# HISTORY

# On the Radiologic Diagnosis of Cerebral Aneurysms with Plain Films and Cerebral Angiography: A Historical Survey

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***Editor's note.***—AJNR *will honor the Radiology Centennial with several invited articles on the history of neuroradiology. Throughout the coming year, these special reports will touch on topics not found in other sources and detail the evolution of neuroradiology in various areas of the world. In this way the* Journal *continues to play its vital archival role in neuroradiology.*

"O Röntgen, then the news is true
And not a trick of idle rumor,
That bids us each beware of you
And of your grim and graveyard humor."
—from *Punch* (London) January 25, 1896

Within a few weeks of the announcement by Röntgen in December 1895 of "a new kind of ray," the cartoons and poems appearing in many popular magazines and newspapers provide a fascinating window on the early printed records of the discovery of x-rays and give us a good idea of its reception by the general public (1). As illustrated by the above quote from *Punch*, not infrequently the records express a certain fear of the ghastly skeletal pictures, which seems to be a true reflection of the ignorance and pessimism expressed about the new rays. It wasn't many years, however, before the triumphal course of events overcame the scattered opposition, and a new science was born.

Before examining the early history of the roentgenologic diagnosis of intracerebral aneurysms, it is rewarding and fascinating to consider the history of the discovery of aneurysms and to plot their slow discovery by the "medical establishment." The incidence of subarachnoid hemorrhage from ruptured intracranial aneurysms is approximately 10 in 100,000 per year (2). Unruptured aneurysms occur in approximately 5% of the general population (3). Therefore, it is surprising that the early historical recognition of aneurysms is so uncommon. According to Stehbens (4) aneurysms were known to the ancient Egyptians, but their religious fears, exceeding their curiosity, prevented them from examining the vast quantity of pathologic material they handled. In the embalming process the cranial contents were removed through the nostrils with hooks, destroying any chance of demonstrating aneurysms, and the skull was then washed out with spices. Galen was probably the first to define and describe the entity of aneurysm, because he was the physician to the gladiators of Rome and therefore must have seen traumatic aneurysms fairly frequently. Galen was an ardent anatomist but had very seldom (some think never) dissected a human body (5). References to arterial aneurysms in which the basic principle of proximal control before sac excision appeared in ancient Indian, Alexandrian, and Greek dissertations (6), indicating that the ancients were already aware of the devastating effects of blindly incising a pulsatile tumor.

After Galen's death his teachings were forgotten until, in the 14th century, the practice of dissection of the human body began again, particularly in the north Italian Universities of Bologna, Padua, and Ferrara. The word *aneurism* first appeared in *Colgroves Dictionaire of the French and English Tongues* (6). The concept of an arterial circle or heptagon at the base of the brain, attributed to Willis in 1664, was actually described 100 years earlier by Fallopius in 1561 and partially illustrated by Casserius in

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1622 and by Vesling in 1653 (7). Because nearly all intracranial aneurysms occur in or near the circle, it is surprising that none of these authors, nor Willis's anatomy artist Sir Christopher Wren, observed an aneurysm (8). In the middle of the 16th century syphilis was considered a cause of aneurysmal dilatation of a vessel. The concept that aneurysms result from dilatation of an artery that is inherently weak can be attributed to Lancisis in 1728 (cited in reference 6).

The skull could be considered as a black box safeguarding its contents, and the concept that aneurysms may occur intracranially took a long time to develop. Monro in 1760 admitted that "authors mention true aneurisms in the brain, but I have met with no account of any within the skull in such books as I have consulted" (citing Erichsen, 1864 [6]). Morgagni of Padua has been given credit for being the first to describe an intracranial aneurysm in 1761 (9). His description states that "both the posterior branches of the carotid arteries, which are, for the most part, very small, [were found to be] so exceedingly dilated . . ."—scarcely a convincing description of an intracranial aneurysm (8).

