think of doing".

Materials and methods

The study was designed to summarize the pituitary surgical experience of Walter Dandy and place it in the context of all pituitary surgeries performed at the Johns Hopkins Hospital. The study covers a period of 116 years, from the time Cushing performed the first case in February 1902 to July 2017. Pituitary surgeries were identified predominantly from the surgical pathology archive of the Department of Pathology, which comprises electronic and paper records.

Electronic surgical pathology records begin on March 20, 1984 and continue to present time. They capture the key information about the incoming surgical specimen, and are then populated by the final pathological diagnosis that is transmitted to EPIC. These records were queried using the keywords "pituitary", "hypophy*", "sellar", "intrasellar", or "craniopharyn*", where the symbol * is used to indicate words with the same root. The found cases were imported into a FileMaker database (FileMaker Inc., Santa Clara, CA) and

then screened one by one to eliminate those that were not pituitary surgeries and classify the remaining majority according to the pathological diagnosis.

From the time the Johns Hopkins Hospital opened (May 15, 1889) to March 20, 1984, surgical pathology specimens were manually recorded into log books that listed surgical pathology number, medical record number, date of surgery, patient name, age, gender, surgeon name, type of operation, and gross specimen type. A total of 271 log books cover this 95-year span, with only a few gaps in the May 1889-May 1892, January 1908-December 1911, and May 1920-April 1921 periods. These 271 surgical pathology log books, stored in the department of Pathology archive facility, were browsed page by page to identify pituitary cases, which were then manually entered into the same FileMaker database from above. To cover the 1908–1911 and 1920–1921 gaps, we screened the Johns Hopkins Hospital general operating room log books, which are stored at the Chesney Medical Archives. The first gap (1889–1892) was not screened because it precedes the arrival to Harvey Cushing to Johns Hopkins, and thus the birth of neurosurgery. The general operating room books list patient's name, surgeon's name, and type of surgery every time the operating room was used. The pituitary cases that were found here were also entered in the FileMaker database. Once the list of pituitary cases for the paper record time period was assembled, we used the surgical pathology case number to locate the full-length pathological report and obtain the final pathological diagnosis. These full-length reports were originally type-written, bound into index books, and then converted into microfilms for the period comprised between October 1923 and March 1984. Microfilms were recently scanned, digitized, and interrogated for this study.

The name of the neurosurgeon performing the pituitary surgery was derived from the pathology log books or pathology full reports. Beginning in 1989, thus in the electronic medical record era, more than one neurosurgeon was occasionally listed in the pathology report. In these multiple-surgeon cases, we used the name listed first to tally the total number of surgeries performed by each neurosurgeon.

The complete FileMaker database was imported into Stata statistical software, release 15 (Stata Corp., College Station, TX) for the statistical analysis. The study was approved by the Johns Hopkins Institutional Review Board. The numbers presented here are likely an underestimate of the total Hopkins pituitary surgeries because operated cases that had no tissue sent to pathology will be missed and human error in reviewing the paper records is possible.

Results

A total of 2847 patients underwent pituitary surgery at the Johns Hopkins Hospital in the 116-year period comprised between February 1902 and July 2017 (Table 1). Of them, 1509 (53%) were females and 1338 (47%) males, with an average ($\pm$ SD) age of 45 ($\pm$ 17) and 49 ($\pm$ 17) years, respectively. Most patients, 2536 of 2,847 (89%), had only one pituitary surgery; 268 patients had two surgeries; 35 patients three; 6 patients four; and 2 patients five surgeries (Table 1).

The yearly number of pituitary surgeries averaged at about 10 cases per year for the first 80 years of the study (from 1902 to 1982). It then increased gradually in the ensuing two decades, and prominently from 2002 to present time (Fig. 1a). The Johns Hopkins Pituitary Center was established in 2007 (Fig. 1a, arrow).

The majority of the pituitary surgeries, 2875 of 3211 (89%), were performed by 21 surgeons (Table 2). A small subset was done by a group of 16 surgeons who performed between 6 and 10 operations each (No. = 111), and a group of 30 surgeons who performed between 3 and 5 operations each (No. = 118). In a minority of surgical pathology reports (107 of 3211, 3%), the surgeon was not indicated (Table 2).

Dandy performed 287 pituitary surgeries in 273 patients between 1912 and 1946, the year of his premature death, a number that ranks him fourth among Hopkins pituitary neurosurgeons (Table 2). His average number of pituitary surgeries per year was 8, a rate that positions him sixth among Hopkins pituitary neurosurgeons (Table 2). Dandy was the main pituitary neurosurgeon during his 35 years of activity at the Johns Hopkins Hospital (Fig. 1a). In his period, the number of pituitary specimens represented on average 0.56% of the total surgical pathology specimens, an average that is significantly higher ($p < 0.001$) than that seen in the following periods (Table 3).

The majority of Dandy's patients (182 of 273, 67%) were operated for pituitary adenomas, followed by craniopharyngiomas (No. = 56), sellar cysts (No. = 12), and more rare conditions (Fig. 2). Dandy used almost exclusively the transcranial approach to reach the pituitary gland (Table 4).

