https://doi.org/10.1590/0004-282X20200113

Denny-Brown and Pennybacker: 80 years after their pioneering article on electromyography, fibrillation and fasciculation

Denny-Brown e Pennybacker: 80 anos da publicação de seu artigo pioneiro sobre eletromiografia, fibrilação e fasciculação

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ABSTRACT

We present a historical review, highlighting the role of Professor Derek Denny-Brown and doctor Joseph Buford Pennybacker in the development of current electromyography (EMG), of the 80 years since the publication of his original report in 1938 on fasciculation and fibrillation potentials and the subsequent studies describing most of the electrical changes necessary to perform and interpret the EMG.

Keywords: Electromyography; Neuromuscular Diseases.

RESUMO

Os autores apresentam uma revisão histórica destacando o papel do Professor Derek Denny-Brown e do doutor Joseph Buford Pennybacker no desenvolvimento da eletromiografia atual, ao longo dos oitenta anos de seu artigo original em 1938, sobre potenciais de fasciculação e fibrilação, e os estudos subsequentes que descreveram a maioria das mudanças elétricas necessárias para realizar e interpretar EMG.

Palavras-chave: Eletromiografia; Doenças Neuromusculares.

Centuries of research and development of concepts of mathematics, physics, electricity, physiology, among other sciences, were needed to allow neurologists to understand and establish some important concepts of electromyography (EMG). One of the most important was recognizing fibrillation and fasciculation potentials, which were described in the pioneering article published by Denny-Brown and Pennybacker[1]. On the 80th anniversary of their original publication, in the era of computer science and communication, these concepts are still useful in EMG analysis.

In 1938, a pioneering study performed the electromyographic record of involuntary muscle potentials, named fasciculation and fibrillation[1]. This study was published in Brain[1], describing most of the electrical changes necessary to perform and interpret these potentials in the EMG. In the following years, Denny-Brown published other studies that also helped interpret these potentials. However, he did not advocate EMG as a separate entity and considered it part of the neurological examination. The development of EMG into a diagnostic clinical subspecialty occurred over the years following the extensive studies of many patients by a number of investigators.

Upon completing his fellowship, Denny-Brown became the resident medical officer at the National Hospital, Queen Square, in 1928; from 1935 to 1941, he worked as an assistant physician at the National Hospital and as a neurologist at St. Bartholomew's Hospital. In 1941, he moved to be Director of Harvard University's Neurological Unit at the Boston City Hospital; in 1946, he was appointed Putnam Professor of Neurology at Harvard[2].

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Conflict of interest: There is no conflict of interest to declare.

Authors' contribution: Hernandez Fustes OJ: conceptualization, data curation, investigation, methodology, formal analysis, project administration, roles/writing – original draft. Kay CSK: conceptualization, data curation, formal analysis, investigation, methodology, validation, visualization, project administration, roles/writing. Lorenzoni PJ: conceptualization, data curation, formal analysis, investigation, methodology, roles/writing. Ducci RDP: conceptualization, data curation, formal analysis, investigation, methodology, roles/writing. Werneck LC: conceptualization, validation, visualization, supervision, writing – review & edit. Scola RH: conceptualization, validation, visualization, formal analysis, project administration, supervision, writing – review & edit.

Received on February 5, 2020; Received in its final form on April 12, 2020; Accepted on July 10, 2020.

When their article was published, doctors Denny-Brown and Pennybacker were affiliated with the medical staff of the National Hospital at Queen Square in London. The Medical Research Council (London) provided the electromyographic apparatus used in their study[2].

Although our knowledge has improved in recent years, the core EMG features of fibrillation and fasciculation are quite similar to those described in the article by Denny-Brown and Pennybacker. By January 2019, this article had been cited in 487 articles in Google Scholar, 332 articles in the Web of Science, and 161 articles in Scopus.

To celebrate its 80th anniversary, we described the main historical aspects of the important contribution made by doctors Denny-Brown and Pennybacker, who recorded and defined fibrillation and fasciculation.

The first recordings of muscle fibrillations after denervation have been attributed to Schiff, who reported visual observations of fibrillations in the tongue muscles of dogs after a bilateral hypoglossal nerve section in his 1851 article[3]. In humans, the first record of bioelectric activity of muscles was made by Marey in 1890, when he introduced the new term "electromyography"[4].

