

## 백서에서 삼차신경 유발전위의 특성과 경로 분석

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= Abstract =

### Characteristics of Trigeminal Evoked Potential and It's Pathway in the Rat

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**Objective :** There are some advantages of trigeminal evoked potential(TEP) recording compared to other somatosensory evoked potential(SSEP) recordings. The trigeminal sensory pathway has a pure sensory nerve branch, a broader receptive field in cerebral cortex, and a shorter pathway. Despite these advantages, there is little agreement as to what constitutes a normal response and what wave forms truly characterize the intraoperative TEP. This study presents the normative data of TEP recorded on the epidural surface of the rat with a platinum ball electrode.

**Materials & Methods :** Under general anesthesia with urethane, the adult Sprague - Dawley male rats(300 - 350g) were given electrical stimulation with two stainless steel electrodes which were inserted into the subcutaneous layer of the area around whiskers. A reference electrode was positioned in the temporalis muscle ipsilateral to the recording site.

**Results :** TEPs were recorded in the Par I area of somatosensory cortex and recorded most apparently on the point of 2mm posterior from the bregma and 6mm lateral from the midline. The typical wave form consisted of 5 peaks (N1 - P1 - N2 - P2 - N3 according to emerging order, upward negativity). Each latency to corresponding peaks was not influenced by the different intensities of stimulation, especially from 1 to 5mA. Average latencies of 5 peaks were in the following order ; 7.7, 11.1, 15, 22.3, 29.4ms. There was also no significant difference between latencies before and after administration of muscle relaxant(pancuronium). For the electrophysiological localization of recorded waves, the action potential of a single unit was recorded with glass microelectrode(filled with 2M NaCl, 3 - 5M ) in the thalamus of rat. A sharp wave was recorded in the VPM nucleus, in which the latency was shorter than that of N1. This suggests that all 5 peaks were generated by neural activities in the supratthalamic pathway.

**Conclusion :** In terms of recording near - field potentials, our data also suggests that TEP in the rat may be superior to other SSEPs. In overall, these results may afford normative data for the studies of supratentorial lesions such as hydrocephalus or cerebral ischemia which can have an influence on near - field potentials.

**KEY WORDS :** Trigeminal evoked potential · Rat · Electrical stimulation · Near - field potential.

서 론

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4)5)11)17). Sakatani  
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 24). Leandri 가  
 17). Stechison (bregma) 2mm 6mm  
 , 2mm  
 7~8mm (craniectomy)  
 28)29). 가 가  
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 가 ,  
 30) 가 가  
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재료 및 방법

1. 실험 준비  
 Sprague - Dawley (300~350g)  
 urethane(1.25g/kg)  
 atropine sulfate(0.8mg/kg)  
 Pancuronium(1.0mg/kg)

(Rodent ventilator model 683, Havard Apparatus, South Natick, MA, U.S.A.)  
 CO<sub>2</sub> (Normocap 200, Datex, Helsinki, Finland)  
 CO<sub>2</sub> 30~40mmHg  
 80~120mmHg  
 (Stereotaxic frame, Narishige Scientific Instrument Laboratory, Tokyo, Japan)  
 35~38  
 (bregma) 2mm 6mm  
 2mm  
 7~8mm (craniectomy)  
 2. 삼차신경 자극  
 (stainless steel needle electrode) 2  
 3mm  
 (A385D stimulus isolator, World Precision Instruments Inc., New Haven, Connecticut, U.S.A.)  
 (Pulsemaster A300, World Precision Instruments Inc., New Haven, Connecticut, U.S.A.)  
 3~4Hz 0.1 msec  
 0.2~0.6mA 가  
 가

3. 삼차신경 유발전위의 기록

1mm  
 (platinum ball electrode)  
 1mm  
 가 가 100ms  
 IBM Pentium computer  
 Spike 2 program(supplied by CED Corp., U.K.)  
 30~3,000Hz  
 (filtering) 10,000 30~300  
 (averaging)

4. 삼차신경 유발전위의 확인 (N) , (P) , 가 N1, P1, N2, P2, N3

1. 기록위치에 따른 삼차신경 유발전위의 변화 가 가 5 0.6~4mA (stereotaxic apparatus, Narishige Scientific Instrument Laboratory, Tokyo, Japan)

5. 삼차신경 유발전위의 전기생리학적 국소화 2M NaCl (glass microelectrode, 3~5M ) (thalamus) 1mm 5 Paxinos Watson Atlas<sup>23)</sup> 3.6mm Watson atlas<sup>23)</sup> Par I 가 2mm, 6mm 가 2.3mm 5.0mm 7.0mm (stereotaxic method) 0.2mm (medial posterior nucleus : P<sub>Om</sub> nucleus) (ventral posterior medial nucleus : VPM nucleus) 2. 기록된 삼차신경 유발전위의 기본 파형 ( 2mm, 6mm) 6. 근육 이완제 투여 전후의 유발전위 검사 비교 ' N1 - P1 - N2 - P2 - N3 ' 5 (Fig. 1).

