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SOURCE
The factors of emergence of neurosurgery as a clinical specialty

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Three main systemic factors (we called them discipline-making factors) are crucial for the emergence of a clinical specialty (in our case this specialty is neurosurgery) − social-historical, scientific and institutional. This first factor includes level of society development (industrialization, urbanization and level of university education) and war. The WWI was characterized by large number of traumatic brain injuries and their consequences which played an important role in emergence of the new surgical specialty − neurosurgery − in Europe and North America. The second factor is special diagnostic methods, surgical instruments and new operative approaches. The third factor is setting up neurosurgery schools, postgraduate neurosurgical training, specialized departments, chairs and institutes, neurosurgical societies and journals. It is concluded that in the interwar period (1920s−1930s) neurosurgery became a separate medical specialty in USSR, Great Britain, France, Germany, USA and Canada. The theory of discipline-making factors might be used for study of emergence of other medical specialties and the phenomenon of specialization in medicine.

Key words: specialization in medicine; discipline-making factors; history of neurosurgery; medicine, 20th century; WWI; craniotomy; scientific schools

Introduction

How do different types of medical practice become separate specializations? This issue has been the subject of historical and medical research, starting with the monograph of D. Rosen dealing with the establishment of ophthalmology. [1] A retrospective analysis of the phenomenon of specialization in medicine led V. G. Rotshtein to the following conclusions: «A medical specialization cannot appear until the following conditions are met:

a collection of medical knowledge and skills inherent to the specialization;
the number of urban dwellers must be large enough to justify the existence of a specialist in the particular area;
limiting scope of practice to the specialization should be attractive to a doctor from a financial point of view» (quoted in [2]).

The formation of scientific disciplines has been given some careful consideration in both local and foreign literature of the 1970s-1980s. As noted by G. Laitko, scientific disciplines (or specializations) can be understood as a system of research activities with a stable orientation towards the object of study. These areas may expand or narrow and their boundaries may change, but their connection with the primary object of study should be maintained. The author considers that a specialization has been established when at least three components have been found to exist: 1) a system of research activities, the participants of which have close contact with one another providing for an exchange of ideas, methods and results, thus forming a complete scientific community; 2) a mechanism to maintain the system’s stability; 3) institutions that provide a social guarantee for the functioning of this mechanism as a whole.

In the presence of all three components, the formation of the discipline is complete and we can talk about its development on its own basis. [3]

The emergence of a new discipline is a result of a combination of internal and external needs and is often associated with the invention of new medical equipment. For example, the invention of the cystoscope played a decisive role in the reclassification of urology from general surgery to an independent specialization and its subsequent development.

As was noted by C. Singer, «a true professional specialization was of mainly Viennese origin.
Neurosurgery is one of the dozens of current medical specializations. One of its founders, Sir G. Jefferson emphasized the importance of the brigade method (teamwork) in the development of medical disciplines, and its appearance is dated to the period between the two world wars. [7] In continental Europe, the heads of clinics subscribed to the old concept of the almighty professor. They saw specialization as a threat associated with a loss of prestige due to the fact that someone else may provide more qualified help. According to Jefferson, the emergence in the 1920s of suction and diathermy had a significant influence on the development of neurosurgery. However, although the technical progress in the first half of the 20th century was enormous, the author placed particular stress on the change in the mentality of the surgeon, noting the growing contribution of surgery in neurophysiology.

According to J. French, neurosurgery became an independent specialty in the 1920s-1930s. [8] Is this really the case? We have tried to answer this question by using a systematic approach, which is based on the study of objects as systems. We believe that a systematic approach to studying the genesis of neurosurgery allows, on the one hand, for the problem to be covered in general, and on the other – to reveal its constituent components. Looking at neurosurgery as a system – with its own history, methodology, scope of scientific and practical interest, specific diagnostic and operational tools and techniques, special approaches to training, etc. – we have identified its collection of core factors. In regard to the subject of our study, these factors can be referred to as system-forming. The factors have been divided into three groups: 1) socio-historical, 2) scientific, and 3) institutional (organizational). [9, 10] Each factor has its own characteristic features.