In 1938, several years later, Denny-Brown and Pennybacker described fibrillations and fasciculations, which became the milestones of clinical EMG[1]. They published the EMG recording of the action potential of a single motor unit in patients with neurological disorders. In addition, they illustrated their article with figures of different involuntary potentials, besides fibrillation and fasciculation, such as 'rhythmical discharge', 'myokymia', and 'cramps'[1]. Figures showed the involuntary muscle potentials of cats that underwent experimental sciatic nerve section and patients with amyotrophic lateral sclerosis[1] (Figures 1 and 2). Next, they waited 4 to 27 days for denervation before exposing the gastrocnemius muscles and examining them both visually for fibrillations and electrically for fibrillation potentials with concentric needle electrodes. From this work, they concluded that:

i) fibrillation potentials "...are to be attributed to the activity of single muscle fibers"; and
ii) "These observations are in agreement with those of Langley and Kato, who stated that fibrillation does not commence until the fifth day after nerve section"[1].

Their article was detailed in sections: 'method of investigation', 'interpretation of observations on muscular function', 'the fine fibrillation of a muscle completely deprived of its nerve supply', 'fascicular tremor appearing with contraction', 'coarse local tetanic fasciculation', 'involuntary multifascicular contraction in affections of 7th nerve', 'on some abnormal contractions elicited by mechanical stimulation of voluntary muscle, and their relation to fibrillation', 'the fasciculation of muscle in motor neurone disease'. The study used the Adrian needle type[5].

The study was helpful in differing fibrillation and fasciculation[1]. In the paper, the authors state that "we would conclude, therefore, that the fibrillation of muscle undergoing atrophy as a result of denervation is due to periodic rhythmical twitch excitation of each muscle fibre sensitized by neural atrophy. The source of the excitation would appear to be the small amounts of acetylcholine in the normal circulation. We would refer to this phenomenon as "true fibrillation," to distinguish it from other more coarse varieties of muscle twitching..."[1,6].

For Buchthal, hardly any electromyographic criterion is more important and more misused and misinterpreted than the spontaneous activity of short duration. Fibrillation potentials have been described as diphasic discharges of 0.5 to 2 ms in duration and 50 to 150 μV in amplitude. In fact, they are usually triphasic, their duration ranges from 0.8 to 5 ms, and, while their average amplitude is 130 μV, potentials of several millivolts may occur when the leading-off surface of the electrode has a

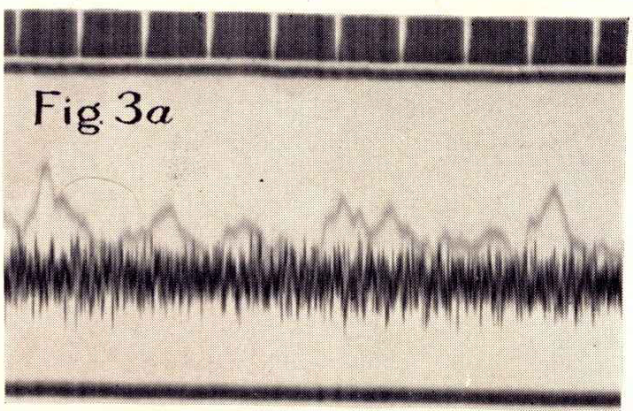

Figure 1. Mechanical and electrical recordo f fibrillation in M. soleus, cat, nine days after section of sciatic nerve. From Denny-Brown D, Pennybacker JB. Fibrillation and fasciculation in voluntary muscle. Brain. 1938 Sep;61(3):311-34. Reprinted with permission of Oxford University Press and Copyright Clearance Center.

