Middle Latency Somatosensory Evoked Potentials Compared among Unilateral, Simultaneous Bilateral, Alternative Bilateral Median Nerve Stimulation

Yuji NAKAZUMI, Kiyoko TAKAHASHI, Asako HIRATSUKA,
Haruo KOMAZAWA, Tsuguo ASAKURA

Abstract: The purpose of this study is to assess the clinical value of the alternative bilateral median nerve stimulation for the recording of the middle latency somatosensory evoked potential (MSEP). Short latency somatosensory evoked potential (SSEP) following unilateral stimulation is standardized as an objective sensory examination in clinical practice. MSEP showed more abnormality than SSEP for patients with brain damage. But MSEP has not been standardized yet because of the wave-form changes due to the arousal level and habituation. Using alternative bilateral stimulation, we could compared the right and the left side wave-form circumventing this problem. The interaction of bilateral afferent inputs did not modify the evoked potential.

Key Words: Somatosensory evoked potential, Brain damage, Sensory disturbance

Introduction

Clinically, sensory examination is difficult for patients with consciousness disturbances, aphasia or dementia. Short latency somatosensory evoked potential (SSEP) elicited within 20 ms following median nerve stimulation at the wrist is widely used for objective sensory examination. Middle latency somatosensory evoked potential (MSEP) is elicited during 20 to 100 ms after the stimulation shows more abnormality than SSEP for patients with brain damage. But MSEP has not been standardized yet because its wave-form changes with the arousal level and habituation in the same subject. Simultaneous bilateral stimulation (STIM-SB) is recommended to compare the difference between right and left sides. In this setting, changes with the arousal level and habituation can be compensated. Another problem occurred in STIM-SB. MSEP consists of a mixture of both afferent input coming from the right and left median nerves. In severely damaged brains, MSEP recorded from the injured side of the scalp is produced mainly by the un-injured side of the brain. Therefore, we tried to assess alternative bilateral stimulation (STIM-AB) in order to retain the advantages and remove the disadvantages of unilateral and simultaneous bilateral stimulation 6).

Materials and Methods

In 32 cases with brain damage, MSEP was recorded using unilateral, simultaneous bilateral and alternative bilateral stimulation. The cases were 20 male and 12 females, aged 18 to 82 years old, 26 cerebrovascular diseases (CVD), 6 traumatic brain injuries (TBI).

Recording electrodes were placed at F3, F4, C3' and C4' (2 cm behind C3 and C4) in accordance with the 10-20 International System. F3 and F4 are located on the motor cortex of the hand, C3' and C4' are located on the primary sensory area of the hand. Linked ears (A1+A2) served as a reference for all

Yamagata School of Health Science
260 Kamiyanagi Yamagata Yamagata 990-2212, Japan

recordings. Stimulus electrodes were placed over the median nerve at the wrist with a cathode 2.5 cm proximal to an anode. Stimuli with a pulse duration of 0.2 ms were delivered at a rate of 3.3 Hz. Pulse intensity was adjusted to 150 % of the motor threshold of the short abductor muscle of the thumb. MSEP were obtained using a 3 to 3000 Hz bypass filter. A total of 256 evoked potentials were averaged to produce MSEP wave-form and this procedure was repeated twice for every set described below.

#1; Stimuli on the right side only (STIM-R)
#2; Stimuli on the left side only (STIM-L)
#3; Simultaneous bilateral stimuli (STIM-SB)
#4; Alternative bilateral stimuli (STIM-AB) with inter-stimulus interval of 150 ms proceeding from the right side to the left.

Using a computer, the waves recorded in sets #3 were subtracted by the waves summated with set #1 and set #2. (SUB-SB ; #3 − #1 − #2)

The waves recorded in set #4 were also subtracted by the algebraic composed set #1 and set #2. (SUB-AB; #4 − #1 − #2)

In figures 1 and 2, #A and #B were elicited by #1 (STIM-R), #C and #D by #2 (STIM-L). #I, #J were elicited by #3 (STIM-SB), #K and #L by #4 (STIM-AB).

