Neuroradiology in Boston: Historical Beginnings

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Within weeks of Röntgen’s report of the discovery of x-rays in December 1895, the news of the discovery rapidly spread by cable and word of mouth to North America. Dr Warren, then professor of surgery at the Harvard Medical School, came back from Röntgen’s laboratory with a “shadow picture of the human hand in which the outlines of the bones were apparent” (1). The Massachusetts General Hospital (MGH) at the time was fortunate to count among its personnel an inspired and enthusiastic young man named Walter Dodd, who was both the hospital apothecary and the hospital photographer (2). Dodd, a British cockney by birth, had entered upon a scientific career after the manner of Faraday, as a janitor in a Harvard chemistry laboratory (3). Because the new discovery was thought merely to be a refinement of photography, Dodd was considered to be the most appropriate individual to be put in charge of the new technology (4). The department at the MGH thus began as an annex of the apothecary. In March 1896, together with his assistant, Joseph Godsoe, Dodd obtained a commercial x-ray tube and, with locally acquired electrical equipment and a static generator energized by a human operator turning a crank, began to experiment (5).

The first clinical use of x-rays in Boston probably was by either Dr Francis H. Williams or Dr E. A. Codman, each of whom published his results in the Boston Medical and Surgical Journal in February and March, 1896 (8, 9). At the same time, John Trowbridge, director of Harvard’s Jefferson Physical Laboratory, was making similar experiments. His article in the New York Journal, which appeared on February 2, 1896 (10), included a photograph of the bones of the human hand. One of the first pictures taken at the MGH, presumably by Dodd and Godsoe, was that of a needle in the palm of the hand (6). Grigg believes that Dodd did not obtain good results until after June or perhaps July 1896 (7). Walter Dodd, after acquiring a medical degree, was named skiatographer to the MGH in 1908/1909. Unfortunately he also turned out to be one of the first victims of excessive radiation exposure, ultimately dying of metastatic lung cancer after carcinoma of the hands in 1916.

Harvey Cushing and Emory Codman, house officers at the MGH in the spring of 1896, also “began to see what we could do in the way of getting similar pictures” (1). There is no publication indicating that their efforts were successful, although Cushing’s biographer, Fulton, states that Cushing, together with Codman, helped install an x-ray tube at the MGH. “We have at last succeeded in having an x-ray machine put in for which I have subscribed largely and hope the conservative staff will ultimately remunerate us for it” (11). Cushing left the MGH in the fall of 1896 (with an x-ray tube that he took with him from the MGH, somewhat to the consternation of the staff there) to go to the Johns Hopkins Hospital in Baltimore, where he was successful in obtaining x-rays of the neck (after exposures averaging 35 minutes) of a Baltimore woman, Lizzie W, “shot in the neck by her bartender husband during a family brawl.” The bullet was identified in the body of the 6th cervical vertebra, and the case was reported—probably the first US publication of the application of x-rays to identify a lesion of the head or spine (12).

Between 1896 and 1910, the chief use for x-rays was to demonstrate fractures or foreign bodies. Attempts had been made in the United States within a few years of Röntgen’s discovery to demonstrate brain tumors by x-ray, as de-
scribed in one questionable case report (13), questionable because the lesion did not contain calcium but was a gliomatous cyst. The best of the clinicians in those days were experts in physical diagnosis and therefore resented any mechanical method that tended to supplant their hard-earned skills (6). In these early years, radiology in Boston, as in the entire United States, can best be considered in its infancy and was seldom used in patients with neurologic problems. For instance, there is no mention of x-rays in the report on nontraumatic brain and spinal cord surgery from the MGH and Boston City Hospital in 1903 and 1904 (14).

Francis Williams, working at the Boston City Hospital, was one of the pioneers in the nascent field of radiology in the United States at the time. In April 1896 he described an x-ray he had taken of a 10-year-old boy in whom the spinal column and the intervertebral spaces were seen (15). In 1901 he published a textbook that actually marks the beginning of American roentgenologic literature (16). In this text he makes brief references to the radiology of the spine, the frontal sinuses, unerupted teeth, dental abscesses, and so forth. He also alluded to the difficulty of obtaining sufficient penetration with existing equipment to examine the skull adequately: “Tumors in the brain with our present apparatus and inexperience must necessarily offer a great deal of difficulty to detection by the rays.”