Bull believes that credit for the first authentic description of an intracranial aneurysm should be given to Biumi who, in 1765, described a 52-year-old woman who died 2 years earlier in whom at autopsy "the internal carotid artery in the sinus, or Vieussen's receptacle, before it turned to the posterior clinoid process, was so distended with blood that the aneurysmal sac pressed directly on the surrounding parts" (Vieussen's receptacle is now known as the cavernous sinus) (8). Atherosclerotic bilateral cavernous carotid artery aneurysms were beautifully described by John Hunter in 1792 and reported by Blane in 1800 (8). The first illustration of subarachnoid hemorrhage from a ruptured aneurysm is seen in Cheyne's (1812) book on apoplexy (cited by McHenry [10]). Subsequently through the 1800s, an increasing number of reports, mostly autopsy observations, on the occurrence of cerebral aneurysms, some ruptured and some unruptured, were published (6, 8). In 1859, Gull commented, "Although we may, from the circumstances, suspect the presence of an aneurism within the cranium, we have, at the best, no symptoms upon which to ground more than a probable diagnosis" (cited by Garvey [11]). Hutchinson in 1875 was probably the first to diagnose an intracranial aneurysm before death in a 40-year-old woman with a third-nerve palsy and a severe unilateral headache (12). She died 11 years later, and the aneurysm was confirmed at autopsy. MacEwan in 1881 described the brain as "the dark continent" (cited by Bull [13]).

In February 1886, within 6 weeks of Röntgen's report, Cushing, who was a house officer at the Massachusetts General Hospital at the time, wrote to his mother that "Röntgen may have discovered something with his cathode rays that may revolutionize medical diagnosis" (14). A most illuminating statement documenting what inflation has achieved over the last century regarding the cost of x-ray machines appeared in an 1896 issue of the *Journal of the American Medical Association* (15): "The electric apparatus is so expensive, $100 and upward, that few surgeons can use it yet in their private practice." Beadles commented in 1907 on the difficulty of diagnosing cerebral aneurysms on any one of the cerebral arteries except in the most unusual circumstances (16).

Radiology came very slowly to the science of neurology, being led by German and Austrian investigators. In 1899 a report appeared (17) in which skiagrams (ie, fluoroscopy) were described as showing a right-sided cerebellar tumor (seen as a shadow not seen on the left side—not a very convincing report, because the tumor was not calcified). Fedor Krause, a German surgeon, included a short chapter on radiology in a textbook, *Surgery of the Brain and Spinal Cord*, which was published in 1907 (cited by Bull [13]). No mention was made of the radiologic diagnosis of cerebral aneurysms.

The next milestone in our story is provided by Dr Arthur Schüller, who in his textbook, *Skull Roentgenology*, published in 1912 and translated into English in 1918, commented on the difficulty of differentiating soft-tissue changes within superimposed denser structure and observed that "such a problem is unattainable" (18). For this reason, Schüller concentrated on the pathologic changes in the bones of the skull (the only soft-tissue structure recognized was the calcified pineal gland). In his book Schüller describes an autopsy on a patient with an aneurysm in which a "lateral roentgenogram obtained [after death] demonstrated erosion of the sella and a dome-like contour [of calcium] bent over the entrance to the sella." The legend to the figure refers to "calcified plates as they some-

times occur in the walls of some hypophyseal tumors."

In the middle of the second decade of this century the radiologic diagnosis of aneurysms were still appreciated only in retrospect. In 1913 Reinhardt published a paper about a 41-year-old man with severe headaches in whom a pulsating tumor overlying the left ethmoid bone was surgically demonstrated. X-ray photographs of the skull revealed obliteration of the sella and of the sphenoid sinus on the left. Postmortem exam disclosed an aneurysm of the left internal carotid artery (cited in McKinney et al [19]).

In 1916 Heuer and Dandy at Johns Hopkins reported a case of a 26-year-old telegraph operator with a history of sudden, violent, frontal headache, nausea, and vomiting 4 years before admission in whom complete blindness in the left eye subsequently developed, followed by partial visual disturbance in the right eye (20). The x-ray demonstrated "a series of shadows consisting of broad curved lines and plaques." The patient refused an extensive operation and allowed only a right subtemporal decompression to be done. Eighteen months later he experienced an explosive headache, vomiting, and loss of consciousness and died. At autopsy two giant aneurysms were found. The authors continue, "The x-ray picture was striking, although we had never seen a similar picture, in retrospect, we should have considered that in no condition would concentric layers of calcification be so likely to occur as in a thick-walled aneurismal sac."

