

수두증 흰쥐 모델에서 수두증 정도에 따른 체성 감각 유발 장전위의 변화

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= Abstract =

Change of Somatosensory Evoked Field Potential according to the Severity of Hydrocephalus in Kaolin-induced Hydrocephalus of Rats

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Objective : Somatosensory evoked potential(SSEP) has been known to be a good method for evaluating brain stem function, but it is not sufficient to check the fine changes of cortical functions. A fine change of cortical function can be expressed with somatosensory evoked cortical field potential(SSEFP) rather than general SSEP. To confirm the usefulness of SSEFP for evaluating the cortical function, the authors simultaneously measured SSEFP and the intracranial pressure - volume index(PVI) in kaolin - induced hydrocephalic rats.

Method : Hydrocephalus was induced with injection of 0.1ml kaolin - suspended solution into the cisterna magna in 60 Sprague - Dawley rats. The authors measured PVI and SSEFP 1 week after injection of kaolin - suspended solution. To evaluate the severity of induced hydrocephalus, we measured the transverse diameter of the lateral ventricle on the coronal slice of the rat brain 0.40mm posterior to the bregma.

Result : The typical wave form of SSEFP in control rats showed a negative - positive complex wave at early latency. In SSEFP of normal rats, N0 is 10.0 msec, N1 15.3 msec, P1 31.2 msec and N1 - P1 amplitude 15.4 μ V. As hydrocephalus progressed, the peak latency of N1 and P1 were delayed. In mild hydrocephalus, negative peak waves were split. The N1 - P1 amplitude was decreased only in severe hydrocephalus. The changes of the characteristics of SSEFP according to the severity of hydrocephalus were well correlated with the changes of PVI. Shunting normalized the characteristics of SSEFP in relation to ventricular sizes and PVI in hydrocephalic rats.

Conclusion : SSEFP may be useful for evaluating the impairment of cortical function in hydrocephalus.

KEY WORDS : Kaolin - induced hydrocephalus · Pressure - volume index · Somatosensory evoked potential · Somatosensory evoked cortical field potential.

서 론

PVI)

10)19)23)27)29)

(compliance),
(elastance) - (pressure volume index ; (EEG),

수두증 흰쥐 모델에서 수두증 정도에 따른 체성 감각 유발 장전위의 변화

(brainstem auditory evoked potential ; BAEP),				1	-
(somatosensory evoked potential ; SSEP),					
(visual evoked potential ; VEP),	12				1
(motor evoked potential)					
		3)8)9)			
가			2. 수두증의 유발		
			Thiopental(1mg/Kg)		
					1
				1mm	
			0.1 0.2ml		
(brain stem)	far field potential		0.1ml		(2gm kaolin/10ml normal saline)
	near field potential		2		
	(thalamus), (internal capsule)		가		
			3. 수두증 흰쥐의 섀트술		
	(somatosensory evoked cortical field potential ; SSEFP)			1.5cm	
				drill	1mm,
					3 4mm
				0.5mm	
			가		
			1		
가			4. 실험동물 마취 및 조작		
			Thiopental(1mg/Kg)		
				5mm	
				mechanical ventilator(Model 808, New England medical Instrument Inc. Medway, Mass., USA)	
				CO2	
				(Capnometer, model 2200, Traverse medical monitors, Saline, Michigan, USA)	
				polyethylene	
				heparin solution(10,000 unit/1,000ml)	
				P40 statham pressure transducer	
			가		
					37.5 38.5
			2 3		(Homeothermic blanket control unit Cat. No. 50 - 7503, Havard Apparatus, South Natik, MA., USA)
10					1

대상 및 방법

1. 실험 동물

350 400gm 60

38

10

(Stereotactic Frame : Scientific Instrument Laboratory, Setayaku, Tokyo, Japan)
 pancuronium bromide (0.04mg/Kg)
 thiopental
 (Microscope : Zeiss, OPMI6-Sf, 123816, West Germany)

5. 압력-부피 계수의 측정

2.5mm 3mm, 1mm
 drill 23G
 PE - 50 3 4mm
 0.025 0.03ml
 [heparin 10,000 unit in 1000ml normal saline]

$$PVI \{ = V - Vo / (\log P - \log Po) \} \quad (\text{Fig. 1})^{19)27)29)}$$

6. 체성 감각 유발 전위의 유발 및 기록

1) 자극

ball
 (Fig. 2).
 (A365D stimulus isolator, A365 high current stimuli isolator, World precision instruments, Inc. New Haven, Connecticut, USA) 5mA
 (Pulsemaster

