Computer-assisted neurosurgery: Yesterday, today and tomorrow

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Computer-assisted neurosurgery is a relatively new marginal discipline from the mid-1980s that leverages the rapid development and wide applications of computer science and technology in medicine. It combines traditional medicine with the rapid development of modern science and technology and significantly improves the diagnosis and treatment of clinical medicine. Here we review the history of computer-assisted neurosurgery, the current status, and look forward to its future development.

Modern neurosurgery as an independent specialty was born in the late eighteenth century on the European continent. In 1890 ZERNOW in Moscow described an apparatus called ENCEPHALOMETER, which was fixed on the patient’s skull and served to localize intracerebral anatomical structures based on superficial landmarks. Actual stereotactic calculations based on a coordinate system were invented by HORSLEY and CLARKE in 1906 and 1908. They described a rigid frame attached to the skull which served as an immovable coordinate system in relation to which each point in the brain could be referred. The stereoscopic method was first applied to humans by KIRSCHNER in 1933. In the United States, HARVEY CUSHING (4/8/1869-10/7/1939), known as the father of neurosurgery, founded the specialty of neurosurgery at John Hopkins in 1912 after a European grand tour and a year in Kocher’s laboratory in Bern where he studied the effects of head injury. His clinical contributions were groundbreaking: the use of X-RAY in surgical practice, physiological saline for irrigation during the surgery and the understanding of pituitary’s function in early neurosurgery.

Stereotactic frame, SPIEGEL and WYCIS performed the first stereotactic thalamotomy on humans in 1947 using the commissura posterior and pineal body as an internal individual reference system. Functional neurosurgery with its different applications, CT focuses on the bony structure, MRI focuses on the surrounding environment of the anatomical structure. Intraoperative localization and navigation helps to maximize the removal of the tumor and reduce injury to surrounding normal tissue. Different medical imaging data have different applications, CT focuses on the bony structure, MRI focuses on soft tissue, MRA and CTA focuses on blood vessels, fMRI focuses on different functional areas of the brain, and DTI focuses on the nerve fibers and its direction. The data can be processed in the same coordinate system after registration and used for localization and navigation.

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