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NEUROSURGERY: SOME STAGES OF DEVELOPMENT

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Abstract

In the article presented the Author describes a long way neurosurgery has come from ancient craniotomy performed with stone tools to high – precision microsurgery and robotics, combining advances of different clinical and theoretical sciences. The invaluable contribution of W. Horsley, N. I. Pirogov, Harvey Cushing, V. M. Bekhterev and other prominent surgeons and scientists is discussed.

Key words: history of neurosurgery development; scientific approach; contribution to science.

Neurosurgery emerged as an independent scientific and clinical discipline in the first third of the 20th century, having come a long way from ancient craniotomy performed with stone tools to high – precision microsurgery and robotics, combining advances in neurology, general surgery, antiseptics, anesthesiology, and radiology.

Cranial trepanation (drilling or scraping bone) was performed as early as the Neolithic, as evidenced by skulls found by archaeologists with signs of healing. These surgeries were performed for trauma or ritual purposes.

In the Peru via necropolis left over from the Inca civilization, approximately 10% of skulls show signs of trepanation, and the nature of the bone changes indicates that most patients successfully underwent the surgery.

About one – third of trepanations were performed for traumatic brain injuries. The indications for craniotomy in the remaining two –thirds of cases remain unclear. Trepanation was performed by scraping the bone, as well as using chisels, nippers, and conical burrs. The Incas also performed bone grafting with gold or silver plates.

Head injuries are described in Egyptian papyri.

The first description of cranial trepanation was given by Hippocrates in his work "On Wounds of the Head," which detailed the rules for trepanation for skull fractures and epilepsy.

During the Middle Ages, medical development in Europe slowed, but Arab physicians (such as Al - Buqasimi) continued to describe surgical approaches for head wounds.

The first neurosurgical manual ("*Tractatus de Fractura Calvae sive Cranei a Carpoeditus*") was published in 1518 in Bologna by Berengario da Capri (1470 -1550). The work is primarily devoted to the author's description of his successful treatment of an occipital bone fracture in Lorenzo de' Medici, but it also provides general recommendations.

Ambroise Pare (1510-1590) made a significant contribution to the development of trepanation techniques, describing in detail the instrumentation and technique of trepanation, removal of osteomyelitic bone, drainage of subdural hematomas and empyemas, and proposing a technique for repositioning depressed skull fractures.

The development of neuroanatomy is primarily associated with the name of Thomas Willis (1621-1675). His "*Cerebri Anatomie*", published in London in 1664, was the most accurate manual of its time. Willis was also the first to propose the term "neurology", understanding it in the anatomical sense, i. e. as the science of neurons, and not as a clinical discipline.

Surgical technique developed alongside anatomical science. Johannes Schultes's (1595-1645) book, "*Armamentarium Chirurgicum*," translated from Latin into many languages, describes and illustrates numerous instruments used for trepanation, some of which resemble modern raspaters, elevators, and nippers.

The second half of the 18th century saw further advances in medical science and

practice. Giovanni Battista Morgagni's (1682-1771) concept of pathological anatomy, linking each nosology to a specific pathological substrate, changed the philosophy of European medicine and, among other things, substantiated the advisability of tumor removal in any location.

The first neuro - oncological surgeries in the history of medicine were performed for hyperostotic (causing localized bone thickening) or bone - destroying tumors of the cranial vault. This is due to the relative ease of intravital diagnosis of such tumors. This experience was summarized in 1773 by the French surgeon Antoine Louis (1723-1792) in his manual "*Memoires sur les Tumeurs Fongueuses de la Dure - mere*," based on 20 cases, the first of which dated back to the mid-16th century, but mostly performed by either the author or his contemporaries.

However, despite individual exceptions, mortality rates for neurosurgical interventions remained catastrophic in the first half of the 19th century. For example, in Paris between 1835 and 1841, all patients who underwent craniotomy died. It was widely believed that trepanation, even without incision of the *dura mater* (DMA), was more dangerous than cranial trauma itself, not to mention a tumor; proponents of trepanation were often accused of mental illness.

The foundations of this surgical technique are attributed to the English physician W. Horsley, who successfully removed spinal cord tumors and performed brain surgery.

The first operation for an intracranial tumor in the Russian Empire was performed in 1844 by Tito Vanzetti (1809-1888), a professor at Kharkov University and a Venetian by birth. Vanzetti described the observation of a patient with a gigantic tumor on the right side of the head and base of the skull without signs of brain dysfunction. During the operation, instead of the suspected cyst, a solid tumor was discovered, which the surgeon removed as much as possible. The patient died on the 32nd day from infectious complications.

