Replica to “Reference values in concentric needle electrode studies”

We thank Stålberg et al. for the comments on our study (Kokubun et al., 2012) to establish reference values for SFEMG using concentric needle electrodes (CN-SFEMG) (Stålberg et al., 2013). We also acknowledge the great efforts of Kouyoumdjian and Stålberg (2008a,b, 2011) who completed a series of studies that also investigated reference values of CN-SFEMG. The difference between the two studies is that ours is a multicenter study whereas theirs were performed at one laboratory, and the actual examination was done by one investigator (the first author of their studies). Both methods of investigation have advantages and disadvantages. The merit of the study from a single laboratory is that the equipment is standardized and the technique is uniform. However, the results from such a study may not be directly applicable to examinations in other laboratories. Lack of uniformity is the disadvantage of a multicenter study. However, such differences may be “diluted” and the results may be more reasonably applicable to results at other laboratories (Stålberg and Trontelj, 1994); especially when inter-institutional differences are negligible, an issue which is discussed later in this reply.

In order to reduce the differences between institutions and investigators as much as possible, before starting this study, we discussed the many technical aspects of SFEMG examinations extensively and established a rigid protocol, especially on the management of possible pitfalls. Special care was taken to avoid composite potentials, dull potentials that may interfere with the jitter measurements, velocity recovery function (VRF) jitter in the voluntary SFEMG (V-SFEMG), and subthreshold stimulation in the stimulated SFEMG (S-SFEMG) (Kokubun et al., 2012).

We would like to explain our measures against individual pitfalls mentioned by Stålberg et al. (2013). The regulation that the stimulus intensity should be set at least 20% over the threshold for each accepted individual potential was strictly adhered. Due to this restriction, we even felt that S-SFEMG may take a longer time than V-SFEMG because when the stimulus intensity was increased from the threshold intensity for a potential to 20% over that, the potential was frequently lost by the slight displacement of the needle due to a stronger contraction, or was interfered by the newly-recruited potentials, which were not accepted either.

Composite potentials were identified not only by their complicated shape but also by the variation of the shape after minute displacements of the needle or during consecutive discharges. Such potentials were carefully excluded from the analysis when it was judged that the jitter measurement became inaccurate due to the contamination of the disturbing potentials. Furthermore, erroneous inclusion of composite potentials should decrease the jitter value, and not increase it, since the jitters of constituent potentials would be averaged and partially cancelled out.

Although we did not automatically exclude potentials with interpotential interval (IPI) values outside ±2 SD, the contamination of SF potentials from non-target motor unit is a fundamental pitfall in SFEMG examinations, and this was well appreciated by all participants, and we believe that exclusion of such potentials were strictly performed.

The criterion that IPI should be less than 2 ms in V-SFEMG might have been too strict considering the description that the contamination of the VRF jitter may make the jitter value inaccurate when IPI is more than 3–4 ms (Stålberg and Trontelj, 1994). However, a more strict criterion in this regard would just decrease the jitter value if anything.

There are a few factors that cannot be unified in the multicenter study. The selection of needle is one such factor because each institution had favorite needles that have been long employed at that laboratory. The EMG equipment is also a typical one, and the triggering method, peak detection or voltage threshold, is often specific to the equipment and is unchangeable. However, we think that the difference of the triggering methods would not have caused much distortion in the obtained results. Riding signals are a situation for which the voltage threshold method may give incorrect results, but we excluded such potentials when we judged that the distortion was significant: a policy belonging to the exclusion of composite potentials. We think that both methods have advantages and disadvantages. Even the peak detection method may have limitations for potentials that have a steep rising phase but a very gradual falling phase, as was often observed.

It is evident that the increased jitter and blocking in the example presented in our manuscript (Fig. 3 in Kokubun et al., 2012) is not due to above known pitfalls such as composite, riding or dull potentials, or contamination of potentials from other motor units.

Plural cut-off values were presented by the following reasons. When the data have a single-layer structure, one can easily judge the “degree” of abnormality using the given mean and SD values. A result with +3 SD would be definitely abnormal. However, the interpretation of an observation with +1.8 SD (> the 95th percentile) might depend on the clinical situation (pre-test probability). The problem is that such a judgment is not simply achieved when the data have double-layer structure, such as in the outlier analysis, since the selection of the cut-off level is done at the first layer. Because +2 SD is widely employed for the judgment of abnormality (Kouyoumdjian and Stålberg, 2008a,b, 2011), we have even newly added the cut-off values corresponding to the +2 SD (Table 1). For EDC-V, for instance, if more than 10% of collected potential pairs have MCD values >50.2 μs, we can infer that this is an abnormality of the degree that would allow 5% false-positive rate (+1.68 SD
level). However, if more than 10% of collected potential pairs have MCD values $>56.8\,\mu$s, we can infer that this is an abnormality of the degree that would allow only 0.8% false-positive rate ($+2.5\,SD$ level). The cut-off values using $+2\,SD$ (bold letters) might be appropriate as the single representative cut-off value.

