

## Walter Edward Dandy (1886-1946)

Walter Edward Dandy studied abnormalities in the developing human brain in the United States in the twentieth century. He collaborated with pediatrician Kenneth Blackfan to provide the first clinical description of Dandy-Walker Syndrome, a congenital brain malformation in which the medial part of the brain, called the cerebellar vermis, is absent. Dandy also described the circulation of cerebral spinal fluid, the clear, watery fluid that surrounds and cushions the brain and spinal cord. That description led Dandy to examine how the impeded flow of cerebral spinal fluid caused congenital hydrocephalus, which occurs when fluid accumulates in the brain causing it to swell. Dandy discovered brain anomalies that primarily develop during embryonic development, and his work helped to detect brain abnormalities.

Dandy was born in Sedalia, Missouri, on 6 April 1886 to Rachel Kilpatrick Dandy and John Dandy. A few years prior to Dandy's birth, his parents had moved to Sedalia from Lancashire, England. His parents raised him in a house by the railroad, where his father was working as an engineer. In 1903, Dandy graduated as class valedictorian from Summit High School in Sedalia.

Dandy next enrolled at University of Missouri in Columbia, Missouri. Neither of Dandy's parents had attended college, making Dandy the first in his family to attend college. During college, Dandy played on the university baseball team, though his academic interests revolved around biology and medicine. In 1907, Dandy completed his BA in biology, and then he transferred to Johns Hopkins School of Medicine in Baltimore, Maryland, to pursue a medical degree. Dandy remained close with his parents, and they followed him to Baltimore in 1910.

At Johns Hopkins Franklin Mall, a professor of anatomy, asked Dandy to study a preserved early stage human embryo. Dandy published his results in 1910, detailing the anatomy of the two millimeter human embryo. After that publication, Harvey Cushing, a neurosurgeon and founder of the Hunterian Laboratory at Johns Hopkins, appointed Dandy surgical assistant in his laboratory. In the Hunterian laboratory, Dandy studied the brains of cats and dogs, focusing on the blood supply of the brain and its flow to the pituitary gland, which is attached to the base of the brain and is responsible for growth and development.

At the age of 24, Dandy graduated from Johns Hopkins School of Medicine and started his residency in neurosurgery at Johns Hopkins Hospital in Baltimore under Cushing's supervision. With Cushing, Dandy worked to discover the causes of hydrocephalus. Hydrocephalus is the accumulation of cerebral spinal fluid within the brain, colloquially called water in the brain. According to historians, during their time working together at Johns Hopkins, Dandy and Cushing developed a strained relationship in part due to disagreements over the interpretation of non-neurological experiments. In 1912, Cushing moved to Harvard University in Cambridge, Massachusetts, while Dandy remained at Johns Hopkins to continue his research.

Later that year, Dandy began to collaborate with Kenneth Blackfan, continuing to search for the cause of hydrocephalus. Blackfan was a resident in pediatrics at Johns Hopkins Hospital. Dandy and Blackfan found that cerebral spinal fluid accumulates in the brain as a result of obstruction of the aqueduct of Sylvius, the connection between two brain cavities called ventricles. They discovered that the obstructed aqueduct of Sylvius blocked the passage of cerebral spinal fluid from the third ventricle to the fourth ventricle of the brain. Dandy and Blackfan noted that the accumulation of cerebral spinal fluid in ventricles caused increased swelling and pressure on the brain, which may damage the brain.

Until 1913, physicians could not explain the cause of hydrocephalus. In collaboration with Blackfan,

Dandy published their work on the origin of hydrocephalus in two studies in 1913 and 1917. In their first study, Dandy and Blackfan induced hydrocephalus in dogs by obstructing the aqueduct of Sylvius in the dogs' brains, preventing the circulation of cerebrospinal fluid. They demonstrated that cerebrospinal fluid forms in the innermost cavities of the brain and migrates outward. The cerebrospinal fluid then is absorbed by the web-like structure called the subarachnoid space, which surrounds the outside of the brain and spinal cord.