Results

I. STIM-SB and SUB-SB

STIM-SB produced clearer SSEP and MSEP responses than STIM-R or STIM-L. The wave-forms were more reproducible, and the peaks were easier to identify. But in 32 STIM-SBs, 9 cases showed new peaks on injured side of the scalp, which were not recorded by unilateral stimulation of the injured side. These peak latencies were similar to N17, P20, N29,

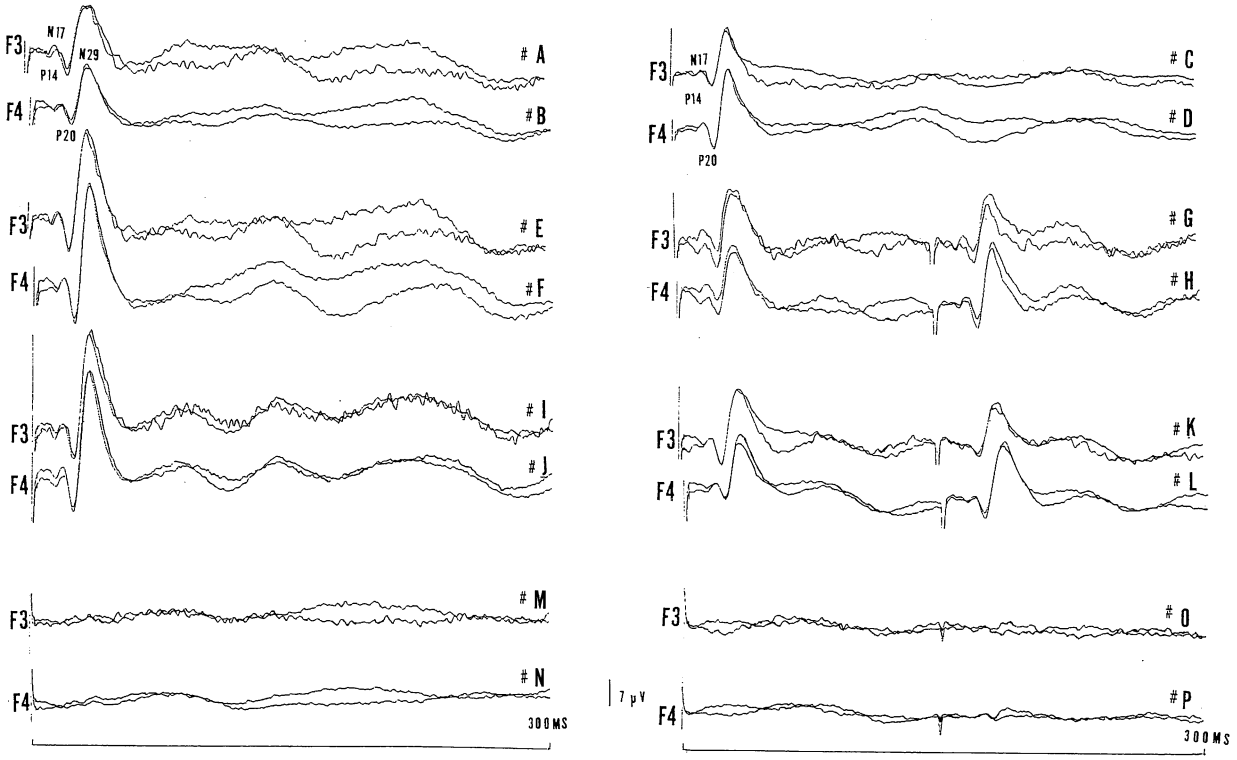

Fig. 1 MSEP recorded from 26 years old female with myoclonic epilepsy.
#A and #B : STIM-R. #C and #D : STIM-L.
#E was algebraic sum of #A and #C. #F was algebraic sum of #B and #D.
#G was algebraic sum of #A and #C with 150 ms delay. #H was sum of #B and #D.
#I and #J : STIM-SB. #K and #L : STIM-AB.
#M was the subtraction of #I from #E. #N was the subtraction (SUB-SB).
#O was the subtraction of #K from #G. #P was the subtraction (SUB-AB).
MSEP elicited by STIM-SB or STIM-AB is nearly identical to the algebraic sum of two MSEPs elicited STIM-R and STIM-L.