As mentioned earlier, the investigation of the inter-institutional variability would be the key to judge the reliability of a multicenter study. Therefore, we added the analysis of the test for the difference between multiple independent groups regarding the upper 10th percentile values of individual subjects for 4 major institutions (Institutions A–D in Table 1 of Kokubun et al., 2012), using one-way analysis of variance, or Kruskal–Wallis test when the variance was not homogeneous. As results, there were no significant differences for the upper 10th percentile values between institutions for all 4 examinations (EDC-V, EDC-S, FRO-V, and FRO-S). However, the variance was significantly inhomogeneous for 3 of the examinations (EDC-S, FRO-V, FRO-S) using the Bartlett test ($p<0.001$). Accordingly, inclusion of the data from institutions showing large variance might have elevated the cut-off values. Actually, exclusion of the data from one institution (labeled as Institution X) that always gave large variance, i.e. frequent outliers, resulted in the cutoff values ($+2\,SD$) of 53.0, 51.8, 44.2, and 40.8 $\mu$s for EDC-V, EDC-S, FRO-V, and FRO-S, respectively. As compared to the values presented in Table 1, the cut-off values for the frontal muscle are considerably lower. Interestingly, institution X is controlled by the most-experienced expert (who was taught SFEMG by Prof. Stålberg over a long period of time), though all institutions were managed by experts. Besides institution X, there was a tendency that the outlier data, i.e. subjects with rather high jitter values, were frequently reported from more-experienced institutions. This suggests that extreme values were not due to known pitfalls that have been much discussed above (the seemingly abnormal data with blocking presented in Fig. 3 of Kokubun et al., 2012 are also from the Institution X).

We think that these paradoxical results support our speculation (Kokubun et al., 2012) that if the examiner hesitates in accepting an abnormal-looking potential, such a potential might be easily lost in the CN-SFEMG examination, for which the fixation of the needle in place is more difficult than with single-fiber needles. One may well anticipate that a control subject would give normal results. A less-experienced examiner would be more likely to lose a potential and would be also less confident that an abnormal-looking potential was not due to known pitfalls. In actual fact, there is considerable inter-individual variation of MCD values in normal subjects (Stålberg and Trontelj, 1994). Even blocking potentials are observed in normal subjects, though rarely (Stålberg and Thiele, 1975). These characteristics of normal data have been well reproduced in our data, and blocking potentials were also observed at a frequency of 0.16% (Kokubun et al., 2012).

Our results on EDC-V seems to be the most reliable since the inter-institutional variability was the least. This may be due to the fact that all participants were most accustomed to this examination. The obtained cut-off value, 52.7 $\mu$s using $+2\,SD$ criterion, is close to the conventional value of 55 $\mu$s (Stålberg and Trontelj, 1979; Sanders et al., 1979) and also to the values from the previous multicenter study (50.1–54.4 $\mu$s; Gilchrist et al., 1994), both obtained using single-fiber needles. We guess that the distortion due to composite potentials in CN-SFEMG (Stålberg et al., 2013) was small, if any, since we carefully excluded composite potentials, and therefore there is no reason why the values should be different between single-fiber and concentric needles.

The similar cut-off values for stimulated and voluntary SFEMG are the remaining enigma. This remained the same even after the exclusion of the data from Institution X. Although the mean or median values were close to the expected 71% of the voluntary studies, the cut-off values became similar due to the more frequent contamination of the rare extreme values in S-SFEMG. We now think that this may be due to an undescribed pitfall that is specific to S-SFEMG using concentric needles. For the concentric needle, the recording surface is surrounded by the sharp edge and tip of the needle. The muscle fiber being recorded may be repeatedly struck by the sharp edge or tip of the needle following synchronous contraction of adjacent muscle fibers in S-SFEMG.

Finally, the remaining discrepancy between our study and those by Kouyoumdjian and Stålberg should be resolved. We would like to propose a new international multicenter studies participated by researchers from various countries, including Brazil, Japan, Sweden, USA, and other countries.