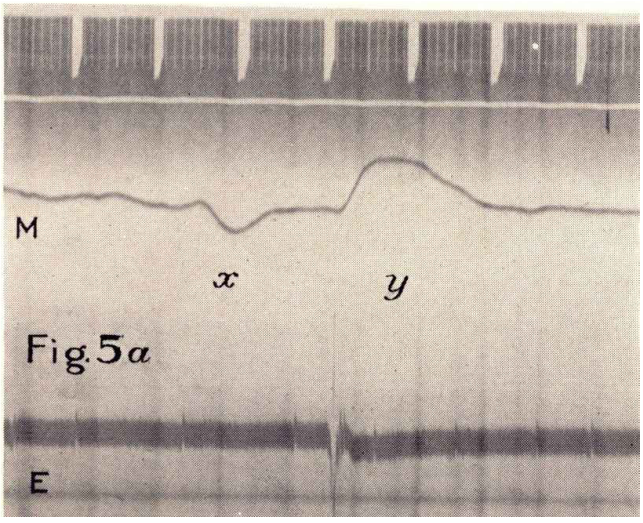

Figure 2. Left pectoral muscle of patient suffering from amyotrophic lateral sclerosis with coarse fibrillation. Mechanical (M) and electrical record € of a fasciculus of the muscle. From Denny-Brown D, Pennybacker JB. Fibrillation and fasciculation in voluntary muscle. Brain. 1938 Sep;61(3):311-34. Reprinted with permission of Oxford University Press and Copyright Clearance Center.

diameter of 50 μ or less. Fasciculation means sufficient twitching of muscle fibers to move the skin but not a joint; the twitching is often insufficient to arouse sensation. Fasciculations are common in wasted and weak muscles due to motor neuron disease, but they also occur in other conditions[7,8].

Following this 1938 report, clinical EMG rapidly developed. In 1941, Denny-Brown and Nevin described myotonic discharges in myotonic disorders. In 1944, Weddell et al. reported an extensive EMG study using a pre-amplifier, amplifier, and cathode-ray oscilloscope unit that improved the EMG technique used by Denny-Brown and Pennybacker in their article[9].

He also referred to the long-duration polyphasic motor unit potentials in patients with chronic neurogenic disorders due to axonal sprouting and grouping of reinnervated muscle fibers[10].

Denny-Brown and Pennybacker described, more than 80 years ago, the periodic contractions of denervated muscle fibers as true fibrillations and differentiated them from fasciculations and myokymia.

Since then, basic and clinical neuroscience have exploded, enhancing our diagnostic EMG skills and management of patients with neuromuscular disorders.

References

1. Denny-Brown D, Pennybacker JB. Fibrillation and fasciculation in voluntary muscle. Brain. 1938 Sep;61(3):311-34. https://doi.org/10.1093/brain/61.3.311
2. Pearce JM. Derek Ernest Denny-Brown (1901–1981). J Neurol. 2003 Jul;250(7):889-90. https://doi.org/10.1007/s00415-003-1135-8
3. Schiff M. Ueber motorische Lähmung der Zunge. Arch physiolog Heilkd. 1851;10:579-93.
4. Marey EJ. Physiologie du mouvement: Le vol des oiseaux. Paris: Libraire de L'Académie de Médecine; 1890.
5. Adrian ED, Bronk DW. The discharge of impulse in motor nerve fibers. Part II. The frequency of discharge in reflex and voluntary contractions. J Physiol. 1929 Mar;67(2):119-51. https://doi.org/10.1113/jphysiol.1929.sp002557
6. Denny-Brown D. Clinical problems in neuromuscular physiology. Am J Med. 1953 Sep;15(3):368-90. https://doi.org/10.1016/0002-9343(53)90090-4
7. Buchthal F. Spontaneous and voluntary electrical activity in neuromuscular disorders. Bull N Y Acad Med. 1966 Jul;42(7):521-50. https://www.ncbi.nlm.nih.gov/pmc/articles/pmc1806478/
8. Buchthal F. Spontaneous electrical activity: an overview. Muscle Nerve. 1982;5(9S):S52-9. PMID: 6763149.
9. Mayer RF. The motor unit and electromyography—the legacy of Derek Denny-Brown. J Neurol Sci. 2001 Aug;189(1-2):7-11. https://doi.org/10.1016/s0022-510x(01)00539-1
10. Kazamel M, Warren PP. History of electromyography and nerve conduction studies: A tribute to the founding fathers. J Clin Neurosci. 2017 Sep;43:54-60. https://doi.org/10.1016/j.jocn.2017.05.018