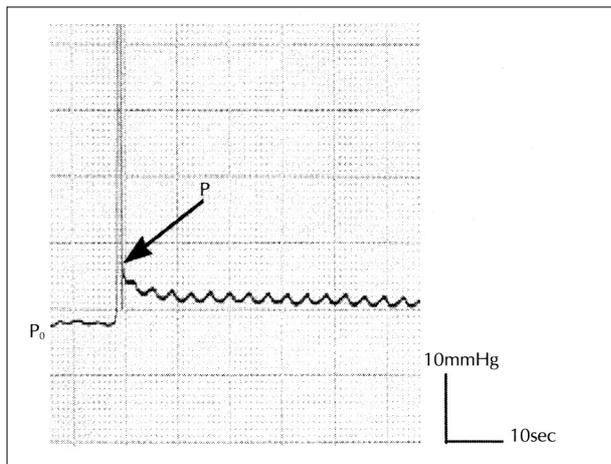


Fig. 1. Measurement of pressure-volume index. PVI was calculated according to the formula $\{PVI = V - Vo / (\log P - \log Po), (P > Po)\}$ after intraventricular bolus injection of 0.025 - 0.03ml heparinized normal saline (Heparin 10,000 unit in 1000ml normal saline).

A300, World precision instruments, Inc. New Haven, Connecticut, USA) 1

4Hz 0.1msec

2) 기록

(stainless steel, NE - 120, Rhodes Medical Instruments, Inc. Distributed by David Kopf Instruments, Tujunga, Calif., USA) (Fig. 2).

1.4mm (insulation) 0.2mm

0.4mm 0.1mm

bregma 2mm 2.5mm
 IBM-PC 586 computer Spike 2 (Spike 2 for windows, version 2.0, AD converter and program supplied by Cambridge electronic design LTD, England)

(sensory evoked field potential wave) 30 3,000Hz 50,000
 (NIC HGA 300 Nicolet Biomedical Instrument, Nicolet Instrument Corp. Madison, Wisconsin, USA) 100 300 Sweep time 100msec

7. 수두증의 확진

23G

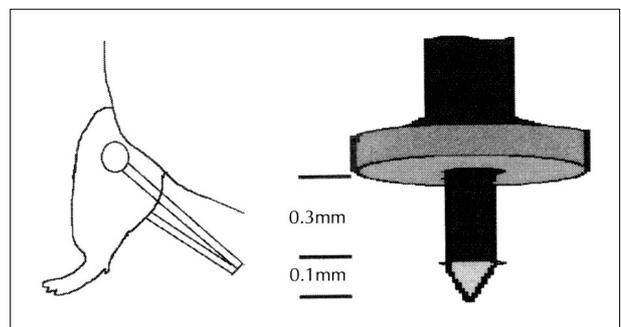


Fig. 2. Stimulating electrode and recording electrode of somatosensory evoked field potential. We transcutaneously stimulated the sciatic nerve with a ball-type electrode made of silver (left figure). The figure at right is a schematic drawing of the recording electrode. This electrode has a recording disk (1.4mm in diameter) and the insulated needle (0.2mm in diameter, 0.4mm in length). The insulated needle is used as a reference electrode after stripping the tip of the needle.

결 과

10% 1 bregma 1. 수두증 정도에 따른 두개강내 압력-부피 계수의 변화
 0.4mm 1mm 10% 0.75 0.95mm
 2 3 0.85 ± 0.06mm 4.8
 (anterior commissure) 5.6mmHg 5.24 ± 0.28mmHg
 1mm 1 2mm, 0.0640 ± 0.0023ml
 2mm (Fig. 3). 24 2.71 ± 0.37mm(2.1 3.4mm)
 8. 통계분석 (peak 1.62 ±
 latency) (peak amplitude) - 5.4
 paired t - test mmHg, 6.79 ± 0.70mmHg, 7.44 ± 0.58 -
 one - way 0.0578 ± 0.0029ml 14
 analysis of variance(ANOVA), Fischer's test, regre- mmHg, 6.5 8.3mmHg, 7.44 ± 0.58 -
 sion test 0.0560 ± 0.0056ml (Table 1).
 Fig. 4
 (p<0.05).