Socio-historical factor

This factor includes two components. First, the developmental level of society (which is characterized by the degree of urbanization, industrialization and the level of university education). Second, wars.

The developmental level of society. Neurosurgery could become an independent specialization only when society had reached a certain level.
of development. This was accompanied by a rapid increase in the number of urban dwellers, especially in large industrial centers. Population density (and hence the concentration of diseases and injuries) is a prerequisite for specialists’ work in various fields of medicine, including neurosurgery. For example, in the Soviet Union, along with Moscow and Leningrad, neurosurgical departments arose in the 1930s in large industrial cities — Kharkov, Rostov-on-Don, Kiev, Sverdlovsk and Gorky.

The development of university education also played a significant role in the emergence of new medical specializations, including neurosurgery. Neurosurgery pioneers were usually university professors (A. S. Tauber, V. I. Razumovsky, L. M. Pussel — in Russia; H. Cushing, C. Frazier, W. Dandy — in the United States; E. Bergmann and O. Förster — in Germany; C. Vincent — France, Jefferson — in England, etc.). The first neurosurgical departments in the inter-war period were often created on the basis of university clinics.

**Wars.** War has always been a factor in the development of surgery and traumatology. Neurotraumatology was given a strong impetus by the Russian-Japanese war of 1904-1905. The first Russian monograph on battlefield craniocerebral injury was published in 1911. [11]

In 1914-1918, World War I was the impetus for the classification of neurosurgery as a separate medical specialization due to the massive influx of those wounded in the head and spine, requiring specialized care.

Traumatic brain injury, according to different authors, amounted to 3-8 percent of the total number of injuries. This raised the issue of creating special, so-called interim infirmaries for them.

The process of separating neurosurgery from general surgery was undoubtedly aided by the medical assistance given to the wounded by major neurologists and surgeons, who became the founders a new clinical discipline.

One of the founders of American neurosurgery, H. Cushing, organized a neurosurgery team in a mobile U.S. military hospital in France. He conducted numerous operations on traumatic brain injuries and mine-explosion trauma with the same care as was taken with planned operations at his clinics. [12, 13] Military experience contributed to the professional convergence of general practitioners, general surgeons and surgical specialists. Of course, there were difficulties in the rapid mastering of specialist areas such as neurosurgery. Of the 11 American neurosurgeons who volunteered in the European theater of operations, 10 were certified and assigned to military hospitals, created at the end of the war. The U.S. government organized a special neurosurgery training school for general surgeons, which published digest journals on military neurotrauma and guides to neurosurgery. [14, 15]

Well-known surgeons T. de Martel (France) and V. Horsley (Britain) also participated in World War I, operating on victims with skull and brain injuries. De Martel summarized his accumulated military experience in the treatment of head injuries in his monograph. [16]

German neurologist O. Förster, who had no surgical training, conducted a lot of operations during World War I. He performed 3,724 patients with peripheral nerve injuries, performing 523 operations on them. With defective nerves, autografts were performed. Reporting on the long-term results of treatment in almost 5,000 gunshot nerve wounds, Förster noted improvement in 45 percent of cases, with a recovery of function in 52 percent. [17]

In Russia during World War I, airborne Red Cross surgical units were created, equipped with surgical instruments and including two doctors, two medical students, 8-10 nurses and a few medical aides. [18] N. N. Burdenko was a non-staff consultant surgeon for the Red Cross. In 1914 he created specialized hospitals in Zhirardov, Vilnius and Riga for those suffering head wounds. [19]

In the spring of 1915 in Kharkov, a neurosurgical department for wounded soldiers opened at the hospital of the Union Congress of Miners of the South of Russia. The hospital’s consultant neurologist selected patients at the medical distribution point. The organization of a neurosurgical department provided for «an increase in the intake of soldiers with injuries of the nervous system.» [20] In addition, this department provided advisory help to other hospitals.

