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A BRIEF HISTORICAL NOTE ON THE CLASSIFICATION OF NERVE FIBERS

Gilberto M. Manzano[1], Lydia M.P. Giuliano[2], João A.M. Nóbrega[1]

Abstract – This is a brief review of the literature focused on the articles that formed the basis for the classification of the nerve fibers. Mention is also made to the origin of the nomenclature of the different motoneurons (α, β and γ).

KEY WORDS: nerve fibers, peripheral nerves, motoneurones, classification, history.

Uma breve nota histórica sobre a classificação das fibras nervosas

Resumo – Os autores fazem uma breve revisão da literatura com foco nos artigos que deram origem à classificação das fibras nervosas. É também mencionada no texto a origem da nomenclatura dos diferentes neurônios motores (α, β and γ).

PALAVRAS-CHAVE: fibras nervosas, nervos periféricos, neurônios motores, classificação, história.

The classification of the nerve fibers is sometimes considered confusing by students and even approaching absurdity according to an important basic introductory textbook[1]. It has been our experience that an explanation of the historical background, of the fibers designation, seems to help to ease the students' understanding. This is the fundamental reason for this note.

Most textbooks for medical students refer to two classifications: one where the fibers are designated in Roman and Greek letters, and another, using Roman numerals and letters. These are indeed the classifications in use by experts in the current scientific literature.

Although "animal electricity" was discovered toward the end of the eighteenth century[2], it was only with the introduction of oscilloscopic recordings that these classifications appeared. This was not a minor technical detail, since, these observations opened up the way for the clarification of time relations within the nervous system as well as the elucidation of other nerve fibers properties, fundamental for the understanding of the nervous system functions[3].

In 1924 Erlanger, Gasser and Bishop[4], working with isolated nerves *in vitro*, to record "action currents", reported the occurrence of several peaks of voltage (recorded through an oscilloscope) as the nerve response following an electric stimulus. To differentiate those peaks, they named them as α, β, γ and δ, according to their sequential appearance on the screen following the stimulus artifact (Figure). As the peaks appeared in succession, the rate of conduction for the different fibers, composing the nerves, were implicated to explain these findings.

In 1927 Gasser and Erlanger[5] showed a correlation of the different peaks to the different conduction velocities of the nerve fibers, and following a suggestion of Prof. Lapicque, they also found a correlation of the velocities to the diameters and to the amount of different fibers in the different nerves.

Also in 1927, Erlanger[6] reported that the motor nerves showed all the described peaks, while in purely sensory nerves, the α peak was missing.

In 1930, Erlanger and Gasser[7] using more sensitive equipments showed that three of the described peaks of voltage (α, β, γ) belonged to a group of fibers that they called A and described two other elevations designated B and C that would appear after the A peak, actually in this report the δ peak was disregarded by its infrequent registration in the preparations studied. However, many of the examples of what was designated as B waves would be soon demonstrated to be the δ peak[8] (Figure).

Also in 1930, Bishop and Heinbecker[8] showed that the B elevation could be subdivided in an initial part identified as the Aδ peak[9] and another that occurred only in autonomic nerves which retained the designation B.

Section on Research and Pos-graduation in Clinical Neurophysiology (Setor de Pesquisa e Pós-Graduação em Neurofisiologia Clínica (SEPENC)), Neurology Discipline, Federal University of São Paulo (UNIFESP), São Paulo SP, Brazil: [1]MD, PhD; [2]MSc. Financial support: FAPESP (grant # 05337-6); CNPQ (grant # 478476/2004-3); Dr. Gilberto M Manzano has a research fellowship from CNPQ.

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Dr. Gilberto Mastrocola Manzano – Rua Dr. Thirso Martins 264/52 – 04120-050 São Paulo SP - Brasil. E-mail: gmmanzano@uol.com.br

