Fedor Krause (1857-1937): the father of German neurosurgery

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Abstract: Rightfully regarded as the father of German neurosurgery, Fedor Krause made a major contribution not only in world neurosurgery, but also in medicine. The aim of this paper is to highlight once more the significance and importance of Fedor Krause's work and exceptional human quality.
Key words: Fedor Krause, history of German neurosurgery, ophthalmology

Birth and youth of Fedor Krause

The one who would one day become the father of German neurosurgery, Fedor Krause (1857-1937), was born on 10 March 1857 in Friedland, a Silesian town from Germany. His father was a public servant in the district of Waldenburg and died when Fedor was still young (6). When he was nine years old, his mother decided to move the family to Berlin, where it led an extremely modest life, at times bordering on poverty. This did not prevent Fedor from studying at "Sophien Gymnasium" in Berlin, where he became known for his talent (6), studying piano and violin and winning many awards (28, 30).

Fortunately, due to financial support from a private sponsor, the young Fedor was able to continue his studies at post-graduate level, choosing medicine (30). He thus began his medical studies in 1875 and wrote his doctoral thesis in 1879, passing his final examinations in March 1880. After graduating from the medical school of Berlin, Krause worked for two years as an ophthalmologist in prestigious ophthalmology clinic of professor Julius Hirschberg's (1843-1925). In this early period, Krause also worked with famous bacteriologists of the time, the likes of Robert Koch (1843-1910) and Karl Friedländer (1847-1887), the pathologist Karl Weigart (1845-1904) and the surgeon Bernhard von

Langenbeck (1810-1887), who left their mark on the young physician and motivated him to study bacteriology and histopathology. In his later works Fedor would approach various unexplored topics in these medical fields. He worked with the renowned bacteriologist Robert Koch at the "Imperial Board of Health" (23) and he aroused his interest to study the systemic manifestations of tuberculosis, especially bone tuberculosis (24). Krause published many articles and papers as a result, the most important of which was "Die Tuberkulose der Knochen unde Gelenke" (Tuberculosis of the Bones and Joints, 1891) (16).

The beginnings of neurosurgery. The collaboration with Professor Richard von Volkmann

Passionate by neuro-ophthalmology and visual pathways, Krause became more and more interested in neurosurgery. Thus, in 1883, he moved to Halle, where he worked until 1892 as a resident surgeon in the famous surgery clinic of Richard von Volkmann (1830-1889), a renowned professor who was also chairman at the University of Halle at that time (3, 15). Volkmann was an important name in German surgery, one of the first Listerians, and the one who introduced the practice of antisepsis in Germany, in the period of the Franco-Prussian war (12). While he lived in Halle, Krause had a beautiful and sincere collaboration and friendship with professor Volkmann (4).

The city of Halle was a heavily industrialized city and work accidents resulting in head injuries were frequent. Thus, in 1885, together with Volkmann, Krause reported 36 surgical interventions for posttraumatic extradural and subdural hematomas, with no postoperative deaths (4). After spending four years in the "Surgical Hospital" in Halle, Krause defended his habilitation thesis entitled "Malignant Neuromas and Their Nerve Fiber Content", in 1887, which, despite being regarded as inadequate for the profession of general surgeon, it was eventually accepted, with Volkmann's help. In 1889, after professor Volkmann died of pneumonia, Krause became the deputy chief of surgery for one year, after which he was replaced by the German surgeon Friedrich Gustav von Bramann (1854-1913). Afterwards, Krause moved to Hamburg where he became employed as an "oberarzt" at "Altona Municipal Hospital". In 1990 returned to Berlin where he was appointed Honorary Professor in the Friedrich-Wilhelms University (e.g. Humboldt University of Berlin) and chief of surgery at "Augusta Hospital" (30).

Throughout his life, Fedor Krause venerated his mentor, and remained loyal to him even after he passed away. His disciples said that Krause always spoke fondly of him, even while scrubbing with his assistants (32). Moreover, Krause also wrote memoires about him and even dedicated a book to him, entitle "Zur Erringerung an Richard von Volkmann" (In Richard von Volkmann's memory), published one year after the professor's death (6).

In Berlin, Krause began collaboration with the neurologist Hermann Oppenheim (1858-

1919) together with whom he studied neuroanatomy, neurophysiology and neurosurgery. Krause regarded this collaboration and friendship very highly as well. Later on, in the foreword to his book "Chirurgie des Gehirns und Rückenmarks nach eigenem Erfahrungen" (Sugery of the Brain and Spinal Cord – Based on Personal Experiences), Krause wrote: "I am most grateful to Hermann Oppenheim. Hardly a week, frequently not a day, passed in which we did not consult at the bedside or in the operating-room. This invaluable and lasting connection, and the constant harmonious collaboration, bore in time fruit that we are now proud of in our operative therapy, despite the numerous and discouraging experiences" (12, 19).