In February 1915, on the foundation of the neurosurgical clinic headed by L. M. Pussel, the N. I. Pirogov First Military Hospital opened in Petrograd for those suffering head injuries. [21]
Russia’s experience in the treatment of head injuries during World War I is reflected in the last book of the 33-volume Velyaminov Surgical Archive, published in 1919, entitled «A Collection of Articles on Surgery,» which contains a number of works on wartime surgery. [22] The Russian army’s losses due to cranial injuries in World War I were about 25 percent. [23]

As M. S. Skoblo noted in his review (1935), «Statistics for skull and brain injuries in the last war by foreign armies were calculated at 8–15 percent, relative to the total number of injuries. The most common complication was skull-wound infections (up to 70–85 percent of frontal wounds of the skull were infected). From 20 to 40 percent of patients suffered meningitis.» [24] According to these data, «55 percent of those with skull injuries die on the battlefield, two-thirds transported to the forward medical station die without being operated upon.» The highest mortality rate, according to the European and American authors, was due to penetrative wounds to the skull and brain. Lethal outcomes, both in the forward medical stations and in the rear hospitals, exceeded 30 percent. [24]

Preparation for World War II was a powerful incentive for state support of neurosurgery, especially in totalitarian countries (Germany and the USSR). For example, debate on the independence of brain surgery arose at the First Congress of the German Society of Neurologists and Psychiatrists in 1935. According to many participants in the congress, neurosurgery was neither part of surgery, nor an independent specialization, and should be classified separately as neurology. This debate was closed by the National Socialist Workers Party of Germany. The Nazis supported the establishment of neurosurgery as an independent discipline. The final decider was that it was necessary for military purposes. [25] In the USSR, the same argument for neurosurgery to be classified as an independent specialization (a large number of head injuries in a future war) was put forward by Burdenko in 1930.

A large number of head and spinal injuries in a future war could be anticipated due to the development of weapons for widespread use by aircraft, tanks, heavy artillery and other means of destruction. Note that the term «traumatic brain injury» appeared in Russian literature only in the 1930s-1940s. Prior to this, the written and spoken terms were «skull injury» or «cranial trauma.» In English literature, and the most common term is «head injury.»

Declining mortality rates were due, primarily, to multi-tiered organization of health care for the wounded, their accelerated transportation and the emergence of antibiotics during World War II.

In this way, World War I and the preparations for World War II have been important factors in the categorization of neurosurgery as an independent clinical specialization at the point where general surgery and neuro(patho)logy meet.

Scientific factor

The origins of the scientific factor. Scientific factors, based on the successes of natural science, made the emergence of modern surgery possible. This includes, above all, progress in microscopic techniques, which contributed to the discovery of the cellular structure of living matter and the emergence of bacteriology, which in turn led to the emergence of aseptics and antiseptics. Successes in chemistry (in combination with a changed attitude to pain and suffering) led to the emergence of anesthesiology.

In parallel to this, marked advances took place in anatomy and the physiology of the central (CNS) and peripheral nervous systems, especially the brain. The idea of the localization of brain functions captured the imagination of European researchers, starting with the founder of phrenology F. J. Gall.

It was aptly described by L. S. Minor as «cellular pathology—the foundation of modern medicine.» [26] The teachings of R. Virchow led to the development of the topical diagnosis of diseases of the nervous system. In 1861, P. Broca isolated motor aphasia to the left third frontal gyrus. In 1870, G. Fritsch and E. Hitzig used electrical stimulation of the precentral gyrus (first with wounded soldiers suffering open traumatic brain injuries, and then in an experiment on dogs) to induce movement in opposite limbs. In 1874, C. Wernicke reported of sensory aphasia in cases of lesions of the left superior temporal gyrus. Advances in intravital topical diagnostics help recognize focal lesions of the brain and spinal cord. Diagrams appeared of the interrelationship between the brain’s sulci and gyri and the surface of the head and skull bones (craniocephalic topography).
I. P. Pavlov and V. M. Bekhterev conducted experimental work on the physiology of the brain. Clinicians (primarily neuropathologists and psychiatrists) tried to discover practical applications from the resulting data. In 1926, Foerster created a map of the cytoarchitectonic fields of the human brain, confirmed by electrical stimulation during operations. In 1929, German psychiatrist H. Berger first recorded bioelectrical potentials of the human brain, becoming the founder of electroencephalography. All of this contributed to the development and establishment of neurosurgery as an independent discipline. However, neurosurgery itself serves as an experimental testing ground for confirming various other physiological concepts, clarifying the role of certain brain structures in normal and pathological conditions.