The discovery of general anesthesia and antiseptic techniques in the mid-19th century allowed surgeons to safely enter body cavities. The work of neurologists and physiologists made it possible to accurately determine the location of lesions in the cerebral cortex based on clinical symptoms. However, the specialty's development began in the 20th century, primarily thanks to the American surgeon Harvey Cushing, who is considered the father of modern neurosurgery. He reduced the mortality rate in brain surgery from 50% to less than 10% through strict hemostasis, electrocoagulation, and careful handling of brain tissue.

By the mid-19th century, the anatomical and technical foundation for the development

of neurosurgery had been established, and some clinical experience had been accumulated. General anesthesia (in 1844 Horace Wells, 1815-1848, proposed nitrous oxide; in 1846 the chemist W.T.O. Morton, 1819-1868, and the surgeon J.C. Warren, 1778-1856, used ether; J.Y. Simpson, 1811-1870, in 1847 - chloroform) made it possible to extend the duration of the operation and better navigate the wound. However, opening the *dura mater* remained rather dangerous.

N. I. Pirogov (1810-1881), in addition to his contributions to virtually every field of surgery, proposed the surgical treatment of post - traumatic epilepsy. In his work "*Principles of General Military Field Surgery*," published in Dresden in 1865-1866, Pirogov presented a comprehensive analysis of morphological changes and both the pathophysiological and sanogenetic mechanisms accompanying craniocerebral injuries. He performed approximately 20 trepanations in both acute and late stages of craniocerebral injuries. Outcome statistics are unclear. Of particular importance for the development of neurosurgery was N. I. Pirogov's early work (1851-1854)—the famous "ice" atlas, which laid the foundations of topographic anatomy. The head section drawings published in Part 1 of the atlas (1851) are strikingly accurate and resemble modern CT scans.

Sir Charles Ballance (1856-1936), a surgeon who managed to diagnose and successfully remove a neuroma of the VIII- th nerve in the pre-X - ray era (1884), described the situation in the 1870s in his *Lister Lecture* of 1933 as "a paralysis of surgery... due to suppuration, cellulitis, erysipelas, septicemia, pyemia, acute traumatic gangrene, and tetanus - diseases for which there were no means of prevention or treatment." Demonstration operations were performed in an auditorium of several hundred people. "The surgeon operated in a frock coat, which... was kept in the operating theater. It was stained with blood and pus from previous operations. The instruments lay on a tray covered with green cloth. When a ligature was needed, a theater attendant pulled it with his left hand, holding the other end in his teeth, and rubbed wax and handed it to the surgeon."

In 1843, Oliver Wendell Holmes (1808-1894) and in 1861, Ignaz Semmelweis (1818-1865) showed that "childbed fever" was transmitted by the dirty hands of obstetricians, and that simple hand washing before and after each examination significantly reduced the incidence of this pathology. Nevertheless, the concept of the bacterial nature of purulent complications developed by L. Pasteur (1822-1895) and R. Koch (1834-1910) was perceived by surgeons as an interesting theory, the practical application of which was not discussed until J. Lister (Lord J. Lister, 1827-1912) developed the theory and practice of antiseptics. Soon,

antisepsis became supplemented by elements of asepsis; in particular, they began to use autoclaving of some surgical materials, washing the surgeon's hands and the patient's skin with brushes, using rubber gloves proposed by Halsted (William S. Halsted, 1852-1922), etc. The introduction of asepsis into practice in full is associated with the name of Kocher (Emil Theodor Kocher, 1841-1917), whose surgical clinic in Bern became the leading center for the development and implementation of this technology, which today seems completely natural. Doctors from many countries came to study with Kocher, including Cushing, who later became an outstanding neurosurgeon. Having introduced asepsis and a number of general surgical operations, Kocher, in addition, improved the technique of trepanation of the skull, methods of treating spinal injuries, and proposed an original operation for epilepsy. The introduction of asepsis and antisepsis in Russia occurred very quickly, and from the beginning By the 1880s, this technique was already being used routinely not only in most large clinics but also in rural hospitals.

Just as the development of neurosurgery was impossible without anesthesia and asepsis, so too was the development of topical diagnostics. Until the early second half of the 19th century, the concept of the brain functioning as a unified whole prevailed. Only after the publication of works by P. Broca (1824-1880) in 1861, G.T. Fritsch and E. Hitzig in 1870, and Carl Wernicke (1848-1904) in 1874, the concept of localizing functions in specific regions of the brain did gain currency.

Perhaps the first surgical removal of a clinically diagnosed meningioma without convexital hyperostosis in the history of medicine was performed in 1884 by the Italian physician Francesco Durante (1845-1934). The patient survived and was successfully re-operated on 11 years later for continued tumor growth.

