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Uncertainty Analysis in Median Sensory Nerve Conduction Study

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Objectives

Nerve conduction study (NCS) is an essential tool to evaluate functions and pathologic conditions of peripheral nerves, and could offer the critical clues for diagnosing neuromuscular disease. However, because of the uncertainty of measurement affected by subject, physician, instruments, and other laboratory environment, there is no standardized reference data according to demographics not only for South Korean but also for the world. It brings out a variety of reference values at each lab, makes diagnosis confusing, and results unnecessary retest. To establish reference standards of NCS measurement index, in this precedent research, we calibrated the instruments and calculated the expanded uncertainty (Uexp) during the median sensory NCS.

Methods

We operated the antidromic way for median sensory NCS, recording at 2nd finger, and stimulated at 14cm distal from active electrode with 20% supramaximal intensity. The skin temperature of hand was between 32° and 36°. We calculated calibration uncertainty (UC), Type A intra-rater uncertainty (UA), Type B inter-rater uncertainty (UBI), and Type B uncertainty according to device resolution (UBR). To calculate UC, we made the EPCs generating 5ms of onset latency (Lo) and 63.456uV of peak to peak amplitude (Aptp), and measured it through electro-diagnostic machines (Nicolet EDX, Natus, USA) 10 times (Fig. 1). The EPCs was secured traceability by accredited calibration company. For UA, a skilled physician measured 10 times of a median sensory nerve in a normal subject who has no neuromuscular disease. And for UBI, 10 different skilled physicians measured the subject (Table 1). UBR was calculated from the resolution of 0.01ms by 0.01uV fields.

Results

The measured EPCs values through the machine were 5.12ms for Lo, and 59.39uV for Aptp. The correction values were -0.12ms and 2.033uV for Lo and peak amplitude (Ap), respectively. The results of Lo and Ap of UC were 0.030ms and 0.635uV, UA were 0.0158ms and 0.5724uV, UBI were 0.0133ms and 0.07767uV, and UBR were 0.0029ms and 0.0029uV, respectively. According to the formula calculating total combined standard uncertainty (Ucom), the Ucom of Lo and Ap were 0.037ms and 1.155uV. At last, the final report of the median sensory NCS for the subject examined by one physician can be described in corrected mean measurand with the Uexp values. These are 2.60 ± 0.073ms of Lo and 45.30 ± 2.309uV of Ap (CI 95%, k = 2) (Table 2).

Conclusions

In this study, we measured Lo and Ap of median sensory nerve with Uexp for the first time. The other reference standards, such as the duration, area and the nerve conduction velocity can be obtained at future, and further study according to age and sex also would be necessary. The further research and web based sharing of NCS reference standards of South Korean can improve inter-laboratory reliability, encourage accurate diagnosis of disease, and establish credible research about neuromuscular disease.