N32, P40 or N60 recorded by unilateral stimulation of un-injured side. (Figs. 3,4)

MSEP produced by STIM-SB were nearly identical to those generated by a computer using two MSEP elicited by unilateral stimulation. (Figs. 1,2)

Ⅱ. STIM-AB and SUB-AB

Using STIM-AB, we can compare MSEP recorded from the right side of the scalp to that of the left side of at the same arousal level and habituation.

MSEP produced by STIM-AB were nearly identical to those generated by two MSEP elicited by unilateral stimulation. (Figs. 1,2)

Discussion

SSEP is widely used in clinical practice 4). The recording procedure has been established by the International Federation of Electroencephalography and Clinical Neurophysiology 3). In our laboratory, SSEP was routinely recorded in patients with spinal cord lesions and brain stem lesions, and judged in reference to our normal values.

MSEP showed more abnormalities than SSEP in cerebral lesion. We studied 127 cases with supra-tentorial lesions, consisting 108 CVDs, 14 TBIs, 3 encephalitis, 1 multiple sclerosis and 1 myoclonic epilepsy. Forty-seven cases (37 %) showed normal SSEP and abnormal MSEP. (Fig. 5)

MSEP changed with the arousal level and habituation (Fig. 6). STIM-SB is recommended 5) to remove these variation. However, in severely damaged cases, the afferent input from the un-injured side has a large influence on the evoked potential of injured side of the scalp. As the result of SUB-SB, these new peaks arose from the afferent input of unaffected side. Therefore, it is controversial to compare both side of MSEP elicited by STIM-SB.

STIM-AB produced MSEP with concomitant afferent input from the right side and the left side. We compared both side of the MSEP wave-form ignoring the arousal level and habituation. As the result of SUB-AB, MSEP is nearly identical to the algebraic sum of the two MSEP elicited by unilateral