References


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Table 1
Proposed cutoff values for the individual MCD.

<table>
<thead>
<tr>
<th>Upper 95% prediction limit (one tail)</th>
<th>Expected false positive rate</th>
<th>Cutoff values for the individual MCD to judge the upper 10th percentile ($\mu$s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EDC-V</td>
</tr>
<tr>
<td>$+2.5,SD$</td>
<td>0.8%</td>
<td>56.8</td>
</tr>
<tr>
<td>$+2,SD$</td>
<td>2.6%</td>
<td>52.7</td>
</tr>
<tr>
<td></td>
<td>Upper 95% prediction limit</td>
<td>5%</td>
</tr>
</tbody>
</table>

MCD, mean consecutive difference; EDC-V, voluntary extensor digitorum communis (EDC) study; EDC-S, stimulated EDC study; FRO-V, voluntary frontalis study; FRO-S, stimulated frontalis study.
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Alpha-frequency EEG artifact from a high-frequency oscillatory ventilator (HFOV)

We describe an artifact in a patient undergoing HFOV for acute respiratory distress syndrome (ARDS).

Artifact is unavoidable when recording EEG, especially in the ICU. Artifact from conventional mechanical ventilation (CMV) is caused by switching magnetic fields within the motor and by the movement of electrodes or leads as the body moves, and consists of rhythmic, high-amplitude slow waves, maximal over the frontal leads (White and Van Cott, 2010).

HFOV is a type ventilator mode which delivers small tidal volumes at high respiratory rates, and is used as a protective ventilation mode in patients with ARDS who are hypoxic despite optimal CMV (Ip and Mehta, 2012).

Case

A 27 year-old man was admitted from an outside institution for ARDS and refractory hypoxemia. He presented 1 week prior for fatigue, myalgias, hemoptysis, fever, and difficulty breathing. He was intubated for respiratory distress and hypoxemia. Initial chest X-ray was unremarkable; a nasal swab on revealed H1N1. He subsequently developed bilateral infiltrates and hypoxemia, refractory to CMV.

He was transferred to our hospital and placed on a HFOV with an improvement in oxygenation. Days later he developed mid-sized, non-reactive pupils. His sedative medications were discontinued, and he had no respiratory drive or ventilator dysynchrony despite an arterial pH of 7.23. He had no movement spontaneously or to noxious stimuli and there were no eye movements with passive rotation of the head. Gag and cough responses were also absent. Somatosensory evoked potentials were performed. On stimulation of each median nerve the N13, N9 were clearly defined and reproducible and the N20 was absent. He was subsequently declared brain dead.

Video EEG was performed, and revealed severe attenuation of all rhythms with EKG and alpha-like artifact posteriorly, greatest in lead O1 (Fig. 1A). This rhythm did not desynchronize with passive eye opening (Fig. 1B). After repositioning of the head the artifact became less apparent (Fig. 1C).

To our knowledge this is the first description of EEG artifact caused by HFOV. Autopsy results are pending, but we believe he was clinically brain dead at the time of the recording. He may have developed diffuse cerebral edema from H1N1, as has been described previously (Kahle et al., 2011). Initial signs of herniation were likely missed due to sedation and paralytics required for HFOV.

The recognition of this type of artifact is important to help understand patterns of physiologic and non-physiologic brain activity in the ICU, especially in an era where the optimal roles for video EEG, continuous EEG, and quantitative EEG are being established.

References


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Bilateral recurrent motor branch of median nerve neuropathy following long-distance cycling

A 53 year old male regular cyclist presented with weakness in both hands after a 300 km cycling event that lasted for 12 h. He described the weather as cold and he started to feel stiffness in his hands during cycling but did not take great notice of it. This stiffness became somewhat worse after the event had finished. When he woke the next day he could not use his hands properly and noticed weakness of pincer grip. He had no major sensory symptoms apart from some paraesthesia over the back of the hands between thumb and index fingers. He also noticed some tenderness in his thenar muscles.

His symptoms remained the same with no improvement and he was referred for neurophysiological testing by his neurologist which was performed 25 days after the event. He had history of intermittent Raynaud’s syndrome with colour change in his fingers which he described as different from the symptoms he had experienced on this occasion. He had no pre-existing hands symptoms otherwise. There was no history of vascular disease or any other medical history of note. There was no family history of neurological disease and he took no regular medication.

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