가 E

3. 삼차신경 유발전위의 확인 가 가 4

7. 통계 처리 SPSS package(version 8.0) (one - way ANOVA test) Scheffe (post - hoc multiple comparison) 가 (Fig. 2). paired sample t - test 가 (Fig. 2).

결 과 (anterior lacerated foramen for maxillary division of trigeminal nerve)

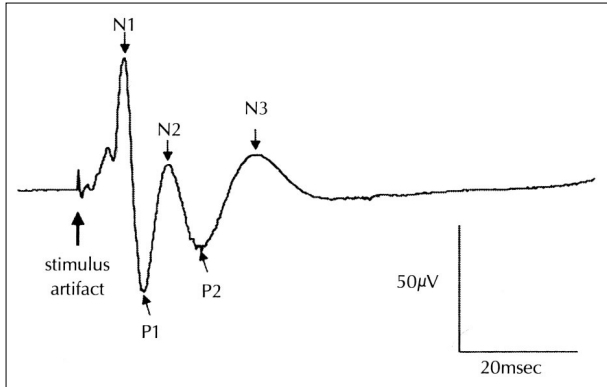


Fig. 1. Basic form of trigeminal evoked potentials recorded at the epidural surface of 2mm posterior from the bregma and 6mm lateral from the midline(recording electrode : platinum ball electrode, intensity of stimulus : 4mA).

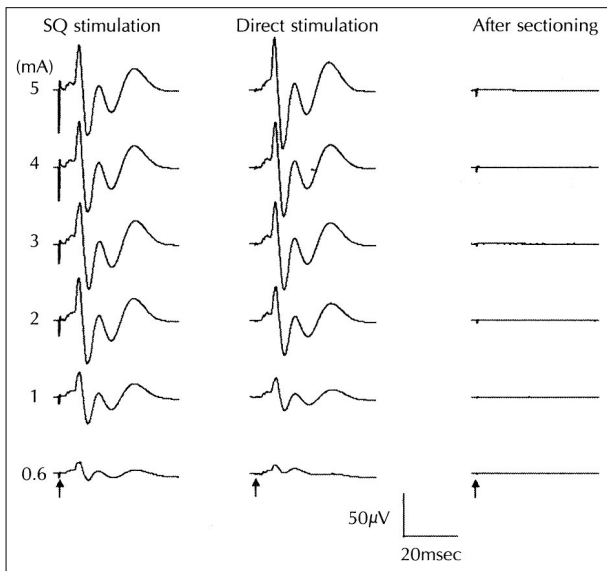


Fig. 2. Trigeminal evoked potentials after direct stimulation and section of subcutaneously exposed maxillary branch of the trigeminal nerve(SQ : subcutaneous, arrow : stimulus arti-fact).

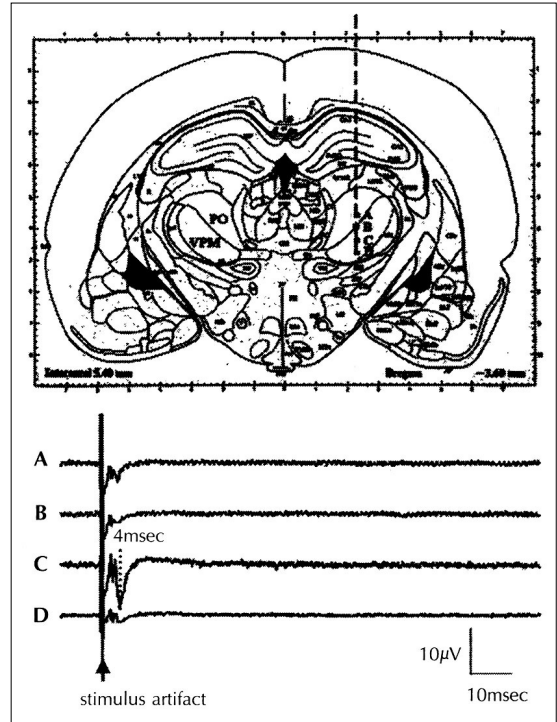


Fig. 3. Upper : A trajectory for the detection of trigeminal evoked potentials with glass microelectrode in the thalamus of a rat(depth in mm from bregma : A ; 5.4, B ; 6.0, C ; 6.4, D ; 6.8). Lower : Trigeminal evoked potentials recorded with glass microelectrode using stereotaxic method in the various positions of thalamus of a rat(intensity of stimulus : 4mA).

