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SHORT REPORT

Dr. Thomas Willis' Famous Eponym: The Circle of Willis

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Short Biography

Thomas Willis is considered one of the greatest neuroanatomists of all time. His name is usually associated with *the circle of Willis*, an anastomotic circle at the base of the brain, but his work also formed the foundation of basic neuroanatomical description and nomenclature, and comparative neuroanatomy. He was born on 27 January 1621 at Great Bedwyn in Wiltshire, England, the son of a farmer who lost his life at the siege of Oxford during the Civil War. Young Thomas was educated in Oxford, at Christ Church College in 1639 (Figure 1). He obtained his medical degree in 1646. His studies were interrupted by the Civil War of 1641-1647 and the siege of Oxford, when he served as a student volunteer with the Royalist army. Willis became a member of an informal group of experimental scientists –the Virtuosi– who, together with the Virtuosi of London were the forerunners of the Royal Society. He was Sedleian Professor of Natural Philosophy at Oxford in 1660 and, on moving to London in 1666, acquired the largest fashionable practice of his day. He died of pleurisy in 1675 in London at age 54 and is buried in Westminster Abbey (1-5).

Thomas Willis wrote *Cerebri Anatome (Cerebri anatome neroorumgue descriptio el usus–The Anatomy of the Brain and Nerves)* in 1664 while Professor of Natural Philosophy at Oxford. This work included Willis' classification of the cranial nerves and his description of the arterial pattern at the base of the brain widely known, even to the present day, as the circle of Willis. When this eponym is not used this pattern of vessels is called the cerebral arterial circle. Willis also wrote



Figure 1. Thomas Willis (1621-1675).

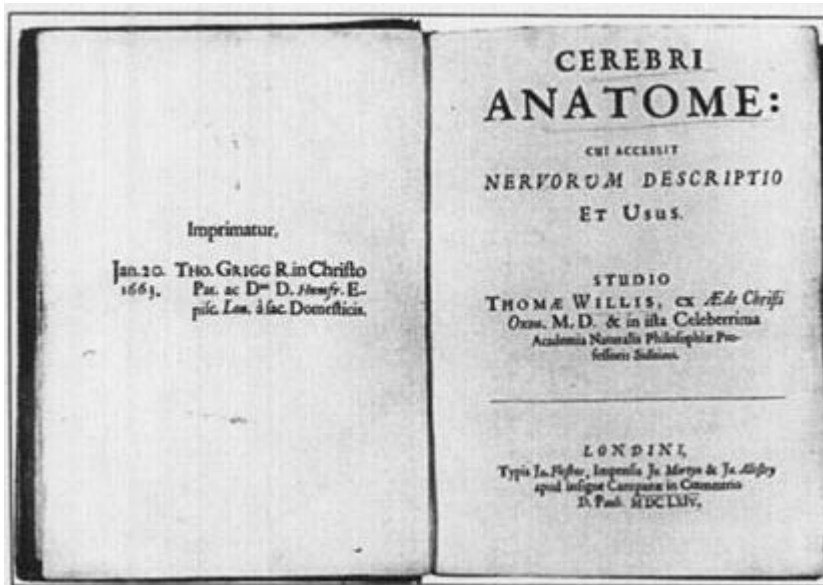


Figure 2. This drawing of the circle of arteries named after Thomas Willis at the base of the brain was done by Christopher Wren, architect of St. Paul's in London. (Ms. Lister B.66 Alt.BTW.12-13, Bodleian Library, Oxford.)

