

## J. Lawrence Pool, M.D.: a pioneer in vascular neurosurgery

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✓The authors detail the life and career of Dr. J. Lawrence Pool, as well as his significant contributions to the field of cerebrovascular neurosurgery. The discipline of cerebrovascular neurosurgery is a young and dynamic field, which underwent rapid and substantial growth during the middle of the twentieth century. As the chairman of the Department of Neurological Surgery at the Neurological Institute of New York, Dr. J. Lawrence Pool was instrumental in the development of new techniques and devices that would ultimately result in decreased mortality rates and improved results from complex cerebrovascular procedures. Passion, ingenuity, and a pioneering spirit fueled Dr. Pool, whose introduction of the operating microscope and use of temporary clip occlusion during aneurysm repair revolutionized the field of cerebrovascular neurosurgery.

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**T**HE discipline of cerebrovascular surgery is a young and dynamic field. In fact, the first successful direct treatment of an intracranial aneurysm, by Norman Dott, did not occur until 1931.<sup>1</sup> During the middle of the twentieth century, cerebrovascular neurosurgery underwent rapid and substantial growth founded on the innovation and ingenuity of a select group of surgeons.<sup>2</sup> The Neurological Institute of New York and its neurosurgical staff played a significant role in the development of the new techniques and devices that would ultimately result in decreased mortality rates and improved results from complex cerebrovascular procedures. At the helm of this department was Dr. J. Lawrence Pool, whose introduction of the operating microscope and use of temporary clip occlusion during aneurysm repair revolutionized the field.

### Early Years

J. Lawrence Pool was born in New York City in 1906. After graduating from the St. Paul's School in 1924, he set sail for Europe on the Italian steamship *Duilio*. The purpose of his European tour was twofold; he would cultivate his interest in the arts as well as witness famous surgeons of the day performing their craft. One of these was the famous orthopedic surgeon Professor Alessandro Putti, whose masterful repair of damaged knee joints helped foster an increasingly intense desire in Pool to follow in his father's footsteps and become a surgeon himself. In his autobiographical memoirs, *Adventures and Ventures of a New York Neurosurgeon*,<sup>4</sup> Dr. Pool speaks of two surgeries he observed. The first was to restore motion to a knee joint that had become fused as a result of infection. Afterward, Pool witnessed the impressive results—the patient could walk without difficulty and even ride a bicycle. The second procedure was to remove several ribs from a young girl in an effort to collapse her lung as a cure for tuberculosis. Dr. Pool, who had contracted “a touch of tuberculosis” in his childhood, noted that he was lucky enough to

have escaped such surgery. Nonetheless, the girl's age and vulnerability resonated with him, and he was tremendously impressed with the surgeon's skill. Dr. Pool later remarked that he felt it was these two operations that “kindled a spark that eventually made [him] want to be a surgeon.”

On his return, Pool was admitted to Harvard. Unlike St. Paul's, which did little to satiate his hunger for the arts, he was delighted to take courses in History, Fine Arts, and English Literature. However, the beginning of his senior year marked a shift wherein Pool decided to pursue a career in medicine, and on graduating from Harvard in 1928, he enrolled at Columbia's College of Physicians and Surgeons.

### Formal Training

Dr. Pool, an extrovert, found the patient care involved in the 3rd and 4th years to be the highlight of his medical school experience. In his 3rd year he participated in an exchange program, wherein he and a student from the University of Pennsylvania switched places. Dr. Pool noted that student exchange is a wonderful experience that “jolts a student out of his rut, opens him up to new experiences, and helps him avoid the inevitable complacency that comes from uninterrupted association with a single prestigious institution.” At the University of Pennsylvania, Dr. Charles Frazier, Professor of Neurosurgery, and his junior neurosurgeon Dr. “Chubby” Grant were favorites of the students and early mentors to Dr. Pool. By his 4th year of medical school, Pool had decided to become a neurosurgeon. Proud and determined to blaze his own trail, he noted that general surgery was his father's turf: “I didn't relish the idea of coasting on his reputation.” For the same reason that many students choose to pursue the field of neurosurgery in the current day and age, Dr. Pool believed that there was an undeveloped quality to the field and that it therefore had amazing potential for advancement.

In 1932, Dr. Pool's father helped develop a rigorous 7-year training program for his son. One early indication of the son's tremendous gift for ingenuity and inventiveness occurred when a patient with telltale signs of advanced tuberculosis was admitted, and the young doctor was given the task of deliberately collapsing the lung, in a manner similar to that which he had first witnessed as a teenager in Switzerland. To perform the surgery, a specific pressure gauge was needed, but one could not be obtained. Based on a picture in the sales catalog, Dr. Pool created a rudimentary apparatus using a jar and stop cocks from the chemistry lab. It was used effectively throughout the year, and on returning to the ward several years later Dr. Pool was bewildered to find that it was still being used.

