High-Density EMG Techniques in Neuromuscular Studies

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Abstract—We would like to present the usability of High-Density surface EMG (HD-sEMG) recording for measurement of neuromuscular activities. In this mini-symposium, how to use HD-sEMG recording for physiological and morphological measurements will be shown. Particularly, significance of “dry” conditions will be mentioned.

I. BACKGROUND

In recent years, multi-channel surface EMG (sEMG) recordings at multiple locations are frequently used to measure motor unit and muscle fiber properties by researchers on neuromuscular studies. In recent studies, multi-channel sEMG recording is called High-Density EMG (HD-EMG) recording [1].

Intramuscular EMG (iEMG) recording was traditionally used to measure motor unit activities and to diagnosis neuromuscular impairments. However, iEMG recording has demerits and limitations for researchers and clinicians. iEMG electrodes for detection of motor unit action potentials (MUAPs) should be placed into muscle fibers through skin and subcutaneous tissue. Then, in Japan, only clinicians are permitted to use iEMG recording. Therefore, ones except clinicians are not easy to measure motor unit activities with iEMG recording. Also, there are some limitations for measurement of motor unit activities. iEMG electrodes can only record MUAPs in very narrow range in a muscle. Another limitation is that movement during exercise should be restricted to prevent impairment of muscle fiber. Because of the problems, iEMG recording has the difficulty in using for a lot of neuromuscular researchers except clinicians.

As compared with iEMG recording, sEMG recording is mostly used to evaluate whole muscle activity. sEMG recordings is recorded with only electrodes putting on skin surface. However, the surface electrodes should be remote from muscle fibers as current sources. Therefore, sEMG signals easily take kinds of disturbance. HD-EMG recording can reduce the failures of sEMG recordings and can increase the selectivity of MUAP waveforms. Therefore, HD-EMG recording enables us to detect MUAPs and easily classify their trains of each MU based on waveform characteristics. Then, HD-EMG recordings let us measure muscle fiber conduction velocity (MFCV) and estimate locations of innervation zone in a muscle.

In this mini-symposium, we would like to introduce to the fundamentals for usability of neuromuscular researches and physiological and morphological meanings of its recordings from previous our researches. Particularly, significances of “dry” conditions with HD-EMG recordings for neuromuscular studies will be mentioned.

II. HIGH-DENSITY EMG TECHNIQUES

HD-EMG technologies is originally reported by Gidykov et al.[2]. Multiple locations of sEMG electrodes provide spatial distributions of motor units on their EMG signals. The direction of arrangement of sEMG electrodes is important factor for measurement of muscle fiber conduction velocity (MFCV). For measurement of MFCV, sEMG electrodes should be located at regular interval to the parallel direction of muscle fibers. The same MUAP waveforms between the neighboring channels are observed with a little “time delay” because a MUAP conducts along muscle fibers. MFCV indicates important characteristics of muscle fiber composition and physiological properties: MFCV of slow twitch muscle fiber is relatively low and fast twitch one’s is high. It is, then, known that MFCV is gradually decreased with the increase of muscle fatigue.

HD-EMG recording can also estimate locations of innervation zone (IZ) in a muscle. Differential sEMG waveform from near IZ is cancelled because IZ generates MUAPs and the MUAP conducts from IZ to both the tendons and, if the bipolar sEMG electrodes sandwich IZ, each electrode obtains the same MUAP waveforms. With bipolar sEMG electrodes, the IZ locations can be specified to find cancellation of MUAP waveforms on sEMG signals.

EMG decomposition is a procedure which classify MUAPs on EMG signals into each trains based on similarities of MUAP waveforms. The increase of selectivity on HD-sEMG recording enables us to decompose MUAPs into each train. Each MUAP train has the characteristics of motoneuron, i.e. rate coding and its size. Therefore, HD-sEMG recording also provides us with their activities of each motoneuron.

REFERENCES