4.0msec (Fig. 3).

3

가 , , ( )

가 20mm, 15mm, 6mm

40m/sec<sup>16)</sup>,

5.5m/sec<sup>1)</sup>,

(synaptic delay) 0.5msec<sup>12)</sup>

1.4msec,

3.1msec가

3.6msec

가

가

4.0msec

4. 유발전위 파들의 전기생리학적 국소화를 위한 실험 결과

5

2M NaCl

4mA

3.6mm

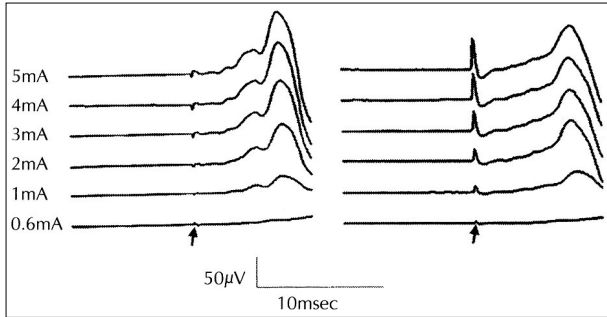
2.3mm, 6.4mm

sharp wave

3.5msec,

5. N1 이전의 파형 분석

N1 peak



**Fig. 4.** Waveforms before N1 peak. Left TEPs show 3 small negative waves with 4mA or above of stimulus intensity. But right TEPs of another rat do not show any definite wave before N1 peak (arrow : stimulus artifact).

sweep running time 20msec

Fig. 4 N1 peak 가  
2~3

4mA  
45.5%  
2.5 ± 0.21msec D

far - field potential

6. 자극 세기에 따른 삼차신경 유발전위의 변화

37 0.6mA

가  
( 2mm, 가 0.6mA  
6mm)

89.7%, 1mA 가 가

2mA

가 7mA 가 가

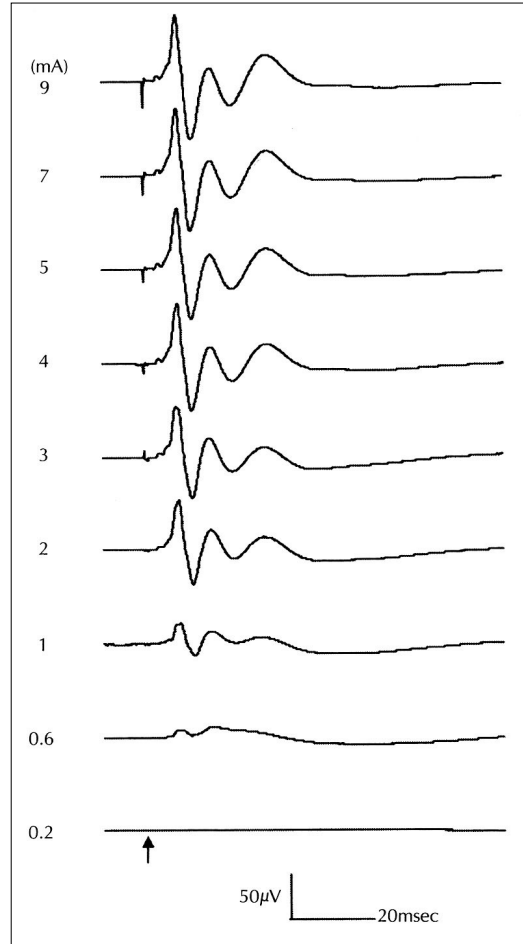
N1 가

(Fig. 5, Table 1). N1

0.6mA 4mA, 5mA 가 가  
가 1mA

가 1mA 5mA

가 가 N1 7.7msec, P1 11.1msec, N2가 15msec, P2가 22.3msec, N3가 29.4 msec 가



**Fig. 5.** Comparison of trigeminal evoked potentials following electrical stimulation with different intensities (arrow : stimulus artifact).