Components of the scientific factors are: the creation of special diagnostic techniques and surgical instruments and the development of new surgical approaches.

**Special diagnostic methods.** For many centuries, injuries and diseases of the central nervous system were diagnosed exclusively by cranial methods, ie. only external changes of the scalp and skull were taken into account. Only in the 18th century, during the diagnosis and prognosis determination of head injuries, did the importance of neurological symptoms and syndromes come to be recognized, and not only local damage to the skull. According to E. Flamm, it marked the transition from «cranial osteology to neurosurgery.» [27] A big role in this was played by French surgeons.

In the 19th century, knowledge of motor and speech functions in the brain, identified via cerebral pathology, acquired an adequate neurological basis. In the second half of the 19th century, objective methods for the diagnosis of focal lesions of the brain and spinal cord appeared. In 1851, H. Helmholtz invented the ophthalmoscope, which enabled the detection of congestion in the fundus in the case of tumors and other expansive processes of the brain.

The first lumbar puncture was performed by J. L. Corning in 1885, but only in 1891 did it became widespread after G. Quincke used it for therapeutic purposes. [28] This puncture yielded valuable information about the state of intracranial pressure and the composition of cerebrospinal fluid.

In 1895, W. C. Roentgen discovered the special properties of X-rays (that were later to bear his name), which marked the beginning of craniography and spondylography. However, if X-rays of the skull and spine constituted only an extrapolation of the Roentgen’s invention on the bone encasement of the brain and spinal cord, W. Dandy’s proposal for introducing air into the cerebrospinal fluid areas of the CNS (pneumoventriculography in 1918 and pneumoencephalography in 1919 ) can already be considered specific methods for the diagnosis of neurosurgical diseases.

As R. Leonardo noted, «at the age of 32, Dandy made his most remarkable discovery. Studying an X-ray of the abdomen of a patient, he drew attention to the intensity of the shadow of air and liquid, and concluded that it will be possible to see the outline of the ventricles of the brain, if cerebrospinal fluids were partially replaced by air. Experiments have shown that changes in the contour of one of the ventricles of the brain on radiographs often allowed for the localization of lesions that previously could not be localized. This method is often called one of the most outstanding achievements in the field of neurosurgery.» [29]

Myelography played a similar role with the introduction of X-ray contrast agents, which was proposed in 1921 by A. Sicard along with cerebral arteriography, proposed in 1927 by the Portuguese neurologist E. Moniz.

Thus, in the late 1920s a set of neurodiagnostic techniques was created, many of which are invasive and can be performed only by neurosurgeons. These methods made it possible to determine the localization of lesions and find pathologic substrate with much more confidence during surgery, which significantly expanded surgical activity in comparison with the previous period.

**Creation of neurosurgical instruments.** Even in leading European clinics, craniotomy was a quite rare operation in the pre-antiseptic era. In St. Bartholomew’s Hospital in London, trepanation for head injuries was not conducted from 1861 to 1866, and in all of France from 1857 to 1866 only four craniotomies were carried out. [30] In 1875, the University College Hospital in London received 57 patients with head trauma.
A trepanation was carried out on just one. During the 1887-1888 academic year at the von Bergman clinic, 643 operations were conducted, of which only two were craniotomies.

In 1864, L. Ollier proposed the method of osteoplastic resection of the skull bones by the creation of a bone flap together with its adjacent soft tissues, but only in 1889 did W. Wagner of Königshütte (Germany) carry out this operation on a living person. He published the article «About the temporary resection of the cranial vault instead of trepanation.» Osteoplastic craniotomy began to be called the Wagner operation. «I use only little firm chisels and elevators. I hope to be able to invent a circular saw driven by a similar dental drill, with which it will be possible to work faster and more accurately,» wrote Wagner (cited in [33]).