Krause's contributions in epileptology and functional neurosurgery

Influenced by the classical cortical stimulation work of Fritsch and Hitzig, Ferrier and Sherrington, Krause thought that he could use electricity in neurosurgery and neurology as well. Through this discovery, Krause was considered to be the first surgeon who performed the first intraoperative electrical stimulation on the cerebral cortex (35).

Throughout his life, Krause operated on 400 epileptic patients, which was by far the highest number of patients at that time (13). He was also the one who performed the first detailed motor map of the human cortex (25), and who used faradic stimulation to differentiate between the facial from the audiovestibular nerve in a patient with tinnitus, when he made a section of eighth cranial nerve (25, 32). It is important to note that Krause was not only the first to describe the locating of a cranial nerve through electric stimulation, but also the first to record the spread of the current artifacts products (8).

Krause's operative neurosurgical techniques

During the First World War, Krause was a surgical consultant ("Generalarzt") for the German army, gaining experience in treating head injuries. After the war, he went to Central and South America, in countries such as Brazil and Argentina, in 1920 and 1911, lecturing and performing brain surgery (5).

In 1893, Krause described the subtemporal extradural approach to the trigeminal nerve roots and Gasserian ganglion (Gasserian ganglionectomy) (17, 25). Despite the proximity of the gasserian ganglion to the internal carotid artery, Krause wrote that, in 70 cases of Gasserian ganglionectomy, he never injuried the carotid artery, which attests to his outstanding surgical skills (12).

Seven years later, Krause removed a bullet from the clinoid process and optic foramen region of a young man who attempted to commit suicide out of love, through a frontal approach to the sella. Krause noticed that he had a very good view of the sellar region. Still in 1900, before the "Berlin Medical Association", he performed surgery on a cadaver (20) and proposed this type of approach for tumors in this region. Four years later he attempted an unsuccessful resection of tuberculum sella meningioma and in 1908 a pituitary adenoma in an acromegalic patient, which was followed by improvement (12).

In 1903 he described the cerebellopontine angle approach, which he performed through an unilateral suboccipital osteoplastic flap (18). Nowadays, this approach is considered to be the predecessor of the retrosigmoid approach (14). It was performed for a vestibular schwannoma and Krause concluded that tumors located in the cerebellopontine angle can be now safely resected. Nonetheless, he considered them to be the most difficult and problematic of all brain tumors (31).

Four years later, Krause resected a cerebellar tumor of the upper vermis, being regarded as the first surgeon who was successful in approaching the fourth ventricle (13). Twenty-six years later, at his funeral, the otologist Güttich wrote in his orbituary: "Krause was the first person who looked into the fourth ventricle of a living human being" (28).

In 1913 he conducted a resection of a pineal tumor through an infratentorial supracerebellar approach which he patented in neurosurgery and which would bear his name (2, 27, 29). Krause also had a contribution in vascular neurosurgery, being the first neurosurgeon who operated cerebral angiomas. He attempted also to ligatures the feeding vessels (33). He also excelled in spinal cord neurosurgery and, together with the German neurologist Heinrich Oppenheim, in "Augusta Hospital" in Berlin, he performed the first discectomy and laminectomy in a patient who had been suffering from severe sciatic pain for several years and who developed an acute cauda equina syndrome. The surgery consisted in laminectomy L2-L4, splitting the dura, mobilization the cauda equina by a retractor, exploring the operation field and removing a small fibrocartilage mass, which they later considered to be an enchondroma (26).

His work (Table no.1) is overwhelming and groundbreaking in the field of neurosurgery in Germany and in Europe at the beginning of the 19th century. One of the most important books he wrote is "Chirurgie des Gehirns und Rückenmarks nach eigenem Erfahrungen" (Sugery of the Brain and Spinal Cord – Based on Personal Experiences) (20). The first volume was published in 1909, comprising the detailed and didactic writings of over 300 craniotomies with hand-drawn coloured illustrations of surgical procedures. Several years later, in 1911 and 1912, the second and third volumes were published. Even though his books were initially written in German, they became famous throughout Europe, in spite of the fact that they were translated into English later on (4). His didactic work represented true atlases and textbooks, comprising at the same time many surgical techniques, described in great detail, and examples of cases from Krause's personal experience (32).