N1, P1, N3 N2,  
P2 가 (Fig. 5, Table 2).

7. 근육 이완제 투여 전후의 삼차신경 유발전위의 변화

13  
(pancuronium 1mg/kg, i.v.)

가 2mA 가 가  
5mA

가 (Fig. 6).

4mA

가

**Table 1.** Normative data and comparison of the latencies of each peak following electrical stimulation with different intensities

Intensity	N1	P1	N2	P2	N3
0.6mA	8.9 ± 0.45	11.4 ± 0.19	15.6 ± 0.20	25.7 ± 1.26	28.9 ± 0.20
1mA	7.8 ± 0.17	11.0 ± 0.27	14.9 ± 0.34	23.1 ± 1.40	27.7 ± 0.97
2mA	7.6 ± 0.15	11.1 ± 0.24	14.9 ± 0.27	22.2 ± 0.80	29.5 ± 0.72
3mA	7.8 ± 0.14	11.3 ± 0.20	15.2 ± 0.17	22.4 ± 0.69	30.1 ± 0.37
4mA	7.7 ± 0.14	11.1 ± 0.22	15.0 ± 0.16	22.0 ± 0.72	29.9 ± 0.36
5mA	7.7 ± 0.14	11.2 ± 0.20	15.2 ± 0.17	21.9 ± 0.73	30.0 ± 0.36
7mA	7.0 ± 0.38	10.6 ± 0.74	14.9 ± 0.46	21.4 ± 0.13	28.9 ± 0.57
9mA	7.1 ± 0.40	10.6 ± 0.76	14.9 ± 0.43	20.9 ± 1.08	29.1 ± 0.75
p value	0.001*	0.722	0.994	0.453	0.308
average(1 - 5mA)	7.7	11.1	15.0	22.3	29.4

value = mean(msec) ± S.E., recording electrode : platinum ball electrode, p value in one-way ANOVA

\* : statistically significant difference between the group with 0.6mA of stimulus intensity and the group with 4 or 5mA(p = 0.042 in post-hoc multiple comparison)

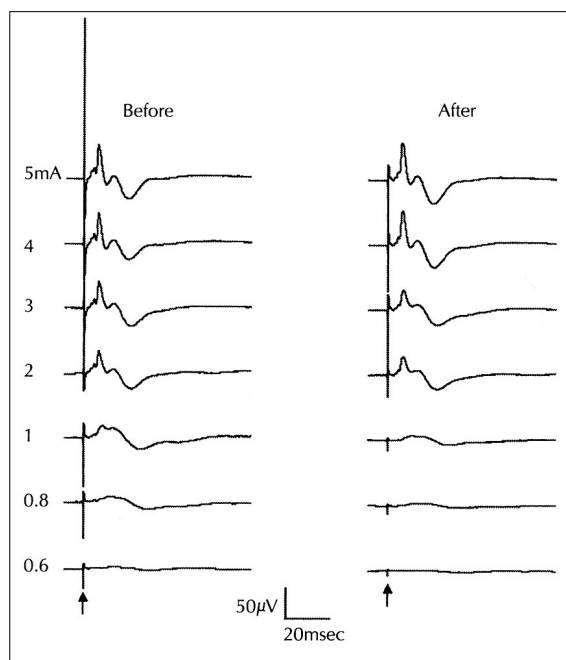
**Table 2.** Normative data and comparison of the amplitudes of each peak following electrical stimulation with different intensities

Intensity	N1	P1	N2	P2	N3
0.6mA	10.3 ± 1.38	2.1 ± 1.29	7.72 ± 0.77	- 3.7 ± 0.69	6.8 ± 2.13
1mA	18.4 ± 2.60	- 3.16 ± 3.07	10.0 ± 0.94	- 5.9 ± 1.61	8.5 ± 2.01
2mA	36.5 ± 4.46	- 17.7 ± 6.27	14.4 ± 1.85	- 14.8 ± 2.43	12.6 ± 3.29
3mA	43.3 ± 4.59	- 26.0 ± 6.82	15.2 ± 1.91	- 17.5 ± 2.36	15.0 ± 3.41
4mA	51.7 ± 5.30	- 35.6 ± 7.45	17.1 ± 2.03	- 21.4 ± 2.72	18.2 ± 3.36
5mA	51.7 ± 5.45	- 43.1 ± 7.43	14.9 ± 2.26	- 23.6 ± 3.31	20.7 ± 3.57
7mA	62.7 ± 1.22	- 77.2 ± 1.49	13.9 ± 3.73	- 34.9 ± 8.51	43.0 ± 6.83
9mA	58.7 ± 11.1	- 73.6 ± 16.11	11.9 ± 3.90	- 33.4 ± 7.08	43.4 ± 7.54
p value	<0.001	<0.001	0.384	0.157	0.002