As noted by Wagner, chiseling bone leads to concussion from the hammer blows on the chisel. However, circular saws did not meet expectations, and the most suitable tool to cut out the bone flap was the wire saw, proposed in 1894 by the Italian obstetrician L. Gigli for cutting the pubic symphysis. In 1898 he perfected his invention, using a curved metal wire to prevent damage to the dura mater when sawing bone flap. [34]

The number of trepanation procedures began to rapidly increase. In 1908, de Martel proposed using the electric drill, which stopped automatically when it perforated the internal bone plate. In Russia, one of the pioneers in the use of the new craniotomy technology was the renowned surgeon S. P. Fyodorov. [35]

The electric suction machine was proposed by F. Krause in 1908 and refined by Cushing around 1920. In 1911, Cushing suggested using silver clips for hemostasis in brain operations, and in 1927 he adapted the Bovie electrocoagulator for the coagulation of blood vessels and removal of brain tumors.

One important indicator of neurosurgery’s development was the use of various foreign materials, contrast agents, drainage and other devices for the diagnosis and surgical treatment of nervous system pathology. By 1930, the neurosurgeon’s arsenal included 12 «foreign substrates.» The 1930s saw the appearance of new suture materials (silk and metal staples), as well as rubber drains for the treatment of hydrocephalus. Further on, the number and scope of the various foreign implants in neurosurgery increased dramatically.

By 1920-1930, neurosurgery possessed the main tools needed for macrosurgical treatments of focal lesions of the brain and spinal cord, contrast agents for X-rays, as well as different implant materials (sutures, sutures, bone substitutes, etc.).

New surgical approaches and experimental validation. In the first half of the 20th century, new surgical approaches were developed: transnasal (for removal of pituitary adenomas), suboccipital (for removal of tumors of the posterior fossa), perforation of the bottom of the third ventricle (the «Stookey» operation), coagulation of the vascular plexus of the lateral ventricles in hydrocephalus, and others.

Study of intracranial hypertension in experiments and clinical practice also played an important role in the development of neurosurgery. Von Bergmann’s experiments studying intracranial pressure (in dogs) were repeated by Cushing in the T. Kocher laboratory in Bern. Cushing interpreted increased blood pressure as a defensive reaction to maintain the blood supply to the brain under conditions of increased intracranial pressure (the so-called Cushing reflex). The development of hypertension, according to Cushing, is a function of the compression of the centers of the medulla oblongata. Hence, he had the idea of bilateral subtemporal decompression with the goal of controlling increased intracranial pressure, which played a key role in the decision to limit the practice of surgical operations on the brain. [37]

Developing in close connection with the doctrine of intracranial hypertension was the doctrine of the dislocations of the brain, which was important for neurosurgery. [38] It should be noted that Cushing’s proposal for infratemporal bilateral decompression to reduce elevated intracranial pressure and eliminate the threat of a fatal brain dislocation was popular in modern neurosurgery. It is contained in clinical guidelines as a last resort to combat uncontrollable intracranial hypertension in cases of severe traumatic brain injury. [39]

New special diagnostic techniques, surgical approaches and surgical instruments contributed to neurosurgery being carried out significantly more often and improvements in these operations’ outcomes.
Consider the statistics for neurosurgical operations conducted for brain tumors in the late 19th to early 20th centuries. By the end of 1887, 14 operations for brain tumors had received mentions in literature: 11 patients were operated on for tumors of the brain hemispheres, and three for tumors of the posterior fossa. In the first group of 11 patients, three died. In the second group, all the patients died of shock in the early postoperative period. In six years time, American neurologist M. A. Starr described 84 published cases of brain tumor surgery: tumors were detected during medical intervention in 52 cases. The total postoperative mortality rate was approximately 60 percent. [40] It is interesting to note that these 52 patients were operated on by 44 surgeons, of which only four had conducted more than one craniotomy. The record holders were W. Macewan and Horsley, each of whom had removed five brain tumors.