Just as the 3rd year exchange program reinvigorated him, Dr. Pool's shift from the hospital to the laboratory in his 2nd year of residency did as well. At Boston City Hospital, under the guidance of Dr. Harry Forbes, he began research on what was to become one of his most absorbing and abiding interests, a study of cerebral circulation. Fellow workers in laboratories adjacent to his included H. Houston Merritt, codiscoverer of the highly effective anti-epileptic drug sodium dilantin and future chairman of the Department of Neurology at the Neurological Institute, as well as Henry G. Schwartz, later professor of neurosurgery at the Barnes Hospital in St. Louis. A hotly debated question of the day, and for some 20 years thereafter, was whether arteries of the brain, like arteries of the rest of the body, were capable of contracting to alter their caliber and thus adjust the flow of blood in the brain. At that time, most specialists flatly stated that brain arteries were not capable of vasospasm.

Dr. Pool's work, described in several scientific articles, showed that at least some arteries of the brain behave like those of the rest of the body. This conclusion was based on almost daily experiments lasting 3 to 5 hours. In those experiments, an animal was anesthetized, then a small glass window was fitted snugly into an opening cut into the skull. Through this window the arteries and veins of the animal's brain could be observed, measured, and photographed through a microscope as different drugs were administered and certain nerves were electrically stimulated. Modern research has, of course, confirmed Dr. Pool's work and indisputably established the existence of cerebrovascular reactivity. He noted that, although modest, his work provided the building blocks on which this further research was based, ultimately leading to better methods of treating strokes and other circulatory disorders. He gained significant satisfaction from these efforts, concluding that it is the creation of these building blocks that are often the justification for research, even if the impact is not immediately apparent.

Dr. Pool began his surgical internship in 1934. He often remarked that he was particularly fond of his time in general surgery because he was assisting in operations that were being performed for the first time ever—once again giving evidence that there was a pioneering spirit always mingled with his motivation to pursue a surgical career.

In 1936, Dr. Pool began neurology training at the Neurological Institute of New York. Here he developed the myeloscope, which "enabled one to inspect the nerve branches inside the lower part of the spine to see if they were affected by a slipped disc, tumor, or abnormally large blood vessels." Although the device became obso-

lete, once again Pool's deeply inventive and pioneering spirit helped him to identify a problem and develop a tool to remedy it. His efforts at the Neurological Institute also resulted in the discovery of the ulnar-adductor reflex, which helped explain the symptoms of a young patient suffering from a spinal tumor.

### Early Career

On completion of his neurosurgical training in 1939, Dr. Pool came to realize that a neurosurgeon exhibits traits not only characteristic of a surgeon but also of a number of other professionals. He enjoyed explaining how neurosurgeons have to drill and cut like a carpenter, understand and repair the "pipelines" and "wires" of the brain much as plumbers and electricians do, work with small delicate structures under magnification as a jeweler does, and mold and shape bone much as a sculptor does clay or bronze. Now, with degree in hand and his studies completed, Dr. Pool applied for an appointment at the Neurological Institute, where he had received his training. However, due to a personality clash with his former chief, Dr. Byron Stookey, his application was denied. Therefore, he headed to Bellevue where Dr. Joseph King offered him an appointment.

Dr. Pool's time at Bellevue was critical to his development as a neurosurgeon. Because the hospital treated only charity cases, there were a significant number of trauma victims, which Dr. Pool had rarely seen during his time at the Neurological Institute. Dr. King and the others on his staff were busy with private practice work, and so Dr. Pool was given a heavy caseload, which he assumed with characteristic zeal. Dr. Pool continued his tradition of innovation when in 1940 he and Dr. Stewart Alexander initiated the first use of cerebral arteriography at Bellevue. To perform this procedure, the carotid artery in the neck had to be exposed in an operating room, after which the patient was wheeled to an x-ray machine. There, Dr. Pool or Dr. Alexander would inject contrast material directly into the exposed carotid artery, accompanied by a shout of "now.... shoot!" to the radiologist. One reason for the initial lag in acceptance of arteriography in America was the toxic effects of Thorotrast, the contrast medium used at the time. Drs. Pool and Alexander began using Diodrast, the intravenous pyelogram contrast medium, in a 35% solution, which turned out to be an ideal choice and was widely adopted.<sup>6</sup> Dr. Pool also found time to create the "Gang of Five" for informal discussions of neurosurgical issues. This was the precursor to the New York Neurosurgical Society, of which he became the first president. In 1942, Dr. Pool's career in New York was placed on hiatus while he served in the Army for more than 3 years.