After discovering how cerebral spinal fluid circulated, Dandy and Blackfan then studied where obstructions occurred in patients who died of hydrocephalus. Their publication in 1917 detailed twenty-six cases of hydrocephalus. In that study, they injected a solution into the brain or spinal column and tracked where it migrated in the brain to see what obstructions caused hydrocephalus. Dandy and Blackfan found that congenital malformations, tumors, or inflammation led to obstructions in several ducts that eventually caused hydrocephalus, including the aqueduct of Sylvius and the foramina of Luschka and Magendie. They also described a congenital brain malformation later named Dandy-Walker Syndrome, which includes obstructed foramina of Luschka and Magendie in addition to other developmental malformations.

In 1916, the Surgeon in Chief at Johns Hopkins Hospital, William Stewart Halsted, appointed Dandy as his chief resident. Dandy collaborated with Halsted to develop a new x-ray technique that better enabled doctors to diagnose brain tumors. During the early 1900s, doctors used x-rays to detect abnormalities of the brain, but x-rays missed many brain tumors due to their inability to provide detailed visualizations. Dandy's work with Halsted led to a new technique for x-ray diagnosis, called ventriculography, which required air to be pumped into the head prior to x-ray. The air enabled clear x-ray imaging that accentuated previously non-visible brain tumors. Doctors used the technique to locate brain lesions and tumors until the 1970s, when computerized tomography (CT) scans replaced x-rays as the primary means for obtaining detailed images of the brain. When Dandy published his ventriculography results in 1918, it marked the end of Dandy's eight-year training period at Johns Hopkins.

Dandy continued at Johns Hopkins as associate surgeon in the hospital and continued exploring surgical treatments for brain abnormalities. In 1919, Dandy published a refined procedure for ventriculography, called pneumoencephalography. He made the procedure less invasive, while still enabling clear imaging. Instead of drilling a hole in the skull to inject the air, Dandy suggested injecting the air into the lumbar spinal canal of the lower back, located between the ribcage and the pelvis. The air then traveled up the spinal canal into the skull to allow for higher resolution imaging. Both techniques enabled the detection and sizing of tumors earlier and helped doctors to detect and treat malformations.

In the 1920s, Dandy received offers from medical institutions to lead their surgical departments, but he declined them and remained at Johns Hopkins. In 1921, Dandy became associate professor of surgery at the Johns Hopkins School of Medicine and assistant visiting surgeon at the hospital. During the 1920s, he began to research epilepsy. Scientists had classified epilepsy as a disease with an unknown cause, but Dandy's observations and experiments linking brain lesions to symptoms of epilepsy demonstrated otherwise.

In October of 1923, Dandy began to date Sadie Estelle Martina, a dietician at Johns Hopkins Hospital. They married the following year, and marrying, Dandy moved out of his parent's house and bought a house with his new wife. Together they had four children, Walter Edward Jr. in 1925, Mary Ellen in 1927, Kathleen Louise in 1928, and Margaret Martin in 1935.

After marrying, Dandy studied different methods of anesthesia. In the early decades of neurosurgery, the use of anesthesia, specifically ether, posed problems for brain surgeons. Dandy found that ether caused swelling of the brain, postoperative vomiting, and postoperative pneumonia leading to a high mortality rate in patients undergoing brain surgery. Dandy researched alternative forms of anesthesia and found Avertin, a German drug, which he started using in 1929.

In 1931, Dandy became clinical professor of neurosurgery at Johns Hopkins. In the following years, Dandy developed techniques to surgically remove brain tumors and brain aneurysms. In 1933, he developed a new treatment method for malignant tumors in which he removed the entire cerebral hemisphere. In 1937, Dandy performed the first surgical clipping, also called ligation, of an in-

tracranial aneurysm, or a bulging of blood vessels in the brain. Clipping the aneurysm involved cutting off the blood supply to the aneurysm, which isolated the aneurysm, preventing a rupture of the blood vessels. Doctors performed Dandy's procedures into the twenty-first century.

Dandy received the John Scott Award in 1943 for his work in creating ventriculography. Additionally, he established a surgical team he called the brain team, which provided clinical services, patient care, and that trained surgical fellows and residents in neurosurgery. The efficiency of that program enabled Dandy to perform, at his peak, greater than 1,000 neurological surgeries a year.

In April 1946, shortly before his sixtieth birthday, Dandy had a heart attack. He died on 19 April 1946 at Johns Hopkins Hospital.

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