Another important work was his monograph "Trigeminal Neuralgia: Including the Anatomy and Physiology of Nerves" in which Krause described his experience with 14 patients suffering from trigeminal neuralgia, and reviewed the entire literature on the subject. His knowledge of ophthalmology allowed him to avoid keratitis, a common complication of the denervation of the cornea by sectioning the first branch of the trigeminal nerve (12).

TABLE I

Chronology of Krause's contributions (11, 12)

Year	Pathology	Approach/technique discovered
1893	trigeminal neuralgia	subtemporal extradural approach (Gasserian ganglionectomy)
1897	tinnitus	cerebellopontine angle approach (section of eight cranial nerve)
1904	tuberculum sella meningioma	frontal transcranial approach to the sella
1908	herniated lumbar disc ("enchondroma")	discectomy, laminectomy
1908	arteriovenous malformation of the brain	ligation of a feeding artery
1909	pituitary adenoma	sphenoid ridge approach to sella
1913	pineal tumor	supracerebellar infratentorial approach

Krause's contributions on the surgical branches of medicine

Apart from his monograph on neurosurgery, Krause also published a series of surgical monographs in which he studied various pathologies or described his innovations in: general surgery, plastic surgery (free transplantation of skin flaps (1)), orthopedics (bone and joint tuberculosis, application of waking casts), urology (total cystectomy, bilateral ureterosigmoidostomy, reimplantation of the ureter into the bladder (1)), endocrine surgery (adrenotomy, transplantation of endocrinous tissue (22)), ENT surgery (sympathectomy, carotid artery ligation (22)), and so on.

Moreover, in the field of anesthesiology, Krause highlighted the risk of cerebral oedema caused by ether and chloroform. Despite the fact that, while working with professor Volkman, Krause used this combination of morphine and chloroform, he was not convinced that this formula was beneficial for neurosurgical interventions. This motivated Krause to continue his research in the field of neuroanesthesiology (10).

Krause the man

Krause was a shy, sensible and nobly modest man (Figure 1). He did not like to attend large international meetings in order to present his techniques, preferring smaller conferences instead. What is more, when he was asked about how he would like people to remember him, he responded rather like a classical pianist than a neurosurgeon (9).

Figure 1 - Fedor Krause (1857-1937), the father of German neurosurgery

Krause was described as a man with big hands, more suitable for manual labor than for brain surgery (34). Nonetheless, he had a sensitive and artistic nature, having difficulty in choosing, in his youth, between a career as a pianist or as a physician.

In a letter from 1889, one year before his death, professor Volkmann wrote that his assistant, Fedor Krause, "had developed into a surgeon capable of performing all types of surgeries, that he led lectures and scientific work, and that he was endowed with an unusual clinical experience, with great talent and humane attitude" (32).

Krause's retirement

After his official retirement, he withdrew to Rome, in 1930, together with his daughter, devoting the rest of his life to arts and music. Krause held a series of private concerts (6), for which he was praised and appreciated by Italian critics (11).

Upon his 80th birthday, while he was being celebrated in Berlin, in 1937, the German surgeon Ferdinand Sauerbach said: "You can look back on your work with pride, and rejoice in its future progress and prosperity. Even the notable progress in surgery of the central nervous system in other countries rests to a large extent on your basic work" (32).

Krause passed away during the same year, in Badgaatstein, forever remaining the father of German neurosurgery in the consciousness of the German people.

Emil Heymann (1878-1936), Karl Max Behrend (1895-1963) and George Merrem (1908-1971) continued on their father's path, contributing to the development of neurosurgery in Germany. They became great professors and modest men, like their mentor (1). George Merrem was trained by Emil Heymann (1878-1936), Krause's successor in Berlin, who perpetuated Krause's neurosurgical school (7) and developed neurosurgery in the German Democratic Republic after the Second World War.

The Faculty of Medicine of Berlin awarded Krause in 1915 with the highest academic position, "ordentlichen Honorarprofessor" (21), and nowadays the German Neurosurgical Society awards the great neursurgeons with the "Fedor Krause Medal" for outstanding work in the field of neurosurgery, which is the highest honor in neurosurgery.

Conclusions

Fedor Krause is the father of German neurosurgery who has remained in the memory of the German people for his contribution not only in neurosurgery, but also in other branches of medicine. His main concern, however, for which he fought his entire life, was with finding safe approaches to inaccessible anatomical areas of the brain, which he actually succeeded. Through his entire activity, Krause is not only a pioneer in German neurosurgery, but a pioneer in world neurosurgery.

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