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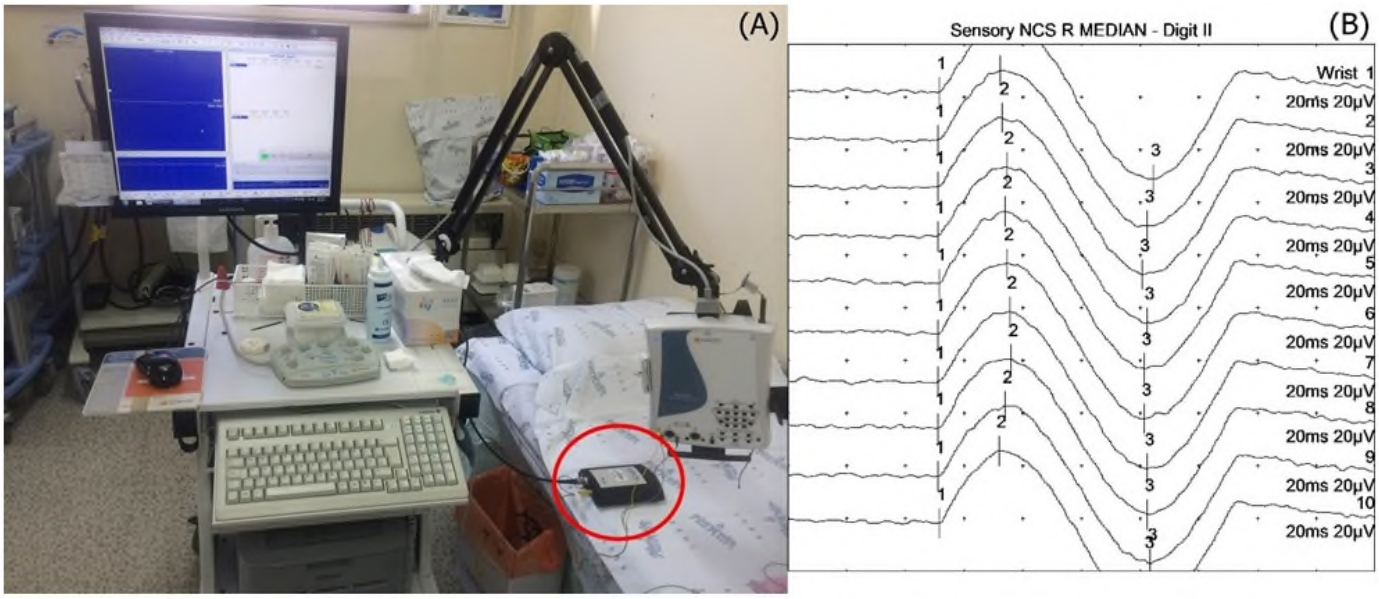

Fig. 1. The electro-diagnostic machine measure the standard signal generator (EPCs, in red circle) (A) 10 times (B). The EPCs was secured traceability from calibration company (KTICC, South Korea) accredited by Korean Laboratory Accreditation Scheme (KOLAS). The difference between the measured values through the machine and the generated values by EPCs was 5.12ms versus 5.00ms for onset latency, and 59.39uV versus 63.456uV for peak to peak amplitude. The correction values were -0.12ms and 2.033uV for onset latency and peak amplitude, respectively.

Nerve / Sites	Onset latency (ms)	Amplitude (μV)	Nerve / Sites	Onset latency (ms)	Amplitude (μV)
R MEDIAN – Conductor 1			R MEDIAN - Conductor from 1 to10		
Wrist	2.71	68.5	Conductor 1	2.72	71.13
2	2.60	72.0	Conductor 2	2.79	72.98
3	2.76	71.8	Conductor 3	2.73	72.15
4	2.76	70.7	Conductor 4	2.81	77.78
5	2.66	72.4	Conductor 5	2.85	67.81
6	2.71	70.8	Conductor 6	2.81	65.11
7	2.76	69.0	Conductor 7	2.81	66.33
8	2.76	70.3	Conductor 8	2.80	71.33
9	2.71	74.0	Conductor 9	2.79	71.24
10	2.76	71.8	Conductor 10	2.83	71.01

Table 1. The measured values for inter and intra-rater uncertainty.

Uncertainty factors	Type	Distribution	Onset latency			Peak Amplitude		
			Values	Divisor	Standard uncertainty (ms)	Values	Divisor	Standard uncertainty (uV)
EPCs calibration (U_C)	B	normal	0.030 (SD)	2	0.015	0.635 (SD)	2	0.317
Intra-rater uncertainty (U_A)	A	normal	0.050 (SD)	$\sqrt{10}$	0.016	1.810 (SD)	$\sqrt{10}$	0.572
Inter-rater uncertainty (U_{BI})	B	normal	0.040 (SD)	3	0.013	2.330 (SD)	3	0.777
Resolution (U_{BR})	B	Rectangular	0.010	$2\sqrt{3}$	0.003	0.010	$2\sqrt{3}$	0.003
Combined standard uncertainty(U_{COM})		Presumed normal			0.037			1.155
Expanded uncertainty (U_{EXP})		Presumed normal			0.073			2.309

The $U_{EXP}$is reported based on a U_{COM}, multiplied by a coverage factor of k=2.00, providing a confidence level of approximately 95%; the U_{COM} is calculated by $\sqrt{U_c^2 + U_A^2 + U_{BI}^2 + U_{BR}^2}$formula;SD, standard deviation.

Table 2. Combined standard uncertainties and expanded uncertainties in median sensory NCS.