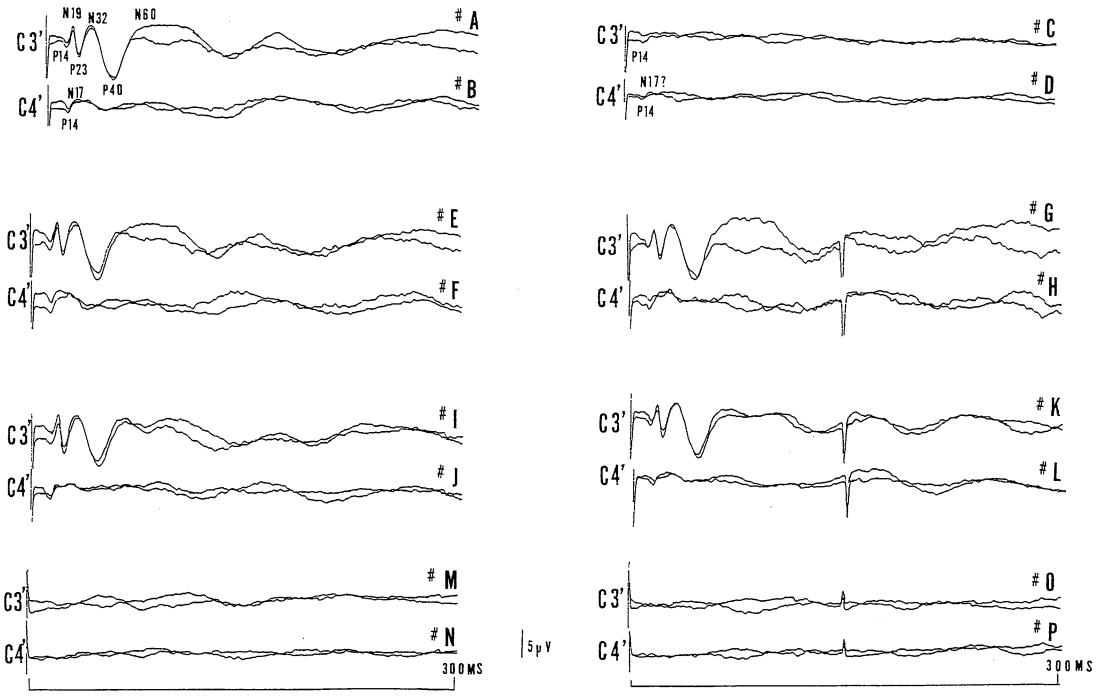

Fig.2 MSEP recorded from 56 years old male with right thalamic hemorrhage.
#A,B,C,D were recorded C3′ or C4′ by STIM-R or STIM-L same as Fig 1.
#E,F,G,H were the algebraic summation by computer same as Fig. 1.
#I,J,K,L were actually recorded wave-forms by STIM-SB or STIM-AB same as Fig 1.
#M,N,O,P were the subtraction of actual wave with algebraic summated wave.
Both side afferent interaction did not modify MSEP in this condition.

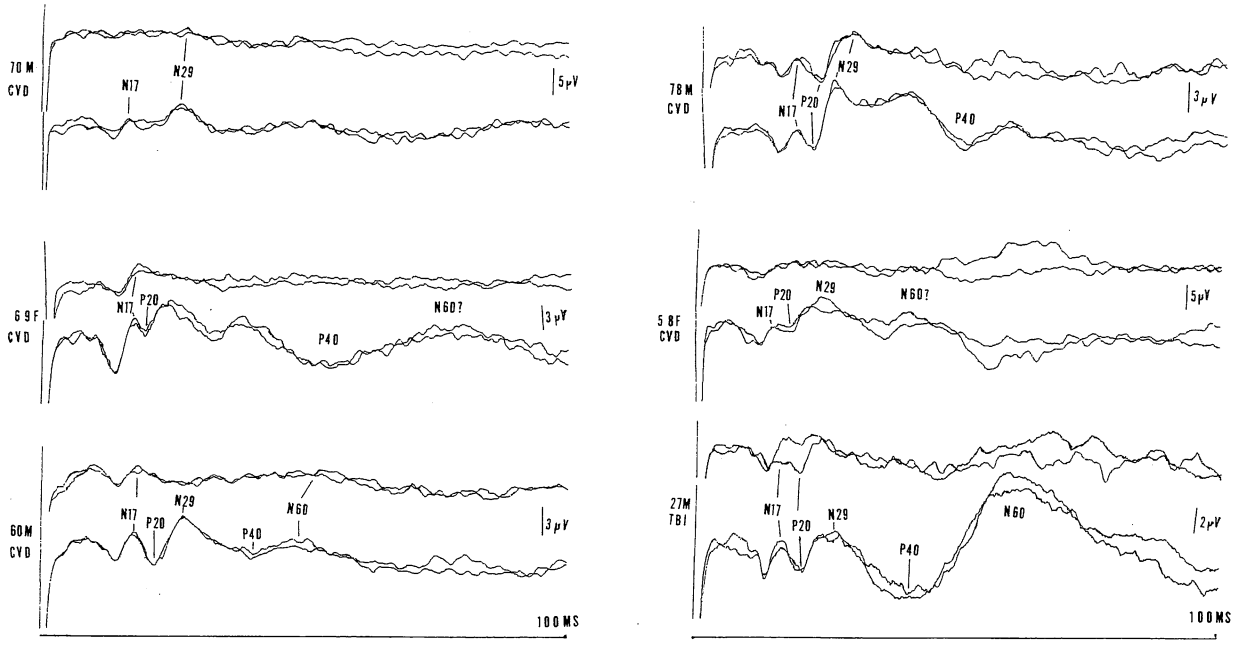

Fig. 3 Examples of wave-forms recorded at F3 or F4 which showed different peaks by STIM-SB compared with unilateral stimulation.
Not only contra-lateral but also ipsi-lateral afferent input elicited potentials.

