Volume 3 • Issue 1 • 2021

Review Article

Journal of Brain and Neurological Disorders

Historical Overview of Electroencephalography: from Antiquity to the Beginning of the 21st Century

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Received: August 18, 2021; **Published:** August 31, 2021

Abstract

The history of epilepsy is intermingled with the history of human existence dating back to antiquity. Hippocrates, the founder of scientific medicine, was the first to de-mystify the condition of epilepsy by providing a more scientific approach to it. Since then, many centuries have passed until the recording of electrical waves was applied. First in experimental animals and close to the human brain. The birth of epileptology was characterized by the advent of electroencephalography and the delineation of underlying pathophysiological mechanisms. Starting in the 16-17th century, *William Gilbert Galileo* and *Thomas Willis* investigated electricity of various substances, and Otto von Guericke developed the first electrostatic apparatus. About two centuries later *Cybulski* and *Jelenska-Macieszyna*, published photographs of EEG, and some years later Hans Berger published its results. From then on, the progress to electroencephalography was rapid in all areas. The aim of this article is to present the historical overview of electroencephalography starting from the ancient years until the beginning of the twenty-first century.

Key words: *Epilepsy; Electricity; Electroencephalography; Historical Documents*

Abbreviations: Provide the list of abbreviations used along with expanded forms. Make sure to maintain the consistency of abbreviations throughout the article.

Introduction

The epilepsy is known since antiquity and the first description of it can be found in multiple cultures, including Mesopotamia, Akkadian, and ancient Babylonians about 2000 years B.C and Greeks (5-4th B.C) [1,2,3,4,5].

Since then, various methods have been applied for the therapy of epilepsy based on therapeutic techniques from medieval times. The basis for therapy fell in to four main categories: conventional, marginal, trepanation, and religious procedures. Several centuries later, the generation of electricity marked the beginning of electroencephalography, starting in the medieval times with Gilbert, Galileo and Willis. Gilbert began to study the electrical properties of various substances. In 1672, Otto von Guericke developed the first electrostatic apparatus (friction machine) that generates static electricity. The first electrical impulses were observed in 1875 by Richard Caton through the galvanometer, which is a type of electrical ammeter to measure electric current in the brain of monkeys and rabbits [6]. In 1890, Ernst von Fleischl-Marxow and his studies on evoked potentials linked nervous system activity to muscle movements. During the same year, Beck using Hermann's galvanometer,

Citation: Christos P. Panteliadis. (2021). Historical Overview of Electroencephalography: from Antiquity to the Beginning of the 21st Century. *Journal of Brain and Neurological Disorders* 3(1). DOI: 10.5281/zenodo.5359323

found constant electric activity in the brains of dogs and rabbits [7]. Hermann von Helmholtz (1821–1894) a German physician and physicist accurately measured the nerve conduction velocity [8].

In 1901, the Dutch physiologist *Wilhelm Einthoven* (1860-1927) devised the first string galvanometer resulting in the discovery of modern electrocardiography [9, 10]. Years later other forms of it were discovered, such the larger Edelmann string galvanometer, *Gustav Wiedemann's* galvanometer with six coils and Helmholtztangent galvanometer. In 1910, Berger used a string galvanometer first, followed by a larger Edelmann model (sensitivity 1mV/cm) later [11, 12].

From then on, the rapid progress of electroencephalography was promptly applied to clinical and experimental studies of epilepsy as well as topatient care. This process was gradually accomplished mainly in the second half of the 20th century. This paper reports the findings of a significant number of sources, ranging from ancient texts until the end of twentieth century.

Before Christ (B.C.)

Hippocrates (460-390 B.C) challenged the theory that epilepsy was a disease of the Gods providing an objective description of a disease that is not divine and not sacred, has the same origin as other illnesses, begins during embryogenesis, and has a worse prognosis for children compared to adults [4]. The discovery of static electricity was first attributed to Thales from Militos, a pre-Socratic "natural philosopher", mathematician and astronomer of Greece, one of the seven wise men of that time, (around 640 or 620-550 B.C), who generated friction using amber (in Greek "electron/ήλεκρον") against silk or fur. "Τρίβω-Triboelectric effect is the origin of the word "electricity".