In a review by P. Knapp, the number of brain tumor operations increased to 267, but the results were equally disappointing. [41] This was due to the fact that all the operations were performed by general surgeons who did not have any experience in brain surgery, nor any special interest in it. Usually one unsuccessful operation was enough to dampen any desire to become a «brain» surgeon.

An analysis of the Surgeon General Index Catalogue for 1886 - 1896 revealed that over 10 years, more than 500 surgeons reported operating on the brain. In the next 10-year period (1896 - 1906) this number did not exceed 80, reflecting the frustration that general surgeons had with brain surgery. From 1906 to 1916, only a few surgeons published the results of their operations on the brain: they had all begun to focus on this particular area of surgery [42].

The heroic nature of brain surgery in the early 20th century is clearly demonstrated by M. Borchardt’s statistics: for tumors of the cerebellar hemispheres, the postoperative mortality rate was 60 percent and recovery was observed in only 12 percent of cases. Of the 19 patients with tumors of the cerebellopontine angle, 14 died during or after surgery, and only two recovered (cited in [43]).

In the early 1930s, over the course of 20 months at the University of Vienna clinic, 138 brain tumors were removed, and in 91 percent of cases the diagnosis was confirmed during surgery. The postoperative mortality rate was 32 percent, postoperative meningitis occurred only in 2 percent of cases (cited in [43]).

If in 1910, according to Krause, postoperative mortality in spinal cord tumors reached 33 percent, in 20 years’ time, according to different authors, it decreased to 5 percent, and in 90 percent of cases the patients’ recovery was observed with previous functionality returned (cited in [44]).

In 1915, Cushing analyzed the results of 149 operations he conducted on 130 patients with brain tumors. The mortality rate was 8.4 percent (cited in [37]).

Thus, by 1920-1930 complex neurosurgery had specific diagnostic and therapeutic techniques, tools and equipment, which largely determined its emergence as a clinical specialty and its further development.

**Institutional factor**

This factor includes the emergence of leaders with their own approach to clinical and research activities, the establishment of surgical schools, neurosurgeon training systems, the emergence of specialized branches, departments and institutes, societies and journals.

**Neurosurgery schools** The concept of a «scientific school» has no clear-cut interpretation [45, 46]. We have taken the following definition as a basis: «A school is an association of people that has emerged in the course of joint cooperation and consists of at least two generations that have developed an epistemological system with particular features and ensured its continuance» [47]. With the epistemological system, new knowledge and skills arise. The concept of «school» is divided into two subclasses: schools as educational institutions, and schools as a form of activity. In turn, the latter is divided into local and global. Among local schools there are: 1) societies arising around some kind of crystallization center (teachers, leadership, magazine, workshop, etc.) — school-factions and 2) regional schools tied to specific geographical locations (eg, Novgorod School of Iconography). Applied to neurosurgery, we can talk about global (Cushing’s school, for example) and local schools (eg, Moscow and Leningrad neurosurgical schools).

In the early 20th century, surgeon-neuropathologists (surgical neurologists) arose
from neurologists, and neurological surgeons (neurosurgery) arose from general surgeons. The first surgeons-neuro(patho)logists are: in Russia, Bekhterev’s student, Pussel; in France, J. Babinski’s student Clovis Vincent; and in Germany neuro(patho)logist Foerster, who independently began to operate on the nervous system. In the United Kingdom and the United States, the pioneers of neurosurgery were such surgeons as Jefferson, Cushing, Frazier and others It was at that moment — when the first neurosurgeons began to transfer their experience to their students, preparing professionals like themselves — that the crucial stage of professional training began. Cushing played a particularly large role here, preparing students not only from America but also from other countries. Typically, training consisted of a one-year internship at Cushing’s clinic in Boston, during which not only surgical know-how was taught, but research work was also carried out. He created the first international (or global) neurosurgical school.