With improvement in equipment, slowly the problem of penetration of the skull was solved, and case reports and brief descriptions followed. The importance of head immobilization in obtaining diagnostic images of the cranial sinuses was described by Percy Brown of the Boston Children’s Hospital in 1915 (17). In 1916, Ariel George at the Peter Bent Brigham Hospital (PBBM) described cranial hyperostosis in a patient with a meningioma, a case of a calcified glioma, and a case of luetic involvement of the skull (18). In 1918 George Holmes at the MGH reported an intracranial aerocele after a fracture of the frontal sinus—a similar observation to that made by Stewart, a radiologist at Harlem Hospital and reported by William Luckett in 1914 (19, 20). (According to Holmes, Walter Dodd also had a case of air in the ventricles after a fracture of the frontal sinuses; this case was not reported.)

Cushing was lured back to Boston from the Johns Hopkins Hospital in 1912 to be chief of surgery at the new Peter Bent Brigham Hospital. Despite his interest in the roentgen ray, Cushing initially felt that there was no need for a full-time radiologist at the hospital (21). In Cushing’s proposal for the organization of the new PBBH, he stated, “In regard to a Roentgenologist... this department will probably involve the employment of one or more technical assistants not graduates in medicine, with the probable supervision of a resident or visiting graduate in medicine”. No mention of the need for a service chief in radiology, much less one willing to help him in radiology of the skull, appears in Cushing’s proposal. Alfred Luger became the first radiologist at the PBBH in 1913 (22). That year, 2 years after Cushing’s book, The Pituitary Body and its Disorders, appeared based on work done at the Johns Hopkins Hospital, Luger read a paper at the annual meeting of the American Medical Association on the radiologic aspects of pituitary disorders (23). In 1914 he published a paper on craniopharyngiomas in the German literature, based on two of Cushing’s patients. Gladys Carr who succeeded Luger as chief of radiology at the PBBH in 1914 (resigning in 1917) produced a paper on imaging of the internal auditory canals by lateral projections (24). This paper coincided with a book by Cushing on lesions of the cerebellopontine angle cistern (25). Carr was succeeded by Lawrence E. Reynolds, who left in 1922 for private practice in Detroit. Cushing, at last realizing his need for a radiologist who could help him in his neurosurgical service, cast his eye in the direction of the MGH for a replacement (21). At the time, Merril Sosman was completing 9 months of training under Dr George W. Holmes (who had trained under Walter Dodd). In 1922, Sosman was appointed roentgenologist to the PBBH. With this appointment a “golden decade” of neuroradiology commenced in Boston.

Schüller had published his textbook Radiology of Diseases of the Head in 1912. The fundamental principles described in that work must have provided the stimulus for the research carried out by Cushing and Sosman. Although Dandy had published his major discoveries of ventriculography in 1918 and pneumoencephalography in 1919, it is not surprising that because of the intense rivalry between the pupil Dandy and the teacher Cushing none of the papers from the PBBH were on these topics. Nevertheless the technique was being used elsewhere in Boston—a case report on the use
of air ventriculography for the diagnosis of a brain tumor was published from the MGH in 1921 (26). (The concept of air as a deliberately introduced contrast medium for radiologic diagnosis was actually suggested as early as 1901 by Francis H. Williams, who observed the valuable radiologic function of air naturally present in the lungs (27). Injection of air into the ventricles might have followed immediately from these early observations but, as already mentioned, was delayed until 1918.)

Cushing undoubtedly was the catalyst for stimulating Sosman to raise the art of plain film diagnosis of the skull to a new level. A series of papers appeared in the 1920s from the pens of Cushing, Sosman, and their colleagues; papers on optic chiasm gliomas, craniopharyngiomas, meningiomas, carotid aneurysms, and tumors at the base of the brain were published in rapid order (28–31). In his invited commentary on this latter paper, Cushing stated, "A roentgenologist, in short, thoroughly versed in pathology becomes a specialist of a high order"—surely a definition for a neuroradiologist. By 1925, more than 1100 cases of verified brain tumors had been seen in Dr Cushing's clinic (31). A paper on internal carotid aneurysms and aneurysms of the circle of Willis (32) appeared in 1926; radiology as an aid in the diagnosis of skull and other intracranial lesions appeared in 1927 (33).