The ability to establish a topical diagnosis, the accuracy of which increased significantly with the work of V. M. Bekhterev, posed the equally pressing problem of choosing the optimal surgical approach to the identified mass. However, the lack of any neuroimaging techniques made this extremely difficult.

The original solution to the problem of lesion projection onto the cranial surface belongs to D. N. Zernov (1834-1917), who in 1889 proposed a device called an encephalometer for determining the projection of various parts of the brain onto the skull. The device was fixed at standard points, almost parallel to the orbitomeatal line, and ensured that all measurements were compared with the atlas.

Until the last decades of the 19th century, all trepanations worldwide were resective.

In 1873, Yu. Kosmovsky demonstrated the possibility of successful engraftment of a free bone flap. In 1889, the German surgeon Wilhelm Wagner (1848-1900) proposed preserving a "pedicle" of periosteum and temporalis muscle to provide nutrition to the bone flap, and this technique became classic for many years.

Technically, performing osteoplastic craniotomy until the end of the 19th century was complex. The chisel and hammer remained the primary instruments. In 1891, Professor Jean Toison of Lille, France, used a chain saw to connect the milled holes. The saw was rather crude and did not find widespread use. Leonardo Gigli (1863-1908), an obstetrician from Florence, proposed a wire saw for symphysiotomy in 1894. As today, Gigli's saws were disposable. Professor Alfred Obalinski of the University of Krakow soon used the Gigli saw for trepanation.

Sir Victor A. H. Horsley (1857-1916) made a significant contribution to the development of neurosurgery; he developed a technique for stereotactic interventions, various surgical options, and performed the first spinal cord tumor removal. Horsley's proposal to suture the surgical wound, which his predecessors considered unnecessary, was also significant.

Professor L. A. Malinovsky of Kazan University was the first to substantiate the need for neurosurgery as a separate specialty. In February 1893, in his report "On the Surgical Treatment of Diseases of the Central Nervous System," delivered at a meeting of the Society of Neurologists and Psychiatrists at Kazan University, Malinovsky clearly formulated the basic principles of neurosurgery and raised the issue of specialized training for surgeons operating on the central nervous system.

Ludwig Pussep (1875-1942), the world's first professional neurosurgeon, made a significant contribution to the development of neurosurgery as an independent specialty.

However, the further development of neurosurgery was hampered by the lack of objective diagnostic methods, which led to a large number of errors. The discovery of X-rays by K. Roentgen on November 8, 1895, fundamentally changed the possibilities for intravital diagnosis of various diseases, including pathological processes in the cranial cavity.

Thierry de Martel (1875-1940) made a significant contribution to the development of neurosurgical technique. His main inventions, proposed in 1908, include the still-used metal guide for the Gigli saw and electric trephine, the self-retaining retractor, a special surgical table for operations in the sitting position, and a corresponding surgical chair. De Martel was also the first to use film documentation of surgeries and was one of the first to use

intraoperative photography. His contemporary, the distinguished German neurosurgeon and neurologist Otfried Foerster (1873-1941), developed the technique of intraoperative electrical stimulation of the motor cortex and electrocorticography—methods that significantly improved the functional outcomes of surgeries. He also first described dermatomes, mapped the motor cortex of the brain, proposed a hyperventilation test to detect seizure activity on the electroencephalogram in epilepsy, and developed surgeries for spasticity and pain syndromes.

Harvey William Cushing (1869-1939) is recognized as one of the founders of neurosurgery. His work on the treatment of pituitary tumors (1912), cerebellopontine angle tumors (1917), and intracranial meningiomas (1938) has become classics for modern neurosurgeons. Cushing's vacuum aspirator, intraoperative wound irrigation with saline, cotton strips for brain protection, and many other innovations are still used in neurosurgical procedures today. Modern neurosurgery also owes much to another American neurosurgeon, Walter E. Dandy (1886-1946). He studied under Cushing, then went on to work independently and achieved brilliant results, primarily in terms of the radicality of neuro-oncological interventions. He was the first to develop and implement the concept of a recovery room equipped with appropriate equipment and a permanent nursing station. Dandy's contribution to neurosurgery, no less important than his surgical achievements, was the development of diagnostic methods such as pneumoventriculography (1918) and pneumoencephalography with endolumbar air injection (1919). These methods radically changed the situation in the diagnosis of various brain lesions. The next revolutionary invention in neurosurgery was the cerebral angiography technique developed between 1927 and 1934 by E. Moniz (Antonio Caetanode Abreu Freire Egas Moniz, 1874-1955), which enabled accurate diagnosis and differentiated treatment of cerebral vascular lesions. Based on cerebral angiography data, W. Dandy performed the first clipping of an intracranial arterial aneurysm in 1936.