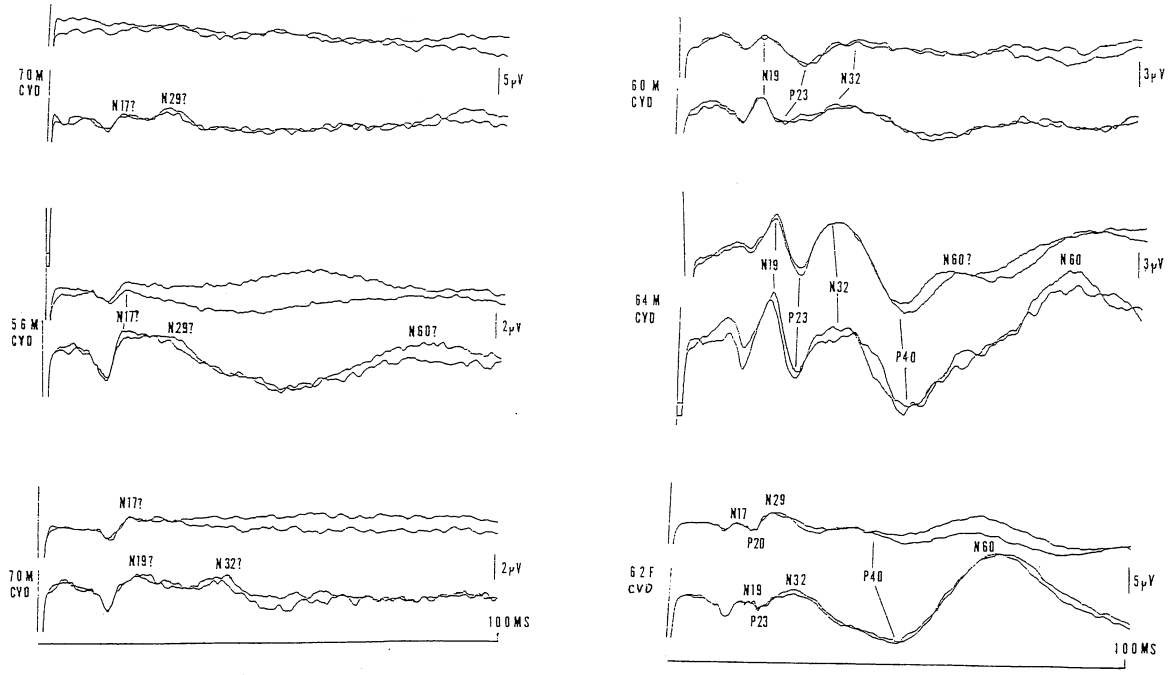

Fig. 4 Examples of wave-forms recorded at C3′ or C4′ which showed different peaks by STIM-SB compared with unilateral stimulation.
In severely damaged case, MSEP recorded at injured side of the scalp was mainly produced by the afferent input from the unaffected side.

stimulation.

Anatomically 7), the sensory cortex collects the afferent inputs from the both sides of the limb. Medial leminiscus is wholly crossed, while an appreciable number of the spino-thalamic tracts ascend on the same side and terminate in the ipsi-lateral thalamus. The second sensory cortex is known to respond to the information from the both sides of the limb. An interaction between both sensory input to evoked potential has been reported 1). But in this study, these interaction did not modify MSEP. We suppose that the potential mainly represents the deep sensation