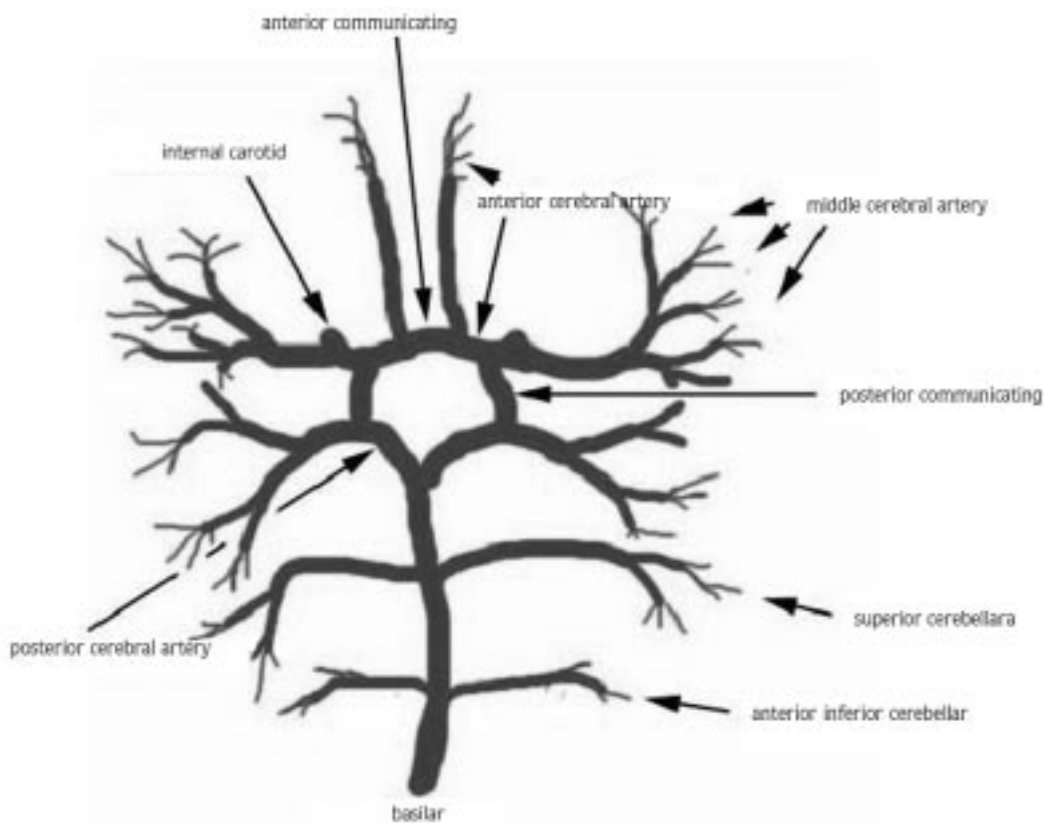


Figure 3. The Circle of Willis anatomy. [<http://uscneurosurgery.com/glossary/c/circle%20of%20willis.htm>]

Pharmaceutice Rationalis (1674), in which he characterized diabetes mellitus and included an accurate description of pulmonary tuberculosis. He described, in English, a plain and easy method for caring for those who have recovered from an infection of the plague, and for curing those who are infected.

Willis performed necropsies on his patients and made extensive anatomic dissections, especially on the brain. His co-workers included the physicists Robert Hooke and Robert Boyle; Richard Lower, an anatomist, physiologist, and clinician, who administered the first blood transfusion; and Sir Christopher Wren, the renowned architect and artist. Wren is responsible for the engraved plates from which the illustrations in Willis' *The Anatomy of the Brain and Nerves* are derived. Willis is usually remembered for his description of the vascular composition of the large arteries at the base of the brain, the so-called circle of Willis. He emphasized the capability for collateral circulation if an artery becomes blocked and the interconnection of blood vessels (6).

Thomas Willis showed that the cerebral cortex covered many subcortical centers that join the 2 hemispheres. The cortical gray matter, he thought, was responsible for animal spirits, while the white matter distributed the spirits to the body, governing movement and sensation (7).

Discovery of the Circle of Willis

Thomas Willis was not the first to describe the arterial circle at the base of the brain, but he was the first to provide a complete description, an illustration of this vascular pattern, and to indicate that he understood the probable function of the arterial circle. Before Willis, a basal arterial circle had been described by Fallopius (1523-1562), Casserio (1552-1616), Vesling (1598-1649) and Webfer (1620-1695). In 1561, Gabriele Falloppio, a pupil of Vesalius, mentioned the existence of an arterial circle at the base of the human brain. Fallopius described the joining of the 2 vertebral arteries and their later division, as well as the union of the anterior rami, corresponding to the anterior communicating artery, but he regarded the posterior communicating artery as only indirectly connected to the carotid artery. Giulio Casserio illustrated an arterial circle in 1627, showing the posterior communicating artery on one side only. In

1658, Webfer described a ring of arteries at the base of the brain and its anastomotic function. He gave an accurate description of the anatomy of the brain vessels including the Circulus arteriosus several years before Willis. Willis acknowledged these previous studies. He realized the clinical importance of the circle and suggested that in 2 cases the anastomosis had prevented apoplexy or paralysis. In his experiments with animals, he showed that dye injected into one carotid stained all the vessels and that ligation of one carotid was compatible with life, thus confirming the functional importance of the circle (8-10). Amongst his clinical highlights was a man who died of a mesenteric tumor, who in life had had no neurological symptoms. He published a case report in *Cerebri Anatome* in 1664:

“ . . .When his skull was opened we noted amongst the usual intracranial findings, the right carotid artery, in its intracranial part, bony or even hard, its lumen being almost totally occluded; so that the influx of the blood being denied by this route, it seemed remarkable that this person had not died previously of an apoplexy: which indeed he was so far from, that he enjoyed to the last moments of his life, the free exercise of his mental and bodily functions. For indeed, nature had provided a sufficient remedy against the risk of apoplexy in the vertebral artery of the same side in which the carotid was wanting, since the size of this vessel was enlarged, becoming thrice that of the contralateral vessel...” (11-15).

This case shows that Willis was fully aware of both the anatomy and the physiological importance of the circle. Thus he founded his understanding of the vascular circle at the base of the brain. And, more importantly, he was able to relate the anatomy to the clinical effects of vascular disease.

“ . . .We have already shown, that these Vessels are variously and very much ingrafted or inoculated among themselves, not only the Arteries with the Veins, but what is more rare and singular, Arteries with Arteries; to wit, the Carotid Arteries of one side, in many, are united with the Carotides of the other side; besides the Vertebrales of either side among themselves, and are also inoculated into the posterior branches of the Carotides before being united. The joinings together of the Carotides, in most living creatures, are made about the basis of the skull under the dura mater...” (16).

Willis dissected bodies of deceased patients, adding information to the animal dissections that he performed. He seems to have directed most of the dissections, performed by Lower in the back rooms of houses and inns. Wren and Millington were frequently present to confer and reason about the uses of the parts. The brain was approached from below and removed from the skull before being sliced from the base upwards, in contrast to traditional methods of in situ dissection. The specimens were then examined through a magnifying glass and drawn by Wren (17).

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