Why did some leaders of neurosurgery (eg. Cushing and A. L. Polenov) create their own schools, while other equally talented surgeons (Dandy and Pussel) failed to do so? This was largely determined by their personal character.

The system of training neurosurgical staff was created in the 1930s. The appearance of neurosurgical departments required a constant influx of specialists. Hence there was a need to create a system of postgraduate specialization. The world’s first private assistant professor course on surgical neuropathology was organized by Bekhterev on the foundations of the Psychoneurological Institute in St. Petersburg in 1908 and was headed by Pussel [48].

However, broad specialization in neurosurgery began later (in the 1930s), with the creation of the neurosurgery department at the Postgraduate Medical Institute in Leningrad (1935) and Moscow (1938), and the department of neurosurgery at the Sorbonne (1938). At the same time, the Soviet Union created a clinical residency and postgraduate program in neurosurgery, as well as training in the workplace on the basis of the Central (Moscow) and Leningrad institutes of neurosurgery, and the department of nervous system diseases at the Rostov Medical Institute.

Analysis reveals that the training of specialists can also be found to be crucial in the creation of independent specializations from many clinical therapeutic and surgical departments in the 20th century (cardiology, cardiac surgery, traumatology and orthopedics, endocrinology, gastroenterology, oncology, etc). Therefore, we can assume that the formation in the 1930s of a system of training neurosurgeons was a key criterion in the creation of this specialization. [9]

The creation of specialized departments, clinics and institutes of neurosurgery. Neurosurgery could become an independent discipline only after a fairly broad clinical base was developed. For a long time, neurosurgical patients were placed in surgical or neurological departments. However, the specific needs of diagnosis, treatment and caring for these patients could best be provided only in a situation where they were brought together in specialized neurosurgical clinics.

The first clinic was established in St. Petersburg in 1910 (its director was Pussel). [48] In Soviet Russia, neurosurgical departments were developed in Petrograd (A. L. Polenov Clinic, 1921), in Moscow (N. N. Burdenko and V. V. Kramer Clinic, 1929) and Rostov-on-Don (P. I. Emdin Clinic, 1925), among others.

In the USSR, the world’s first neurosurgery research institutes were created: The Institute of Surgical Neuropathology in Leningrad (1926), reformed in 1938 into the Leningrad Neurosurgical Institute, and the Institute of Neurosurgery in Moscow (1932), reformed in 1934 into the Central Institute of Neurosurgery (TsNKhI). The distinguishing characteristic of domestic neurosurgery institutions was their complex organization in structures that included various specialists, research laboratories, and a strong clinical base. This allowed them to cover all the main areas of neurosurgery (neurooncology, neurotrauma, brain edema, epilepsy, parasitic diseases of the central nervous system, diseases of the autonomic and peripheral nervous systems, and others).

In the 1930s, a network of neurosurgical departments and clinics was established in a number of large industrial centers of the USSR (Kharkov, Kiev, Sverdlovsk, and Gorky, among others).

In the United States, the first neurosurgical department was in fact created by Cushing in
1912, when he led the surgical clinic in Boston, which received routine neurosurgical patients, especially those with tumors of the brain and spinal cord. This significantly increased not only the number of patients operated upon but also improved outcomes. In 1934, the Montreal Neurological Institute opened in Canada. It was headed by W. Penfield.

H. Olivecrona, a student of Dandy’s in the 1920s, created a neurosurgery clinic in Stockholm (Sweden), where he operated on patients from all over Europe, and trained several European surgeons in neurosurgery.

In 1933, France’s first neurosurgical department was created by Vincent as part of the Paris municipal health system.

In 1934, Germany’s first neurosurgical department was created in Wurzburg. It was headed by W. Tönnis.

Thus, in the 1920s, and especially in the 1930s in the world’s leading countries, there was a network of specialized neurosurgical departments and clinics, which gathered patients with neurosurgical pathologies and used special methods of diagnosis and treatment of focal diseases of the brain and spinal cord, as well as peripheral nerves. This fulfilled one of the necessary conditions for neurosurgery to gain its independent status.