More efforts to produce electricity using the same method were undertaken during the Paleontological ages, which is demonstrated by cave findings such as in the Petralona Cave in Greece, as well as in other caves with anthropo - paleontological importance, where human skeletons were discovered. This phenomenon (of electricity production) is also mentioned in ancient manuscripts of Egyptian, Greek, Roman and other cultures [3-5]. Another source of light in ancient times (chalcolithic, bronze to byzantine Ages) were oil lamps, used at home or in religious ceremonies, while there was no electrical activity. An oil lamp is an object used to produce light continuously for a period of time using an oil-based fuel source. Oil lamps are a form of lighting, and were used as an alternative to candles before the use of electric lights. The first oil lamps of manmade materials were found in caves and temples, in Egypt, Greece and Rome and are considered probably the first mass produced objects in history. In small towns and rural areas the latter continued in use well into the 20th century, until such areas were finally electrified and light bulbs could be used [13]. However, it was not before another 2000 years, until electricity in living organisms was discovered. Despite the fact that the knowledge about epilepsy was adequate at that time and it had already been recognized that seizures could be triggered by sleep deprivation or flashing lights, electric recording was still impossible.

The Byzantine era

In the early *Byzantine*, late Antiquity era, initially the views of *Hippocrates, Galen* (131-201 A.D), Alexander of Tralles (525-605), Oribasius of Pergamon (320-400 A.D), Paulus of Aegina (625-690 A.D) und Aetius of Amida (6th-7th century A.D.) prevailed. Islamic and European medicine were mainly influenced by the hellenistic and Roman traditions. [3,4,14]. Galen of Pergamum A.D. (2nd century), the most eminent Greek physician after Hippocrates, marked the history of medicine for more than fourteen centuries. *Alexander* of Tralles , who was one of the most eminent representatives of Byzantine medicine, distinguished three kinds of epilepsy in his Books on Medicine (twelve books) and reproduced Galen's views on epilepsy [14]. *Alexander* in his Therapeutics, provideddietetic advise and other natural remedies, and concentratied on epilepsy in infancy and the special dietary requirements, such good quality milk. Trephination or Trepanation was the most important surgical procedure since the ancient times and was employed during this period in the therapy of epilepsy. A number of tools for trephining were described in the 16th and 17th centuries [15].

In the ancient years, there was enough knowledge regarding epilepsy and several methods of treatment were used [16]. However, the diagnostic criteria and the management were both empirical. Several centuries later, the discovery of electrical phenomena took place and the concept of an "*action current*" began.

The era of electroencephalography (beginning)

The development of electroencephalography (EEG) required first the discovery of electricity followed by the knowledge of the connection between electricity and living organisms. The discovery of static electricity was first attributed to Thales from Militos, a pre-Socratic "natural philosopher" of Greece, one of the seven wise men of that time, (around 640 or 620-550 B.C.), who generated friction using amber (in Greek "electron/ήλεκρον") against silk or fur [17]. After rubbing amber with hemp, Thales noticed the amber acquired an electrical charge and was able to attract light materials such as feather and dust. More efforts to produce electricity with the same method were observed during the Paleontological ages too in cave findings (e.g., Cave-museum/Petralona-Greece). This phenomenon (of electricity production) is also mentioned in ancient manuscripts of Egyptian, Greek, Roman and other cultures [1-3]. However, it was not before another 2000 years, until electricity in living organisms was discovered.

Starting in the 16-17th century, the scientist's William Gilbert (1544-1603), Galileo (1564-1642) and Thomas Willis (1621-1675) investigated electricity of various substances [18, 19, 20].