Discussion

This study unveils the significant body of pituitary surgical work performed by Walter E. Dandy, a work that ranks him fourth in the volume of surgeries among all time Hopkins neurosurgeons, despite having worked at a time when pituitary surgery elsewhere was rare. Although the contribution of his predecessor and mentor, Harvey Cushing, during his Hopkins years (1896–1912) is well recognized and published [10, 18–23], Dandy performed four times more pituitary surgeries than Cushing. He was also the first to recognize that, based on the technology available in those days, the transcranial approach to the pituitary yielded superior curative results than the transphenoidal approach pioneered in America by Cushing, a transcranial route to which Cushing himself converted in later years [18]. Several decades would pass after Dandy's death, with the development of modern micro-instrumentation and powerful antibiotic drugs, before the transphenoidal approach re-established itself as the procedure of choice for treating pituitary lesions [24]. It is informative to consider that at the time when Dandy began his pituitary work at least 10 different ways of reaching the *sella turcica* had been tried, as written and illustrated in the outstanding review published in 1916 by Cope [3]. It was up to Dandy's brilliance to select the route that turned out to be the most effective and mainly used for the first seven decades of the twentieth century. Judging from the clinical notes written in the pathology reports, Dandy's patients were most commonly affected by large pituitary adenomas, with long histories of vision loss and/or hypopituitarism. On the contrary, the Hopkins pituitary

patients operated by Cushing featured a broad spectrum of conditions, in some cases not clearly attributable to the pituitary gland and of uncertain diagnosis (see Supplemental Table 1).

Dandy's clinical service work was matched by his scientific productivity. He published 167 scientific articles (listed in Supplemental Table 3), 8 of which focused on the pituitary gland. His first two pituitary papers originate from dog and cat studies and focused on the blood and nerve supplies to this gland [25, 26]. The third article, entitled "A new hypophysis operation", describes Dandy's transcranial approach to the sella, distinct from the transphenoidal approach that his mentor Harvey Cushing had shown him [27]. In a follow up paper entitled "An operation for the removal of large pituitary tumors", Dandy modified the transcranial approach used by Heuer because he considered it unsatisfactory for large pituitary tumors, which in those days represented the majority of the patients [28]. His fifth pituitary paper ascertains the role of the hypophysis as an organ essential for life, a topic that elicited great controversy at the time. Some investigators had shown that hypophysectomized animals were able to survive, while others, including Cushing, maintained the hypophysis was essential for survival. Dandy critically analyzed the problem, providing technical reasons for the discrepancies. He showed that carefully hypophysectomized dogs survived, while early post-operative deaths were caused by brain damages caused by less careful procedures [29]. It emerges clearly from this paper how much Dandy benefited from this experimental work in dogs to perfect his surgical approach in patients. In the next two articles Dandy investigated the relationship between the hypophysis and diabetes insipidus [30, 31], a condition then of unknown pathogenesis. Dandy was not able to provide mechanistic insights into this disease, noting that his results in the dog model were "inconsistent" and "capricious" and could not be extrapolated to humans due to important anatomical differences. In the last pituitary paper, Dandy used again dogs to investigate the somatic and mental changes of hypophysectomy [32]. With great attention to details and a gift for clear graphical illustrations, Dandy showed that hypophysectomized animals have stunted skeletal growth, immature genital features, tire easily, and are more susceptible to pneumonia than normal dogs.

Walter E. Dandy made numerous contributions to neurosurgery, which have been described in numerous publications and monographs [1, 33]. Only a few are mentioned here to provide a snapshot of Dandy's versatility and talent. Following his pioneering studies where he reported the first experimental model of hydrocephalus via obstruction of the aqueduct of Silvius, Dandy was able to apply this knowledge to patients by injecting a dye into the ventricles and consequently classify hydrocephalus into "communicating" and "non-communicating" types [34, 35]. While a surgery resident, possibly inspired by the X-ray visualization of sub-diaphragmatic air as in bowel perforation, he devised a method to inject air into the ventricles through the holes of the infant fontanel. With this pneumo-ventriculography, Dandy was able to localize and characterize intracranial tumors, an absolute breakthrough for the times. Although initially criticized by Cushing, the approach was innovative and yielded Dandy a Nobel prize nomination [14, 36]. Always interested in craft and technology, Dandy introduced in neurosurgery the endoscope, an instrument he had seen from the gynecology professor Howard Kelly, laying the foundation for modern minimally invasive neuroendoscopy [37]. Since childhood, Dandy had a passion for baseball

and also served as captain of the Johns Hopkins baseball team. In letters to his parents, he credited baseball and manual works for helping him refine his surgical skills: "...playing baseball and all the outdoor exercises and manual work...made me quite adept with my hands and I can really operate very skillfully when given a chance". Combining these skills, he designed the "armored cap", the first protective gear to reduce traumatic brain injuries in sport [38].

