Strength-duration time constant and rheobase measurements

Comparison of the threshold tracking method and a non-automated procedure

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OBJECTIVE. To compare the strength-duration time constant (SDTC) and rheobase measurements obtained by the threshold tracking method (TT) and by a non-automated method (MM).

METHODS. The MM procedure involves measuring, using a routine electrodiagnostic device, the intensity required to evoke a motor response whose amplitude corresponds to 40% of the maximum amplitude for four stimulus duration (1.0, 0.7, 0.5, 0.2 ms), and studying the linear relationship between stimulus charge and stimulus duration (slope = rheobase, intercept on the x-axis = SDTC) (figure 1). Using TT (regular TROND protocol) and MM, 20 successive healthy subjects (mean age = 38 y.o.) underwent a prospective evaluation of SDTC and rheobase of the median nerve motor axons at the wrist. Nerve stimulation (cathode-anode) and bipolar recording of evoked motor responses are performed with disposable self-adhesive surface electrodes. These are positioned only once for both techniques. The cutaneous temperature at the wrist is maintained above 31° C and the median impedance under the stimulation electrodes around 2 kΩ.

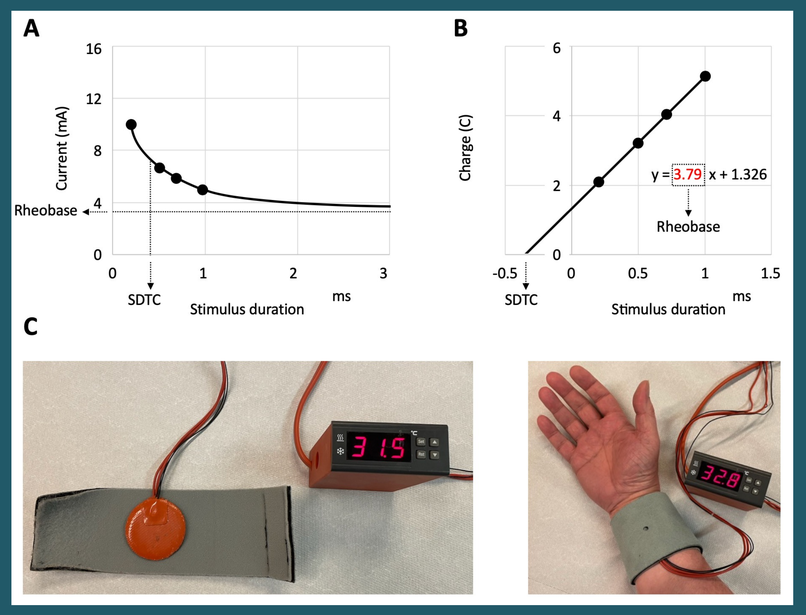

Figure 1: Strength-duration relationship evaluated by the manual method. A. *The intensity necessary to reach a target fixed at 40% of the maximal motor response amplitude was measured for four stimulus durations : 1.0, 0.7, 0.5 and 0.2 ms. The rheobase was the estimated threshold current for a stimulus of infinitely long duration. The strength-duration time constant (SDTC) is the minimum stimulus duration for a current twice rheobase.* ***B.*** *In practice, thanks to the empirical law of Weiss (1901), the curve in A was linearized by considering the relationship between the delivered charge (current X stimulus duration) and the stimulus duration. The rheobase was defined by the slope of the linear relationship (3.79 mA in this example) and the SDTC by the intercept on the x-axis (0.35 ms in this example).* ***C.*** *The hand temperature was maintained above 31°C using a splint with heating silicone (50 mm diameter), digital thermostat, 5V/12V transformer, and USB connection.*

RESULTS. Median values obtained by TT and MM are respectively 430 µs and 425 µs for SDTC and 2.97 mA and 3.02 mA for the rheobase. The Spearman correlations between the two methods are 0.82 (p < 0.0001) for SDTC and 0.97 (p < 0.0001) for the rheobase. The Bland-Altman analysis does not reveal any systematic bias of MM compared to TT (figure 2). The Spearman correlation matrix revealed weak negative correlations between SDTC and rheobase. There were no significant correlations between stimulation electrode impedance and rheobase. The Wilcoxon signed-rank test between the data derived from the two procedures did not show significant differences.