In 1672, the German physicist, engineer, and natural philosopher Otto von Guericke (1602-1686) developed the first electrostatic apparatus (a sulphur ball that rotated on a shaft to produce electrical fields) for basic animal experiments [21]. In the following years this experiment inspired the development of several forms of "friction machines". Later, the first experiment was performed on frog legs by the Italian Luigi Galvani from Bologna (1737-1798); he provided evidence that the body reacted to electricity [22]. In 1745, the German Ewald Georg von Kleist (1700-1748) a Bishop of Pomern (Prussian) and physicist, and the Dutch scientist Pieter van Musschenbroek of Leiden (Leyden) (1692-1761) introduced the Leyden jar machine for storing static electricity (a high voltage electric). This friction machine could produce electricity (positive and negative electricity) but was not suitable for deriving electrical activity from the brain on to other electrical and electronic equipment [23].

The nineteenth century

In the nineteenth century, important discoveries about the nervous system structure and function involved the electrical properties of nerve tissue. In 1820, Hans Christian Ørsted (1777-1851) a Danish physicist and chemist discovered a compass needle was deflected from magnetic north by an electric current from a voltaic battery, confirming a direct relationship between electricity and magnetism [24,25]. In 1825, Leopoldo Nobili (1784-1835) an Italian physicist, working in thermos-dynamic and electrochemistry, devised a static galvanometer with a double coil of 72 terms and two magnetic needles [26]. In 1828 he measured the 'frog current' with his galvanometer. This apparatus was refined in 1858 by William Thomson (1824-1907) in England [26]. Carlo Matteucci (1818 -1868) a prominent neurophysiologist from university of Pisa worked on "animal electricity" following the great tradition of Galvani. Matteucci paved the way for the development of modern electrophysiology. In 1964, Giuseppe Moruzzi (1910-1986), a prominent neurophysiologist with a scholarly interest in the history of science, published an extensive and insightful analysis of the work and personality of Carlo Matteucci [27]. In 1843, Heinrich Emil Du Bois-Reymond (1818-1896) a German electrophysiologist discovered that the peripheral passage of a nerve impulse was accompanied by an electrical discharge, the action potential, an apparatus to observe the nerve signal. He proposed a molecular explanation for the slight electrical currents that he detected in frog muscles and nerves. After Matteucci, whose work he disparaged, he is often regarded as the founder of electrophysiology [27, 28].

Du Bois-Reymond proposed a molecular explanation for the slight electrical currents that he detected in frog muscles and nerves [28]. There was a long controversy and rivalry between Du Bois-Reymond and Matteucci fueled by their differences in the interpretation of the electrophysiological process in frog muscles and nerves [29].

Some years later, Alesandro Volta (1755-1832) from Pavia Italy, George Ohm (1789-1854) a German physicist and British Michael Faraday (1791-1867) worked on the same topic and contributed to the understanding of the transmission of electric potentials of brain activity in experimental animals [30,31,32]. The fundamental principles of electricity generation were discovered in early 1830s by Michael Faraday [25,33]. Primarily, Faraday studied the electrolysis of water and used the name "voltameter". Robert Bentley Todd (1809–1860) a clinical scientist, was an eminent neurologist and neuroscientist in England and along with Michael Faraday laid the foundations of electrical activity in epilepsy. In 1849, Todd in his Lumleian lectures presented the first electrical theory of epilepsy based on his own clinical examinations and scientific work and the knowledge in electromagnetism from Faraday [32,33]. In 1841, West was the first to describe infantile spasms, and in 1954, more than 100 years later, Gibbs published their EEG-description on hypsarrhythmia [34, 35]. Some years before, in 1951, Hess and Neuhaus studied 518 children with seizures and described an identical EEG, naming it diffuse mixed convulsive pattern (Blitz-Nick-Salaam convulsions) and other types of seizures [36].