The diagnosis of cerebral aneurysms remained retrospective. Viets in 1918 and Kirby in 1924 described cases of surgically and pathologically confirmed aneurysms in whom, in the first case, a single glass x-ray plate showed faint areas of calcification to the right of the sella turcica and, in the second, x-ray photographs revealed "a mass in the right middle cranial fossa eroding the sella, and the floor of the middle fossa" (21, 22). Neither aneurysm was diagnosed prospectively.

Merrill Sosman is considered by some to be the first neuroradiologist in the United States, and by collaborating with Cushing and encouraging his own and Cushing's assistants to publish, he made magnificent use of the rich material passing through his department at the Peter Bent Brigham Hospital at that time (14). Sosman and Vogt in 1926, reporting on 20 patients with cerebral aneurysms, found abnormalities on skull x-rays, indicating the presence of cerebral aneurysms, in 5 of their patients. Probably, they were the first to report on the prospective use of roentgenograms for this purpose and wrote that "it is remarkable that not more had been written regarding the possibilities of roentgenologic recognition of this condition when we consider the large number of cases that have been reported" (23).

The angiographic diagnosis of aneurysms was slow in coming, even though Egas Moniz published his paper on arterial encephalography in France in 1927 (24). Cerebral angiography was slowly accepted, probably because the study involved making two scars, one on each side of the neck, an unpleasant stigma to carry for the rest of one's life (13). Also, the initial use of sodium iodide often resulted in epileptiform attacks and hemiplegia. Angiography was carried out through an open arteriotomy, and Saito et al recommended that the injection be made into the superior thyroid artery rather than the common carotid or external carotid artery (25)—a particularly cumbersome technique. In a *Lancet* editorial the comment appeared, "It is not easy to see what advances in the diagnosis of cerebral disease can come from arteriography but it may have a definite value in the investigation of angiomatous tumours . . ." (26). In another editorial in *Lancet*, later in the same year, the editor wrote that "it [cerebral arteriography] may be of use in the accurate diagnosis of aneurysms and certain angiomas" (27). In 1933 Moniz published a paper demonstrating an aneurysm arising from the internal carotid artery at the base of the brain (28). Norman Dott, a British neurosurgeon also reported in 1933 on a case of a young woman in whom a severe headache developed after she struck the vertex of her head on a mantle shelf (29). An aneurysm at the origin of the posterior communicating artery was diagnosed after "arterial radiography" with thorium dioxide, the contrast medium of choice at the time.

Intracranial aneurysms were still considered rare. McKinney et al in 1936 reported that a "careful search of the literature has revealed 29 cases of aneurysms of the intracranial portion of the internal carotid artery confirmed either at autopsy, at operation or by definitive x-ray findings" (19). Lindon in 1936 reported on an angiographically documented case of an elongated saccular aneurysm projecting backward

from the internal carotid artery just proximal to its bifurcation. The procedure used was a cutdown on the internal carotid artery and the injection of thorium dioxide after stopping the prograde flow of blood through the artery by occluding it below the injection site immediately before the injection (30). In 1938 Matas reviewed the preoperative diagnosis of intracranial aneurysms and mentioned that false-positive studies may occur because of errors in technique or the failure to delineate small thrombosed sacs (31).

A milestone was reached in 1936 when Loman and Myerson in the United States described the percutaneous technique of direct puncture of the artery (32). This technique was endorsed by Shimidzu in Japan in 1937 and was firmly established by Engeset in Norway in 1944 (33) (cited in Engeset, 1944 [34]). Our story ends with the report by Seldinger on his catheter technique in 1953 (35). Although the direct puncture method persisted well into the 1970s, the radiologic diagnosis of intracranial aneurysms gained in popularity, and carotid angiography became a standard procedure.

Progress in the understanding and diagnosis of intracranial aneurysms (culminating now with the use of magnetic resonance imaging to diagnose incidental intracranial aneurysms) has progressed so rapidly that the significance of much that happened in previous centuries seems particularly remote. Nevertheless, we must not forget that the fundamental principles of the past have led to today's accomplishments. What lies in the future in the nature of the radiologic diagnosis (and in interventional therapy) of intracranial aneurysms is purely speculative.

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