### Later Years

After being discharged from the Army, Dr. Pool finally received an appointment to the staff of the Neurological Institute of New York. Despite the Institute's vast resources and specially trained physicians, there was significant turmoil within the organization. Most importantly, the Department of Neurosurgery was in dire need of a chief, and to Dr. Pool's complete surprise, he was assigned this post on January 1, 1949, at the age of 43.

## J. Lawrence Pool, M.D.: a pioneer in vascular neurosurgery

As his career progressed, Dr. Pool took particular interest in cerebral aneurysms. During the 1950s, 35% of patients undergoing surgical clip occlusion of an aneurysm either died or were incapacitated. The high mortality rates resulted from limited experience on the part of surgeons, inadequate diagnostic tools to determine when to operate and how to detect aneurysms, and a high occurrence of intraoperative hemorrhage during exposure and dissection of the aneurysm. Dr. Pool set about investigating many of these issues and the results changed the face of cerebrovascular neurosurgery.

As his experience in aneurysm surgery increased, Dr. Pool realized that the high intraoperative rupture rate occurred primarily during the exposure and dissection of the lesion. As a result of these observations he started to place temporary clips on the feeding arteries, and with this technique he was able greatly to decrease the rate of intraoperative rupture. Dr. Pool realized, however, that if these arteries were shut off for more than 3 to 5 minutes, permanent brain damage would occur. He addressed this problem by inducing hypothermia to slow the brain's metabolism, thereby allowing increased time for safe occlusion with the temporary clips. Once again, there was a catch; hypothermia appeared to make patients unusually susceptible to cardiac arrhythmias. In animal experiments, Dr. Pool, along with Drs. Purpura and Housepian, was able to prove that appropriate sedation prevented cardiac arrhythmias during hypothermia.

Perhaps his most striking achievement came in 1963, when Dr. Pool pioneered the use of the operating microscope to perform aneurysm surgery. In the middle years of the last century, the morbidity resulting from direct surgery on intracranial aneurysms was substantial. (In fact, in what may have been the first randomized neurosurgical trial, McKissock, et al.,<sup>3</sup> demonstrated that conservative therapy yielded better results than did a direct attack on anterior communicating artery aneurysms.) It is remarkable to think that before this innovation, aneurysms were clipped based on observations made with the naked eye. The introduction of the microscope to neurosurgery drastically reduced morbidity and mortality rates following this procedure. Dr. Pool also extolled the use of the microscope as an educational tool, because it allowed students to view the surgeon performing the operation via a live video transmission from the microscope to a television. With this new technology, Dr. Pool translated his earlier research on cerebral vasospasm into the clinical realm, by directly observing vasospasm induced by mechanical stimulation of cerebral arteries and the results of topical application of 3% papaverine.<sup>5</sup> Perhaps the greatest impact of the microscope was the way in which it sharply raised the slope of the learning curve so that young neurosurgeons were able, within a few years, to achieve results comparable to those of experienced practitioners.<sup>2</sup>

Dr. Pool was also instrumental in the development of "scalp artery to brain artery hook-up," the forerunner of the modern extracranial-intracranial bypass. His technique involved using a plastic tube coated with an anticoagulating agent to connect an extracranial artery to an intracranial artery, distal to the sacrificed portion of that same artery, which supplied the aneurysm. Dr. Pool appro-

priately anticipated that the tube would eventually occlude itself, but he correctly assumed that over time smaller arteries would expand to provide collateral circulation and consequently keep the brain viable. Dr. Pool took particular pride in this procedure, calling it "something of a blockbuster."

A further aspect of cerebrovascular surgery that was of particular interest to Dr. Pool was how best to deal with aneurysms that bled during the third trimester of pregnancies. The majority of doctors at the time favored bed rest or a cesarean section to avoid the strain of labor. Dr. Pool, preferring surgical treatment of the aneurysm during pregnancy, was in the minority. By 1964, he had successfully treated four women with aneurysms during their pregnancy, with no postoperative complications. Two of the women went on to have vaginal deliveries of second children as well. A colleague, writing in response to Pool's paper on the subject, said that he wished the paper had come out earlier because a patient of his died of an aneurysm bleed the day before she was due to undergo a cesarean section.

### Conclusions

Dr. Pool was fond of the following simile: "The long saga of aneurysms and angioma surgery is like that of aviation. In both instances there were at first many failures, and in both instances it took the efforts of many pioneers and the development of many technical advances before both aviation and blood vessel surgery of the brain attained their present high degree of effectiveness and safety." Dr. Pool was truly such a pioneer, helping to usher in the modern era of cerebrovascular surgery. As we, the neurosurgical progeny of Dr. Pool and his contemporaries, begin a new century, we can reflect on the dedication, ingenuity, and passion of our predecessors, and take inspiration from their efforts as we continue to drive our field forward.

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