In 1870, the German neurophysiologist Gustav Fritsch (1838-1927) and the German psychiatrist Edvard Hitzig (1838-1907), a pioneer in using electrical stimulation in cerebrum, succeeded in inducing seizures in a dog by electrical stimulation [37]. Five years later, in 1875, the English physician and physiologist Richard Caton (1842-1926), an English scientist practicing in Liverpool, used a sensitive galvanometer, a type of electrical ammeter, to register oscillations of electric potential in the cerebral hemispheres of rabbits and monkeys, and his findings were published in the British Medical Journal [6]. Caton placed unipolar electrodes either on the surface of both hemispheres or one electrode on the cerebral cortex or on the grey matter and the other on the surface of the skull. Caton reported his initial findings to the British Medical Association in 1875 [6]. This led him to assume the existence of evoked potentials. 1870, John Jackson (1835-1911) defined 'Epilepsy as the name for occasional, sudden, excessive, rapid and local discharges of the gray matter' [38]. Some years later, in 1877, similar studies were published by Vasili Yakovlevich Danilewsky (1852-1939), an eminent physiologist from Russia, now Ukraine (Charkow) [39]. His work, based on electrical activity in the brain of animals, followed Cattons work [6].

In 1890, Adolf Beck (1863-1942) a physiologist from Cracau wrote his dissertation on the cortex, entitled "Investigations into the Physiology of the Brain". He electrically stimulated the brains of dogs and rabbits and argued that the brain had priority over the electrical activity of the body [7]. By using a galvanometer, Beck found constant electric activity in the brains of dogs and rabbits that were asynchronous to respiration and heartbeat. He also measured the velocity of nerve conduction, which had been vastly overestimated up to that time. Beck placed electrodes directly on the surface of brain to test for sensory stimulation. Beck was characterized as a pioneer in electroencephalography in between Caton and Berger. About two weeks later, Ernst Fleischl von Marxow (1846-1891), a physiologist and physician from Vienna, claimed to have conducted similar unpublished studies [40].

The twentieth century

In the early days of the 20th century research continued, and the understanding of the cortical function expanded. The aim of all these efforts was to put the electrical activity of the brain down on paper. Beck and his teacher Napoleon Cybulski (1854-1919) continued their work on dogs and apes to produce a cortical map of evoked potentials termed "experimental electroencephalographic studies" [7,41]. Cybulski's technique after opening the skull under anesthesia, was much improved compared to Kaufman's. Similar findings were published by the physiologists Francis Gotch (1853-1913) and Victor Horsley (1857-1916) who electrically stimulated the cortices of mammals [42,43].

In 1912, two Russian physiologists, *Pavel Yurevich Kaufman* (1877-1951), and *Vladimir Vladimirovich Pravdich-Neminsky* (1879-1952), noticed electric changes in the brain (first animal EEG) during experimentally induced seizures. They associated epileptic attacks with abnormal electric discharges in the brain and these observations were the beginning of clinical electroencephalography [44,45]. Two years later, in 1914, the neurophysiologists Cybulski and *Jelenska-Macieszyna* (1854-1919) from Cracau, published the first photographs of EEG recording action potentials from a dog's brain by using an Einthoven galvanometer [41]. At the same time, Prawdicz-Neminski, a Ukrainian physiologist, published studies on cortices of dogs that strengthened the understanding of electrical waves in the cortex (seven different types of waves) and introduced the term electrocerebrogram [45]. In 1924, Joseph Erlanger (1874–1965) described in the Harvey Society the technique (oscillograph) of the action potential of nerve. During 1920-1930 Erlanger und Gasser first used the cathode ray oscilloscope to visualise the precise form of nerve action potentials [46].

Ten years later, in 1924, the German psychiatrist Hans Berger (1873-1941) from the University of Jena managed to demonstrate neural oscillations in human brain and was the first to use the term 'electroencephalography' [47]. Except from the EEG, in 1920 Berger also described intellectual changes after prefrontal cortex injuries, and in 1923, the perseveration after damage to the frontal lobes. From 1926 to 1929, Berger managed to establish a good EEG recording of alpha waves using a more sensitive double-coil galvanometer in cooperation with Siemens [48,49]. Berger's paper "Über das Elektrenkephalogramm des Menschen" (On the EEG in humans), published in 1929, was the first of 23 publications on this topic. He described or touched upon a large number of normal and abnormal EEG phenomena, for example EEG changes associated with attention and mental effort, a number of causes in other types of epilepsy, and alterations in the EEG associated with cerebral injury [50]. In 1929, Berger cited Caton's valuable earlier contribution to the field. The findings of Berger were later confirmed by the English physiologists *Edgar Douglas Adrian* (1889-1977) and *Matthews* (1906-1986) who conducted experimental investigations in *Faraday cages* [51, 52].