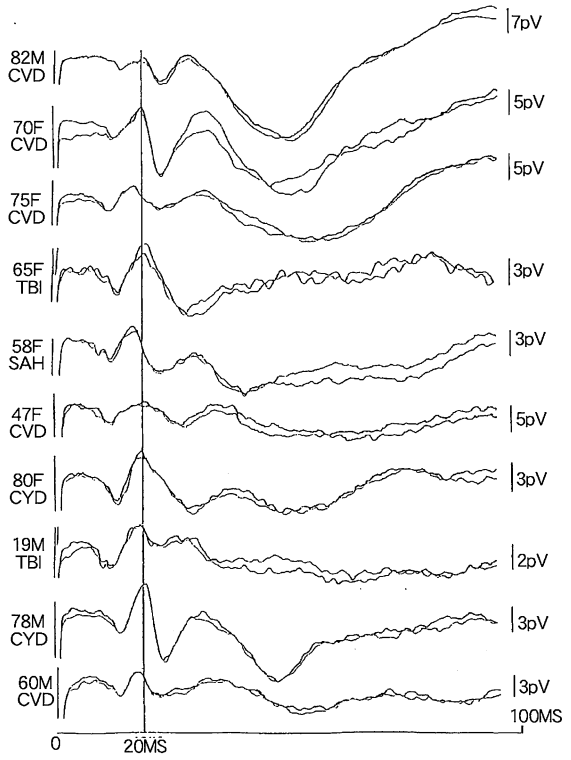

Fig. 5 Examples of wave-forms which showed normal SSEP and abnormal MSEP.
MSEP was more sensitive than SSEP for patients with brain damage.

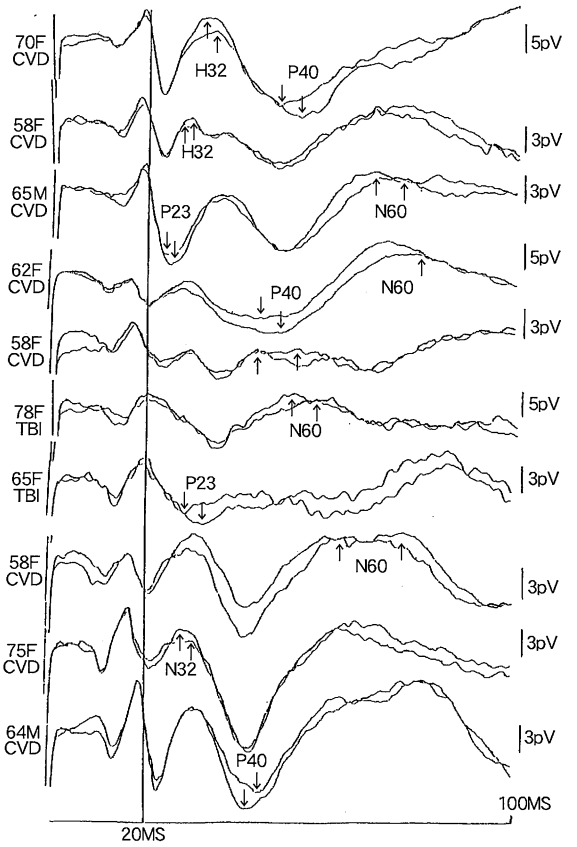

Fig. 6 Examples of wave-forms which showed significant changes of MSEP in the same subject. SSEP was reproducible but MSEP changed according to the arousal level and habituation.

conducting through medial leminiscus.

We conclude that STIM-AB is a useful method for recording MSEP for patients with brain damage.

References

1) Cohn R. : Bilateral simultaneous summated cortical responses to delayed bilateral and single median nerve stimulation. Electroencephal Clin Neurophisiol 29, 612-615, 1970.

2) Kimura J. : from Electrodiagnosis in diseases of nerve and muscle : Principle and practice. Somatosensory evoked potentials. pp339-427, Philadelphia, FA Davis, 1983.

3) Standars of clinical practice for recording of evoked potentials (EPs) : Recommendation for the practical clinical neurophysiology. Electroencephal Clin Neurophisiol 42 ; 69-80, 1983.

4) Yamada T., Kimura J. et al : Short- and long-latency median somatosensory evoked potentials. finding in patients with localized neurological lesions. Arch Neurol 40 : 215-220, 1983.

5) Yamada T., Kimura J. et al : Somatosensory evoked potentials elicited by bilateral stimulation of the median nerve and its clinical application. Neurol 28 : 218-233, 1987.

6) Yamada T, Dickins Q.S. et al : SEPs to bilateral simultaneous median nerve stimulation in man : method and clinical application. In Cracco R.Q., Bodis-Woller I (ed) ; Frontiers of clinical Neuroscience "Evoked Potentials" vol 3 : 58-67, Alan Liss Inc, New York, 1985.

7) Warwick R., Williams P. : The thalamic nuclei and their connections. In Gray's anatomy 35th, pp892-901, Longman, Edingburgh, 1973.

Received : December 16, 1999.
Accepted : February 2, 2000.