Despite having a dominant personality and being nicknamed "The Captain", Dandy was very much aware of the importance of teamwork in surgery and established the "Brain Team". Irving J. Sherman, one of Dandy's assistant residents, describes the Brain Team as "legendary because of the magnificent neurological surgery performed". It consisted of Dandy, his resident and assistant resident, a first-year general surgery resident, the anesthetist, a full-time scrub nurse, an assistant scrub nurse, a circulating nurse, a full-time nurse anesthetist, a part-time nurse anesthetist, and a full-time orderly [39, 40]. The Brain Team performed a high volume of operations per year and followed patients also after surgery, an innovation for the time that significantly improved outcomes and decreasing mortality [13, 39, 40]. Neurologists, neuro-ophthalmologists, and neuro-otologists were frequently consulted and considered ex officio members of the Brain Team [40]. In this panorama, Dandy introduced several innovative surgical techniques with significant improvement in the surgical outcomes. His approach for the removal of acoustic tumors [41], the treatment of Tic Douloureux [42], the development of the first surgical treatment for Meniere's disease [43] and the treatment of intervertebral disk rupture [44] are some of his remarkable contributions [13, 14].

In conclusion, this study highlights the contributions of Walter Dandy to pituitary diseases and insert them in the context of the entire Johns Hopkins Hospital experience, an experience that spans over a century, from Cushing's groundbreaking efforts in 1902 to present time.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Fig. 1.

a Yearly counts of pituitary surgeries performed at the Johns Hopkins Hospital between February 1902 and July 2017. The total number for year 2017 was imputed (*) from the counts observed in the first 7 months. The main neurosurgeon operating in the bracketed period is indicated under the calendar year. **b** The yearly counts of pituitary surgeries (*solid lines*) are compared to the total surgical pathology specimen counts (*dashed line*) and the total surgical admissions (*dotted line*). The later counts were available from 1889 to 1946

Fig. 2.
Distribution of pathological diagnoses in the 273 pituitary patients operated by Dr. Walter E. Dandy between 1912 and 1946

Table 1

Distribution of 3211 pituitary surgeries performed in 2847 patients at the Johns Hopkins Hospital between February 1902 and July 2017, according to gender and number of surgeries per patient

Pituitary surgeries per patient	No. of patients	No. of surgeries
1	2536	2536
2	268	536
3	35	105
4	6	24
5	2	10
Total	2847 (1509 F; 1338 M)	3211

Distribution of 3211 pituitary surgeries performed at the Johns Hopkins Hospital between February 1902 and July 2017, according to the neurosurgeon

Table 2

Neurosurgeon	No. of pituitary surgeries	Total years of activity at JHH	First calendar year	Last calendar year	Yearly rate
Surgeon 1	553	30	1984	2013	18
Surgeon 2	483	12	2005	2016	41
Surgeon 3	363	10	2008	2017	36
Walter E. Dandy	287	35	1912	1946	8
Surgeon 5	265	48	1961	2008	6
Surgeon 6	164	28	1990	2017	6
Surgeon 7	136	25	1991	2015	5
Surgeon 8	116	10	2008	2017	12
Surgeon 9	89	3	2015	2017	30
Harvey W. Cushing	71	11	1902	1912	6
Surgeon 11	64	32	1944	1975	2
Surgeon 12	55	29	1952	1980	2
Surgeon 13	42	22	1985	2006	2
Surgeon 14	38	12	2003	2014	3
Surgeon 15	38	20	1963	1982	2
Surgeon 16	27	20	1994	2013	1
Surgeon 17	26	24	1947	1970	1
Surgeon 18	17	25	1980	2004	1
Surgeon 19	15	18	1989	2006	1
Surgeon 20	14	8	1914	1921	2
Surgeon 21	12	22	1957	1978	1
16 surgeons with 6–10 pituitary surgeries each	111				
30 surgeons with 3–5 pituitary surgeries each	118				
Surgeon not listed in the path report	107				
Total	3211				

Pituitary specimens as percent of the total surgical pathology specimens in the six periods of neurosurgery at the Johns Hopkins Hospital

Table 3

Period	Years of activity	Main neurosurgeon	Pituitary specimens	Total surg. path specimens	Percent	p value
1	1902–1912	Harvey W. Cushing	73	9576	0.66	0.214
2	1913–1946	Walter E. Dandy	307	56,619	0.56	Ref.
3	1947–1975	Surgeon 11	284	297,109	0.10	<0.001
4	1976–1986	Surgeon 5	251	231,873	0.10	<0.001
5	1987–2004	Surgeon 1	1440	734,595	0.13	<0.001
6	2005–2016	Surgeon 2	2126	1,052,286	0.14	<0.001

The periods were chosen according to the main neurosurgeon, with Dandy's period as the reference category for statistical comparisons

Table 4

Type of surgical approach used by Water E. Dandy to reach the pituitary gland

Type of surgery	No.	Percent (%)
Not listed in the pathology log books	78	27
Right craniotomy	77	27
Left craniotomy	73	25
Craniotomy non-otherwise specified	58	20
Transphenoidal operation	1	0.3
Total	287	100