This publication left no doubt about the rhythmic resting activity of the brain and the EEG was added enthusiastically to clinical diagnostics in the Anglo- Saxon world. Several years later, in 1934, he showed that the occipital areas in children and adults usually have more alpha activity and the frontal/parietal lobes more 15 to

30/c/s activity than any other area [53]. In 1932, Adrian with Sir Charles Scott Sherrington (1857-1952) a neurophysiologist, won the Nobel Prize in Physiology or Medicine for their discoveries regarding the function of neurons. In 1932, Bishop (1889-1973), an American axonologist, published the nerve and synaptic conduction [54], and in the same year, Berger reported on postictal EEG's after generalized tonic-clonic seizures. Later, in 1933, he described the first patterns of interictal changes with a 3/s rhythmic pattern in the EEG (petit mal). Pyknolepsy was a term used to describe frequent petit mal seizures in children [55]. In the same year (1932,1933), Alois Kornmüller (1905-1968) observed distinctions in the electric activity in different parts of the cortex by using direct leads from the cerebral cortex in animals and later in man (electrocorticogram) [56]. He also was the first to describe seizure-related electrical discharge in epileptics. Kornmüller and the outstanding engineer Tönnies built an oscillograph, called "neurograph" [57]. Between 1939 and 1944, pre- and postoperative EEG were established routinely to identify the epileptogenic area as "*best guide for surgeon's*".

Oscar Vogt (1870-1959), a prominent German neurologist and neuroanatomist and his wife Cecile (1875-1962) from 1920 and thereafter, laid the foundations of cytoarchitectonic on the brain with correlation between anatomy and physiology [58]. In 1933 and 1935, Joseph F. Tönnies, Otfrid Foerster (1873-1941) a German neurologist and system physiologist and Herbert Altenburger reported the first use of intraoperative leads directly to the human cortex [59]. In the years 1932/34 Tönnies (1902-1970) developed a five-channel electroencephalograph [60]. Toennies recorded without arc distortion simultaneously from five different brain regions. In 1934, Fischer and Löwenbach published the first demonstration of epileptiform spikes [61]. In 1935, the psychologist Hubert Rohracher (1904-1972) investigated the effectiveness of this method by attempting to objectify the human experience through neuroelectric examinations and developed a theory about alpha waves [62]. In same year, in 1935, Alfred Loomis (1887–1975), Blake and Gerard in 1937 showed that EEG patterns in humans changed dramatically during a night's sleep and hosted a conference on "The electrical potentials of the brain" [63, 64]. During the same year (November 1935) Loomis organized a conference on "The electrical potentials of the brain" and Hallowell Davis presented the history of the EEG. In 1936, Grey Walter (1910-1977) an English psychologist, pioneer of clinical electroencephalography and co-worker of Adrian and Matthews, described delta slow waves in EEG by patients with brain tumors, and in 1942 the encephalography in cases with mental disorders [52, 65, 66]. In 1936, the first EEG laboratory opened in Massachusetts General Hospital, followed by the clinical laboratory a year later.