World War I again brought to the forefront the issue of providing care to the wounded with nervous system damage.

In the early 1920s, neurosurgical departments were opened in Kharkov within surgical or neurological clinics (V. N. Shamov and A. M. Grinshtein), staffed by general surgeons and neurologists. A number of manuals were published, notably V. V. Kramer's "The Doctrine of Localizations" (1929), which played a significant role in improving the quality of neurological diagnostics.

Of particular importance for neurosurgery was the establishment of neurosurgical wards by N. N. Burdenko (1876-1946) in 1924, based at the Faculty Surgery Clinic. Having

accurately assessed the prospects of the new specialty and trained a group of specialists, in 1929 N. N. Burdenko and V. V. Kramer organized a neurosurgical clinic at the State X-ray Institute, which in 1932 became the Central Neurosurgical Research Institute (now the N. N. Burdenko Research Institute of Neurosurgery).

W. F. House's proposal to use a microscope and specialized microsurgical instruments for brain surgery (1963) radically changed neurosurgery. Almost simultaneously, W. Loughheed, Th. Kurze, R. Rand, J. Jacobson, M. G. Yasargil, and other neurosurgeons began using the operating microscope. L. I. Malis's proposal to use bipolar coagulation to stop bleeding played a significant role.

Significant contributions to the development of treatment methods for cerebral vascular lesions, primarily arterial and arteriovenous aneurysms, were made by Ch. Drake (Canada), M. G. Yasargil (Switzerland), and K. Sugita (Japan). A breakthrough in vascular surgery was associated with the invention of the detachable balloon catheter in 1971 by F. A. Serbinenko (1928-2002).

Endovascular intervention technology has been successfully refined and is increasingly used to treat a wide range of vascular diseases of the central nervous system, including such dangerous ones as arterial aneurysms and arteriovenous malformations.

Important areas of modern neurosurgery are stereotactic and functional interventions. Stereotactic neurosurgery utilizes spatial calculations and allows for the precise insertion of specialized instruments into targeted areas of the brain—biopsy cannulas, electrodes for destruction or stimulation, etc. For these procedures, specialized stereotactic devices with a frame fixed to the patient's head are used, one of the prototypes of which is the encephalometer. The stereotactic method has been successfully used to treat Parkinsonism, other hyperkinesias and muscle tone disorders, severe pain syndromes, and deep-seated tumors. Since the mid-20th century, pediatric neurosurgery has developed alongside general neurosurgery as a relatively independent field. Important for the development of pediatric neurosurgery was the proposal by several authors to use valve shunt systems to treat hydrocephalus, a common childhood condition, to drain cerebrospinal fluid outside the central nervous system (into the venous system or abdominal cavity).

Technological innovations that significantly expanded the treatment options for nervous system diseases include the use of endoscopic techniques.

A true breakthrough in the development of neurosurgery was associated with the advent of neuroimaging techniques – CT (G. Hounsfield, J. Ambrose, 1971), digital

angiography, and later MRI. The ability to visualize the pathological lesion has enabled the use of gentle, minimally invasive approaches, significantly reducing mortality and improving the quality of life of patients after neurosurgical interventions. At the same time, stereotactic interventions can now be performed without relying on averaged atlas data, instead targeting an individually defined "target."

The computerization of medical devices has not only expanded diagnostic capabilities but also led to the creation of new implantable computing devices used in the treatment of pain, hyperkinesia, spasticity, and hearing impairment.

The development of neurosurgery in the second half of the 20th century has made it technically possible to intervene on any structure of the central and peripheral nervous system (PNS). However, it is clear that the malignant nature of most intracranial tumors precludes reliance on surgery as the sole treatment option. Under these conditions, precision, stereotactically oriented radiation techniques are being intensively developed, allowing a high dose of radiation energy to be delivered to the site of the pathological process with minimal impact on healthy tissue: the gamma knife proposed by L. Leksell in 1951, linear accelerators and installations that provide irradiation with a beam of protons or heavier particles.

Finally, the development of the pharmaceutical industry played a significant role in the development of neurosurgery, providing physicians with medications to combat cerebral edema, anticonvulsants, and many other drugs, as well as cytostatics successfully used in the treatment of previously incurable CNS tumors, such as medulloblastoma.

Over the past century, the capabilities of neurosurgery have changed dramatically. The goal of neurosurgical treatment, especially in elective situations, is no longer an attempt to save the patient's life at any cost, but rather to ensure its high quality and duration.

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