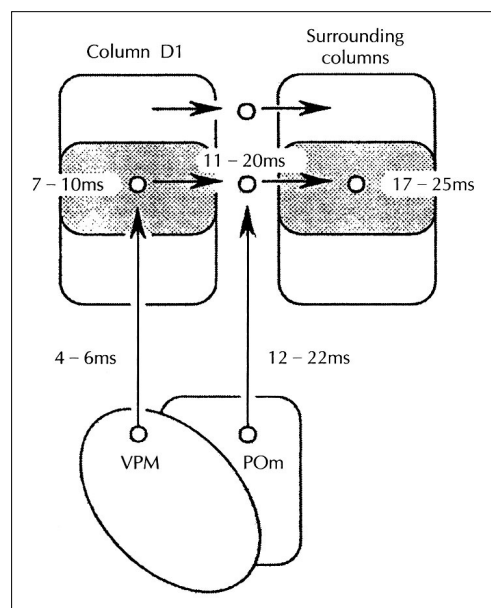
value = mean( μV) ± S.E.

recording electrode : platinum ball electrode

p value in one-way ANOVA



**Fig. 6.** Comparison of trigeminal evoked potentials before and after administration of muscle relaxant(pancuronium 1mg/kg i.v., intensity of stimulus : 4mA, arrow : stimulus artifact).



**Fig. 7.** Schematic drawing of responses of the thalamic nuclei and cortex following selective mechanical stimulation of one whisker(D1) in a rat(suggested by Diamond<sup>8)</sup>).

고찰

noncephalic montage N7 ,  
 cephalic montage N10 가  
 cephalic montage  
 far - field potential 21),  
 Sakatani 0.2~0.6mA  
 cephalic montage  
 positive - negative - positive wave(upward positivity)  
 가 6.5~8msec  
 positive wave 2 가  
 28), 24), 가 0.6mA  
 가 Sakatani  
 peak 2~3 N1  
 cephalic montage  
 near - field potential far - field potential .  
 가 가  
 가 가  
 가 far - field potential  
 near - field potential  
 (sensory threshold) . Soustiel  
 3~4 , 0.8, 1.6, 2.9, 4.9, 7.2msec 5 3 가  
 가 50% , 5 가  
 가 1mA 1)11), 27), Leandri  
 가 0.9, 1.8, 2.5msec 3  
 가 5mA ,  
 가 2mA (presynaptic  
 potential) 4, 5, 6msec  
 1mA 5mA , , 7msec -  
 2mA 가 , 10msec  
 17)19 - 21),  
 가 Findler 가 8, 14, 18, 23, 38, 44, 56, 90,  
 cephalic montage 114msec 7 가 11),  
 noncephalic montage Barker 20, 29, 37msec  
 far - field potential 가  
 가 1)9). Leandri 4), Fagade 23, 39msec 가

10). Stechison 6msec 가 N1, P1 peak 가 N2, P2 peak 가 N2, P2 가 가 Diamond 가 N1, P1 2가 N1, barrel column far - field potential P1 peak barrel column near - field potential N2, P2 peak barrel column 가 가 Di N1 가 7msec sharp wave 가 4msec 8, 16, 32, 80msec 가 4msec 5 (suprathalamic pathway), 2 (postsynaptic potential) barrel field 7). 가 near - field potential near - field potential 30). 결론 2가 가 30). 1) Par I 2mm, 6mm 가 가 가 2) ' N1 - P1 - N2 - P2 - N3 ' 5 가 barrel column 가 barrel 1mA 가 column 가 2~3 N1 cephalic montage 2)3)6)14)22)25). 1992 Diamond 가 far - field potential 가 (Fig. 7)<sup>8)</sup>. 가 3) 1mA 가



가  
 1mA 5mA  
 가  
 N1 7.7msec, P1 11.1msec, N2가 15msec, P2  
 가 22.3msec, N3가 29.4msec

4)

가

5)

가 N1

6)

가 near - field potential

potential

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