In his 1931 annual report, Sosman claimed that he and his group were accurate in locating almost half of all verified intracranial tumors from the neurosurgical service and the type of tumor in about one quarter (26%). Most of the tumors were pituitary adenomas, meningiomas, and acoustic neuromas (34). Interestingly, by the last year that Cushing was chairman (1932), ventriculography had become accepted at the PBBH and was successfully used to locate 59 of 62 verified tumors. Thus in spite of Cushing's opinion about Dandy, he realized the true value of ventriculography and placed the patient's welfare above that of his personal animosities. In fairness to Cushing, the reported risks of ventriculography were substantial—four deaths in 25 patients were reported by the British neurosurgeons in 1924 (35). However, years later, in his 1938 book on meningiomas (36), Cushing referred to "Dr. Dandy's brilliant and useful discovery" (page 522) and also admitted that he and his colleagues were altogether too conservative "...probably due to the insistence...upon a thorough neurological examination in each case and the apprehension lest this be glossed over by the junior staff if a diagnosis in some instances could be more quickly arrived at in other ways" (page 724). Clinicians today who may forgo or shorten the neurologic examination in favor of computed tomography or magnetic resonance imaging can learn from Cushing's wisdom.

Not only did Sosman collaborate with Cushing on many seminal papers on neuroradiology, but Sosman also was largely responsible for investigating the value of x-ray therapy for several groups of radiosensitive tumors (3). During these years Jacob Vastine and Kenneth Kinney, who were at the PBBH, published their important work on displacement of pineal calcification in the anteroposterior as well as vertical planes for locating brain tumors (37).

Sosman believed that x-rays could be used as individual markers of a person's identity, much like fingerprints are used today. In fact, according to Dr Leland Sosman, Merrill's son, his father coined the phrase "you can tell a fella by his sella" (personal communication, 1994). In 1922, Cornelius Dyke was appointed house officer at the PBBH, when Cushing was still active and when Sosman was presiding over the richest collection of neuroradiologic material in the world. Dyke left the PBBH in 1929 for the Neurological Institute in New York, where he became director of the Department of Radiology in 1939. There, together with Leo Davidoff, also one of Cushing's pupils, they produced three books on neuroradiologic roentgenology, of which one, The Normal Encephalogram, published in 1937, can be considered a classic (22). Back in Boston in 1931, Eley and Vogt reported on 350 pneumoencephalograms performed at the Boston Children's Hospital for patients with cerebral atrophy, porencephaly, developmental defects, and trauma (38).

As a result of the high esteem in which Sosman and Dyke were held by their neurosurgical colleagues, they were both elected presidents of the Harvey Cushing Society, the forerunner of the American Association of Neurological Surgeons. The importance of personality in (justifiably) influencing patient referrals is exemplified by the fact that after Cushing's retirement in 1932, the great volume of unusual and fascinating cases at the PBBH regretably fell to a minimum.

Two other notable neuroradiologists sprung from the Boston school. Dr John Camp had his
basic training at the MGH in the early 1920s and went on to lead a most successful service at the Mayo Clinic. Also, by the end of 1936, Harold Peterson had completed 2 years at the MGH. The MGH was not particularly renowned for its neuroradiology at the time, and Harold Peterson ascribes his neuroradiologic interest to sitting in on workshops on plain skull films presented by Merrill Sosman at the PBBH (39). Peterson maintained that through the triumvirate of Sosman, Dyke, and Camp, neuroradiology in the United States can be considered to have had its origins in Boston.