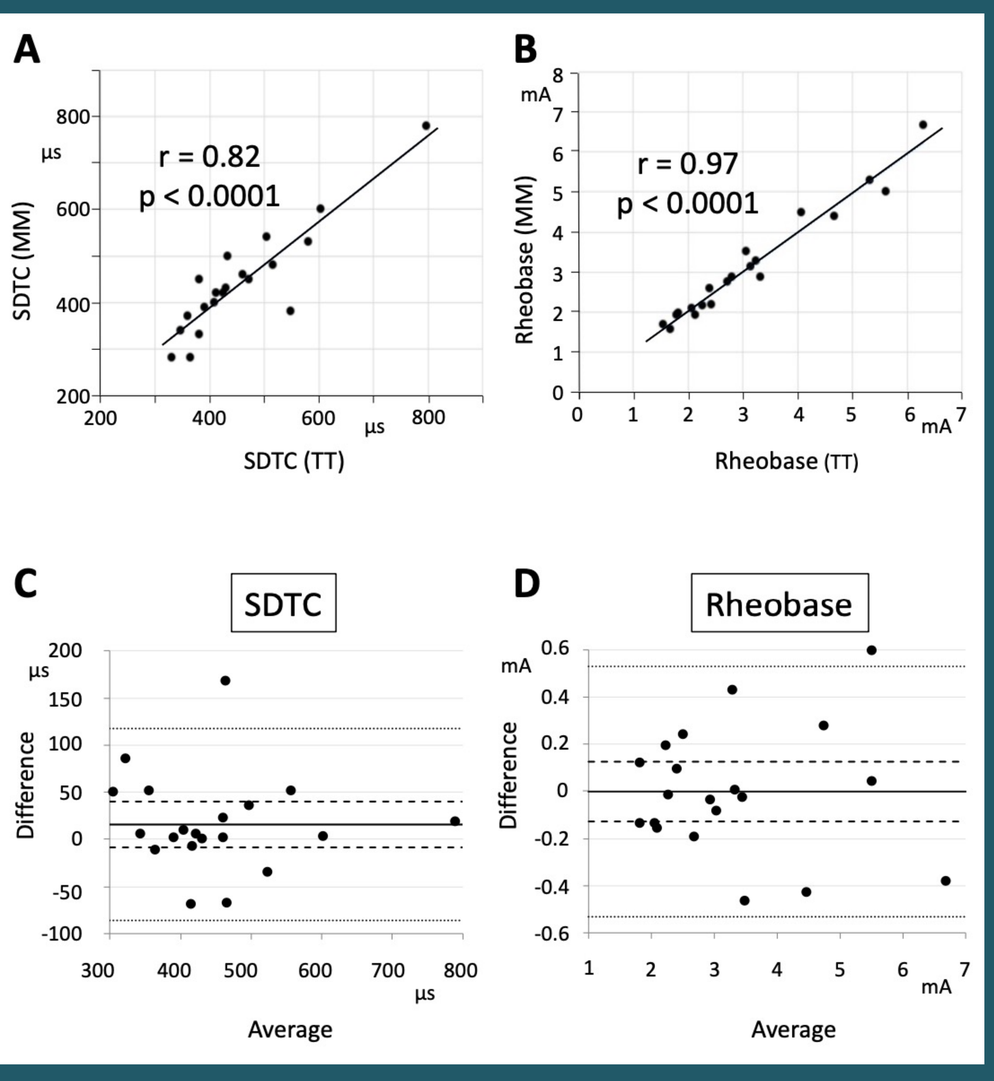

Figure 2: Spearman correlations between the data obtained by the threshold technique procedure (TT) and the manual method (MM). A. Strength-duration time constant (SDTC). B. Rheobase. The Bland-Altman analysis did not reveal any systematic bias of MM compared to TT for SDTC (C.) and rheobase (D.)

Table 1: Excitability & technical data (n = 20)

	Median (Q2)	Q1	Q3
THRESHOLD TRACKING METHOD			
Peak (mV)	9.29	8.31	10.72
SDTC (µs)	430	380	515
Rheobase (mA)	2.97	2.30	3.89
MANUAL PROCEDURE			
Maximal CMAP (mV)	8.90	8.00	10.70
SDTC (µs)	425	375	490
Rheobase (mA)	3.02	2.23	4.16
STIMULATING ELECTRODE IMPEDANCE			
Anode (kΩ)	2.25	1.25	4.15
Cathode (kΩ)	1.95	1.25	3.40
Earth electrode (kΩ)	1.60	0.80	2.90

SDTC = strength-duration time constant: CMAP = compound muscle action potential

CONCLUSION. These results suggest that both techniques can be used to assess the excitability of peripheral motor axons accurately, and their use will depend on researchers' preferences and the availability of measurement devices. The manual establishment of rheobase and SDTC (chronaxie) as proposed in this study is reliable. Moreover, it is a fast procedure that takes no more than few minutes. We encourage neurophysiologists, who do not have dedicated threshold tracking equipment, not to hesitate to use these simple tools to assess peripheral nerve excitability.

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