**Creation of neurosurgical societies and journals.**

Neurosurgical societies in the United States and Europe appeared, following the traditions and local conditions of each country. They aimed to unite neurosurgeons, provide an opportunity to discuss scientific and clinical issues and explore the experience of leading experts.

The first meeting of the Society of Neurological Surgeons was held in Boston on November 26–27, 1920, at Cushing’s clinic. It was attended by 11 people. The leading members of the society arranged a meeting twice a year at their clinics. They included morning surgery demonstrations and afternoon scientific sessions, during which clinic staff made presentations. These meetings were attended by members of the society and guests, from whom they chose new members.

Following the format of the American Society of Neurological Surgeons, the Society of British Neurological Surgeons was founded in December, 1926. Following national traditions, the British Society functioned as a private gentleman’s club, where, according to its statutes, there was to be no more than 15 members. Another feature of the society was regular offsite meetings in other European countries.

In the USSR, the Neurosurgical Council initially played the role of the neurosurgeons’ scientific society. It was founded in 1934 at TsNKhI on the initiative of Burdenko. It consisted of leading neurosurgeons and neurologists in those regions of the country where there were neurosurgical departments. From 1935 the council held annual sessions, which were attended by hundreds of experts, and many days were spent discussing important problems of neurosurgery.

The formation of neurosurgeons’ scientific societies in the 1920s-1930s was an essential feature of the institutional factor that created this discipline in the United States, Britain and the USSR. However, this feature does not belong to the list of mandatory features necessary to establish neurosurgery as a clinical discipline. In France, Germany and Austria, neurosurgical societies emerged only after World War II.

An important role in the discussion of neurosurgical problems in the interwar period was also played by neuropsychiatric and surgical congresses and conferences. Interdisciplinary dialog undoubtedly contributed to the development of neurosurgery as an open dynamic system.

The accumulation of experience in the field of neurosurgery and the need to disseminate it gave rise to special monographs and manuals in the late 19th century in Germany, France, the United States and Russia.

However, by the 1930s, when neurosurgery began to develop features of an independent clinical discipline, there was an increased need for more timely discussions and sharing of experience among professionals. Periodicals (magazines usually) could play such a role.

Zentralblatt für Neurochirurgie became the first neurosurgical magazine. It was founded by Tönnis in 1936 and published quarterly. The magazine was conceived as an international publication, which published articles in German, English and French. The editorial board was also international. In 1937, the Problems of
Neurosurgery journal was published in the Soviet Union, appearing four times a year.

The emergence of professional periodicals was certainly indicative of the formation of neurosurgery as a clinical discipline. In turn, specialized periodicals became catalysts for this process.

**Conclusion**

The specialization and differentiation of clinical disciplines in medicine is an objective and necessary process associated with their development. However, each specific clinical specialty is characterized by its own unique and different (both major and minor) discipline-forming factors and their components. For example, the main discipline-forming factor for radiology was the discovery by Roentgen of X-rays. Helmholtz’s invention of the ophthalmoscope played a decisive role in the development of ophthalmology, as did the emergence of the cystoscope in urology.

As concerns neurosurgery, the situation is more complex and mediated by the sum of the three analyzed factors (socio-historical, science and institutional). One could, of course, associate the formation of this specialization with the appearance of specific diagnostic methods (such as ventriculography, pneumoencephalography, angiography, etc.). However, without denying their essential role, we believe that neurosurgery could have become an independent clinical discipline without them. Such significant socio-historical factors such as large-scale wars (especially World War I) demanded the development of clinics, diagnostic approaches and methods of multi-stage treatment for those suffering from injuries to the head and spine.

The 1920s-1930s saw an almost simultaneous convergence of all three discipline-forming factors that determined the formation of neurosurgery as a clinical discipline in the interwar period in the leading countries of the world (the United States, Canada, the United Kingdom, France, Germany and the USSR). However, in many countries neurosurgery became an independent specialization only in the second half of the 20th century, when the main components of the institutional factor came into being there.

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