The injection of oily contrast material into the spinal canal for myelography was conceived in France in 1921 by Sicard and Forestier (40). News of this procedure at first received a lukewarm reception in the United States. Among the first Americans to try it were Ayer and Mixter at the MGH (41). They were not encouraged by their results because of the irritating effects of the oil. Percival Bailey, of Cushing’s celebrated neurological clinic at the PBBH, in fact, in a discussion on Ayer’s and Mixter’s paper, commented that he, Bailey, refused to use the iodized oil “locked up at the Brigham Hospital which we have not used” (41). The Boston school was therefore found wanting, and it was left to others, particularly Dandy, to pioneer and promote the use of the Sicard-Forestier technique. In spite of their initial skeptical comments, Ayer and Mixter reported using Lipiodol on two terminal cancer patients with metastatic spinal involvement and apparently successfully demonstrated spinal blocks in both (41). Mixter expanded on his experience and in 1925 published another paper on the use of Lipiodol in tumors of the spinal canal (42). In 1934, Mixter and Barr exonerated themselves by being the first to diagnose a ruptured intervertebral disk through myelography (43). Subsequently, in 1936, Hampton and Robinson, radiologists at the MGH, expanded on the MGH experience, clarifying the myelographic features of the herniated lumbar disk (44).

A notable milestone occurred in 1936 when Julius Loman and Abraham Myerson, working at the Boston State Hospital (now defunct) in Mattapan, Massachusetts, described performing carotid angiography by percutaneous puncture of the carotid artery (45). Drs Loman and Myerson both had appointments at Tufts College Medical School (as it was then known), where Dr Myerson was a professor of neurology and worked mostly at the Boston State Hospital. (personal communication from Paul Myerson, MD, 1994). The idea of radiologic imaging of blood vessels was not new; as early as 1897, a Dr Raw in Manchester, England, had injected a solution of calcium sulphate into the femoral artery at autopsy, which demonstrated the arteries with x-rays (46). Stimulated by the early dismal effects of ventriculography, Moniz was stimulated to develop another method of cerebral structural imaging, and in 1927, together with his colleagues, was successful in obtaining in vivo studies by surgically exposing the common or internal carotid artery, ligating the vessel, and rapidly injecting Thorotrast. (Prior percutaneous injections were unsuccessful.) Loman and Myerson simplified Moniz’s technique by percutaneously puncturing the common carotid artery, also injecting Thorotrast, and taking single lateral films of the head. The genesis for this work dates back to 1925, when Myerson and his colleagues described the percutaneous injection of Neo-salvarsan for the treatment of patients with general paralysis of the insane, a technique originally performed by Knauer in 1919 (47–49). One can only speculate on how close these early investigators were to discovering cerebral angiography!

For many years, neuroradiology in the United States was a stepchild of the surgeons who performed the procedures; the radiologists were relegated to taking appropriate exposures. The radiologists had mixed feelings about this turf battle, but the facts were that, in general, the hospitals were not properly qualified to supply maximum service in a field as specialized as neuroradiology (22). The first neuroradiologists in the United States, functioning as subspecialists, became successful not only through the technical mastery of their profession but also through a willingness to cooperate closely with neurologists and neurosurgeons. Notable examples of this cooperation were Drs Camp and Adson at the Mayo Clinic, Drs Davidoff and Dyke at the Neurological Institute in New York, and Drs Schechter and Gutierrez at St Vincent’s Hospital in New York. In a 1940 presidential address to the American Roentgen Ray Society, Sosman referred to the genesis of this cooperation and considered subspecialization necessary for radiology (50). Thus Sosman can be considered a prophet as well as a scientist. His cooperation with Cushing was unquestionably
instrumental in the future development of the subspecialty in the United States.

The final historical achievement relevant to neuroradiology in the Boston community is that of A. M. Cormack, a professor of physics at Tufts University, who in 1963 and 1964 described the mathematics that would allow a cross-sectional image to be reconstructed by scanning an object from various directions (51, 52). By suggesting that such a reconstruction could be applied to radiographic cross-sectional imaging, Cormack’s work provided the basis for computed tomography. He was recognized for this achievement in 1979 when, together with G. N. Hounsfield, a computer expert working in the Central Research Laboratories of EMI Ltd in England, he won the 1979 Nobel prize in medicine.

Before the discovery of x-rays, the brain remained a “dark continent.” It was the neurologists and neurosurgeons who desperately needed to develop techniques with the aid of contrast substances to diagnose and treat their patients successfully. Boston, with its strong neuroscientific community, felt these needs as much as anywhere. The Boston radiologists responded to these needs and, through their willingness to cooperate with their clinical colleagues, helped foster and develop the new science. These radiologists can justifiably be proud to have played a significant role in the early development of neuroradiology in the United States.

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