Berger's work on the EEG in epilepsy was completed by the findings of the American neurologist Frederic Andrews Gibbs (1903-1992) and his wife and technician Erna Leonhardt-Gibbs (1904-1987). In cooperation with Hallowell Davis and William G. Lennox they established the correlation between EEG findings and epileptic convulsions and was the first to describe the pathognomonic feature "3c/sec spike-and-wave" of petit mal epilepsy, in fact a rediscovery of some of Berger's work [67, 68]. In this epoch, two axonologists, Alexander Forbes (1882-1965) and Hallowell Davis (1896-1992) were the pioneers who developed the EEG in America [69]. Around this period Joseph Erlanger (1874–1965), and Herbert S. Gasser (1888-1963), both physiologists, described the technique (oscillograph) of the action potential of the nerve in the Harvey Society [70, 71]. In 1935, Albert Grass constructed a three-channel preamplifier, later ten-channel and an ink writer that recorded on rolls of paper [72]. In 1936, Jasper described cortical exitatories and a variability in human brain rhythms [73] and in 1937, began the first cooperation between Penfield and Jasper. Starting in 1939, Wilder Penfield (1891-1976), a neurosurgeon from America, and Herbert Jasper (1906-1999) a psychologist, neurologist, and epileptologist born in Oregon, from 1946 introduced EEG as a routine method in brain surgery in Montreal (McGill University) Neurological Institute [74,75]. In 1941, Gibbs and Gibbs published their monumental monograph "Atlas of Electroencephalography", in which they included the mechanical and mathematical analysis of EEG. In the same year Jasper and Kershman published the electroencephalographic classification of diverse epilepsies [75]. Many years later, the renowned neurophysiologist Mary Brazier (1904-1995) translated Beck's studies into English and the year before that she published a study about the historical note on the EEG in epilepsy [5].

Between 1920 and 1940 the technological and scientific foundations of electroencephalography were laid. EEG was established as the standard diagnostic tool in clinical practice, epilepsy research, and wherever the electrical activity of the brain is impaired [76]. Between the years 1940 and 1947, many manual and mechanical types of frequency analyzers became available, and several were applied to EEG problems. There was much debate about whether such a development was practical and useful. However, this had not been widely accepted. Many manual and mechanical types of frequency analyzer are possible. Variant types of electrical filters were used. At that time, more EEGs of both normal individuals and patients with nervous and mental diseases were analyzed. A prototype of Grey Walter's analyzer in cooperation with Davis developed a system with filter and band-width proportional to the frequency [76, 77]. In 1944 the Nobel Institute awarded the prize in Physiology and Medicine jointly to Erlanger and Gasser for their discoveries regarding "the highly differentiated functions of single nerve fibres" [70].

In 1947, Still WC from New Orleans published a study of the electroencephalogram of Hellen Keller (1880-1968), who from 19 months of age had a severe illness, of sudden onset and short duration, which left her totally blind and deaf. A critical analysis of the EEG of Keller, who was 64 years of age, showed better organized alpha activity in the frontal and motor areas than in the occipital area, and that hyperventilation increased the α- activity in the occipital leads, whilst it did not increase the amplitude of the potentials [78]. Meyers et al. (1950) claimed that the previous hypothesis of Jackson, Fritsch, Hitzig, and Ferrier (1843-1928) that a hyperirritable cortical "epileptogenic" focus is a main factor in the pathogenesis of epileptic seizures, is limited [37, 79]. In 1947 in London, during the First International EEG Congress and 1949 in Paris, Jasper recommended methods to standardize the placement of electrodes used in EEG [80, 81]. The first Annual Meeting of American Society of Electroencephalography took place in June 1947 in Atlantic City.

In 1950, Williams D a neurologist in St. George Hospital Queen Square described that the EEG has influenced knowledge in the field of epilepsy in four main ways: 1) types of electrical discharges have been related to clinically differing seizures, 2) discharges identical with those seen in an attack but of shorter duration have been seen without visible changes in behaviour (larval attacks), 3) focal origins of seizures have been demonstrated and studied, and 4) differences have been found between the EEGs of epileptics and non-epileptic patients irrespective of the occurrence of a seizure [80]. Grass AM in a last publication described into detail the 50 years before Berger and the 25 years after Berger, the electromagnetic and electrons theory, microprocessors and digital techniques [82].

In April 1964, the International League Against Epilepsy (ILAE) met in Marseilles and discussed a possible international classification. In September 1965 Gastaud presented this scheme of classification in Vienna [83]. Clinical electroencephalography reached its peak in the years 1960-1970. The range of diagnostic techniques and therapy available for a series of brain diseases increased and the study of epilepsy revolutionised [84].