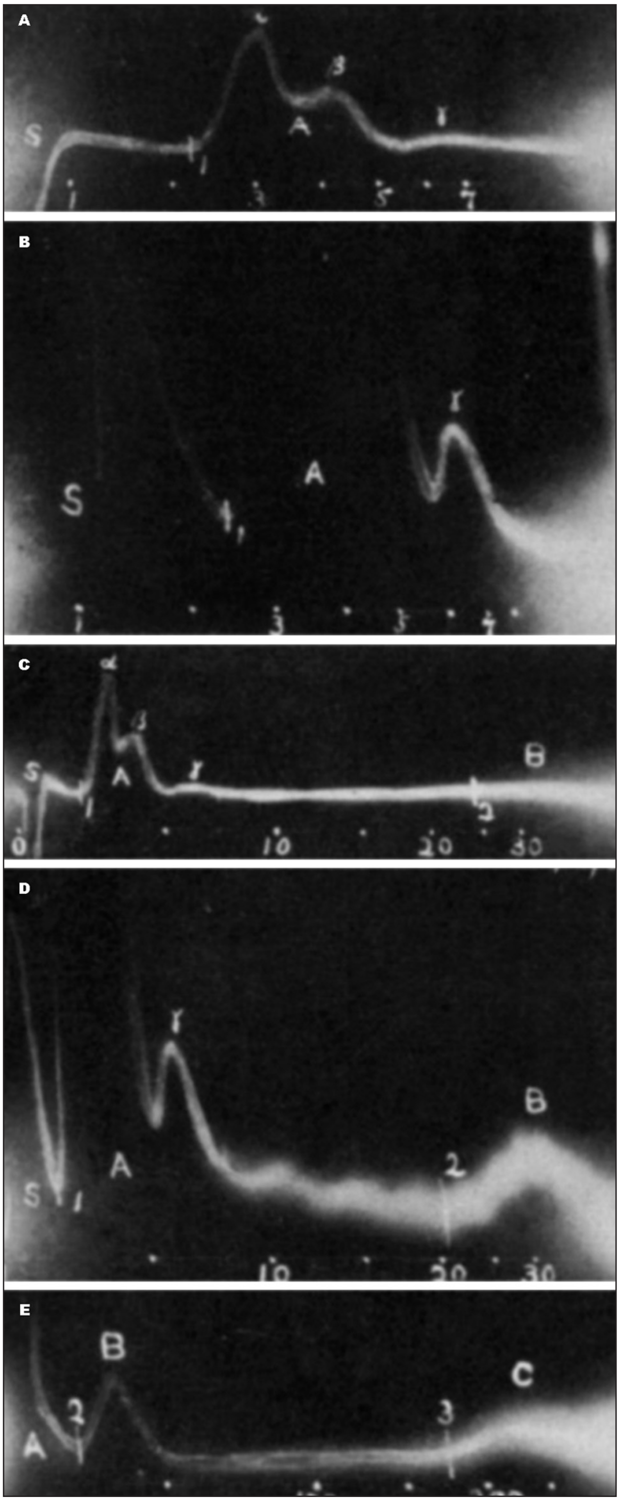

Figure. This is the figure published by Erlanger & Gasser (1930) used with permission of the American Physiological Society. This shows pictures from the oscilloscope screen obtained after stimulation of a frog sciatic nerve and recording 9.1 cm away from the stimulus point. Pictures a and c refers to responses with the same amplification and different time base, while pictures b and d show similar records of a and c with larger amplification. Picture e shows records with larger amplifications and on a different time base. In this figure what is designated B was, on the 1924 paper, designated δ and would soon be so designated again. S refers to the stimulus artifact (see text for details).

In 1941, Gasser[9] published a review describing the relation of the different peaks with the nerve fibers conduction velocities, establishing a relation with their diameter and showing that the separation of the fibers in groups A, B and C was justified especially by the differences found in the return to the baseline of their action potentials ("after potentials"). From the components described in this review (Aα, Aβ, Aγ, Aδ, B and C) only the Aγ component was suppressed from the today's classification of sensory fibers, based on a latter finding of Gasser[10] that this was a recording artifact.

Part of the problem, of the Aδ fibers, for a certain time, being designated B, rested on the fact that, in the frog, B fibers pass through the grey rami into somatic nerves but they do not do so in mammalian nerves[9]. It is accepted today that B fibers, in mammals, are represented by sympathetic preganglionic fibers[11].

From these observations the classification arrived at its present version: in mammals, the motor nerves are composed of Aα, Aβ, Aγ, Aδ and C fibers and pure sensory nerves are composed of the Aβ, Aδ and C components.

Although it was said that the Aγ component was a recording artifact, why was it kept in the fiber's classification of the motor nerves?

While the nerve fiber classification was developing, the study of the motor fibers disclosed that the ventral roots were composed of fibers with diameters showing a bimodal distribution[12]. Although this distribution was initially believed to be related to phasic and tonic motoneurones[12], it was shown by Leksell[13] that the fibers conducting in the "gama range" (according to the classification of Erlanger and Gasser) were in fact motor fibers directed to intrafusal muscle fibers. The observations that extrafusal muscle fibers were innervated by fibers conducting in the alpha range led to the designations of α and γ motoneurons[14]. Following physiological and anatomical evidence, of the existence of some motoneurons innervating intra and extrafusal muscle fibers[15-17] and the recognition that these motoneurons had axons conducting in the lower α range (and apparently following a suggestion of Lapporte)[17],these motoneurons are referred to as β motoneurons[18,19].

There are variations between species in relation to the spectrum of fibers constituents of nerves and therefore the border between the different fiber groups are arbitrary[20] and shows some variations[21]. Considering these, we may quote the classification given by an important textbook on human neuroanatomy[11] where Aα fibers are described as having sizes between 12-22 μm and velocities from 70 to 120 m/s, Aβ from 5-12 μm and velocities 30-70 m/s, Aγ 2-8 μm and velocities 15-30 m/s, Aδ 1-5 μm and velocities 5-30 m/s, B<3 μm and velocities 3–15 m/s and C 0.1-1.3 μm and velocities 0.6–2.0 m/s.

Although this classification is not ideal, as recognized by Gasser[9], this is what we have at this time. More than having a precise border between the different fibers, in broader terms, it seems important to keep in mind that Aα and Aβ fibers refer to thick myelinated fibers, having the highest conduction velocities, Aδ to thin myelinated fibers, having intermediate conduction velocities, and C to unmyelinated fibers, having the lowest conduction velocities. For the same reason, on the motor fibers, it is important to keep in mind that α refer to fibers innervating extrafusal muscle fibers, β to fibers innervating intra and extrafusal muscle fibers and γ to those innervating intrafusal muscle fibers.

Besides this classification, Lloyd in 1943[22], used a slightly different classification of nerve fibers, studying reflex activities in animals, which also acquired widespread use. He classified the fibers in the following way: type I–fibers with diameters from 12 to 20 μm found only in afferent muscle nerves (equivalent to the Aα fibers of the previous classification); type II–fibers with diameters from 6 to 12 μm, prominently represented in cutaneous nerves and having a poor representation in muscle nerves (equivalent to the Aβ fibers of the previous classification); type III–fibers with diameters between 3 and 4 μm, representing the Aδ from Erlanger and Gasser classification; and type IV–fibers represented by the unmyelinated ones(equivalent to the C fibers of the previous classification). Fibers of type I are frequently subdivided in type Ia and Ib to differentiate among afferences from muscle spindles and Golgi tendon organs, although they have the same diameter. Note that by that time a direct relation of diameter and velocity was already implicit, thanks to the early studies referred above.

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