The epileptic activity of single neurons was first described in 1959, a few years after the development of microelectrodes, which were also essential for studying the connection between neurons. In 1962, Fisher-Wiliams et al. [85] demonstrated the safe and successful use of subdural grids in epilepsy patients. In 1976, Ludvig, Marsan and van Buren combined the first subdural, epidural and depth electrodes for their investigations in temporal lobe epilepsy and thus established a standardized implantation plan for temporal lobe epilepsy [86]. In the following years, subdural grids became more popular, especially outside Europe. In 1991, Erwin Neher (born 1944), a German biophysicist specializing in the field of cell physiology, and Bert Sakmann (born 1942), a German cell physiologist, received the Nobel Prize in Physiology or Medicine for the development of the patch-clamp technique (measurement of the flow of current through single-ion channels) [87].

The role of clinical encephalography has significantly evolved in the last 40 years in all fields including video-EEG monitoring, EEG recording techniques and methodology, neurocongnition, of traumatic brain injury, coma, digital technology, and advances in neonatal seizures. Magnetoencephalography is useful for the study of neocortical epilepsy and could differentiate between patients with mesial and lateral temporal epilepsy, e.g., for use in the neurosurgical field. Together with computer tomography and magnetic resonance imaging can be used in the diagnosis of structural disorders of the brain. The digital technology has brought EEG and evoked potentials into emergency rooms and intensive care units. Pre- and postoperative EEG were established routinely to identify the epileptogenic area by placement of subdural grid electrodes in patients with non-lesional epilepsies. The intraoperative electroencephalography, computerized or digital, is useful in several operating room procedures and has many advantages over conventional EEG [87]. In the 1990s, digital data storage increased and computer networking enabled remote real-time EEG reading, which made continuous EEG monitoring possible [87, 88].

In many forms of epilepsy, typical characteristics were identified, while in others the foundations for the diagnosis were laid. Refinement of techniques, and EEG recording machines contributed to better diagnosing and understanding the different types of epilepsy. Today EEG is firmly established as a tool in the diagnosis and

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management of epilepsy and is the most specific method to define epileptogenic cortex. Modern invasive EEG recording techniques are the result of an interdisciplinary research process between neurologists and neurosurgeons in the 20th century. EEG's sensitivity and specificity depend on several factors, such as age and recording procedures, sleep recordings and activation procedures (hyperventilation, photic stimulation). Ictal video/EEG recording is considered to be critical in localizing the epileptogenic zone.

Conclusion

The birth of epileptology was characterized by the advent of electroencephalography (EEG). The generation of electricity marked the beginning of EEG. Starting in the 16-17th century, William Gilbert, Galileo and Thomas Willis investigated electricity of various substances. In 1875 Richard Caton through the galvanometer, which is a type of electrical ammeter, was able to register oscillations of electric potential in the cerebral hemispheres of rabbits and monkeys. Hans Berger in 1924 recorded the first human EEGs. In 1934, Fisher and Lowenback first demonstrated epileptiform spikes, in 1935, Gibbs, Davis, and Lennox described interictal epileptiform discharges, and in 1936, Gibbs and Jasper described focal interictal spikes. The first clinical EEG laboratories were established in the United States in the years 1930-1940. In 1947, founded the American EEG Society, and later the American Clinical Neurophysiology Society. Today EEG is firmly established as a tool in the diagnosis and management of epilepsy and is the most specific method to define epileptogenic cortex.

Acknowledgments

The author would like to thank Dr. Maria Zacharioudaki, Dr. Erich Rutz and PhD student Georgios Sofianidis for their contribution in editing and proofreading the manuscript.

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Citation: Christos P. Panteliadis. (2021). Historical Overview of Electroencephalography: from Antiquity to the Beginning of the 21st Century. *Journal of Brain and Neurological Disorders* 3(1). DOI: 10.5281/zenodo.5359323