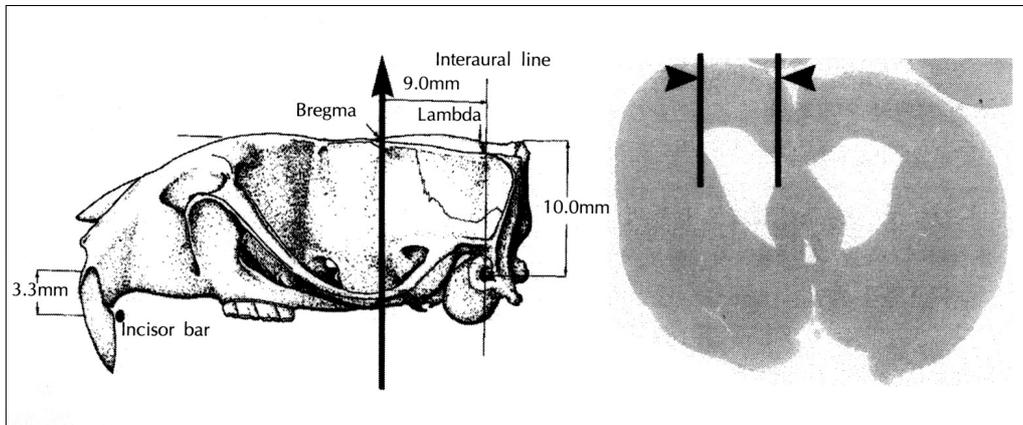


Fig. 3. Confirmation and classification of induced hydrocephalus. We measured the transverse diameter of the lateral ventricle on the coronal slice of the rat brain 0.40mm posterior to the bregma. The normal transverse diameter is defined as less than 1.0mm, mild hydrocephalus as 1.0 to 2.0mm, and severe hydrocephalus as more than 2.0mm.

Table 1. Changes of intracranial pressure and pressure-volume index 1 week after intracisternal injection of kaolin-suspended solution

Classification	Control	Mild hydrocephalus	Severe hydrocephalus	Treated hydrocephalus*
Number of animals	12	24	14	10
Diameter of lateral ventricle(mm)	0.85 ± 0.06 (0.75 - 0.95)	1.62 ± 0.21 (1.2 - 1.9)	2.71 ± 0.37 (2.1 - 3.4)	1.04 ± 0.16 (0.85 - 1.3)
Intracranial pressure(mmHg)	5.24 ± 0.28 (4.8 - 5.6)	6.79 ± 0.70 (5.4 - 7.9)	7.44 ± 0.58 (6.5 - 8.3)	5.19 ± 1.13 (3.0 - 6.9)
Pressure-volume index(ml)	0.0640 ± 0.0023	0.0578 ± 0.0029	0.0560 ± 0.0056	0.0599 ± 0.0086

* : Rats in this group were treated with shunting 1 week after intracisternal injection of kaolin-suspended solution
 The data are mean ± standard deviation
 Numbers in blank mean the minimal and maximal value

($p < 0.05$) (Fig. 5).
 10 ± 0.16 mm (0.85 1.3mm), 1.04
 3.0 6.9mmHg, 5.19 ± 1.13 mmHg
 (3 6.9mmHg).
 가
 0.0599ml 0.0086
 ml

가 가

2. 실험 동물군별 체성 감각 유발 전위

1) 대조군에서 체성 감각 유발 전위의 특징
 가 가

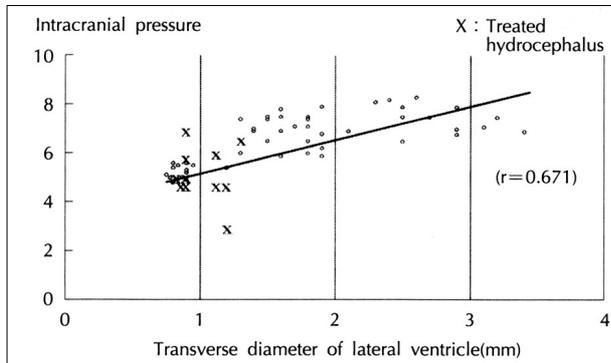


Fig. 4. Change of intracranial pressure according to the severity of induced hydrocephalus ($r = 0.671$, $p = 0.001$).

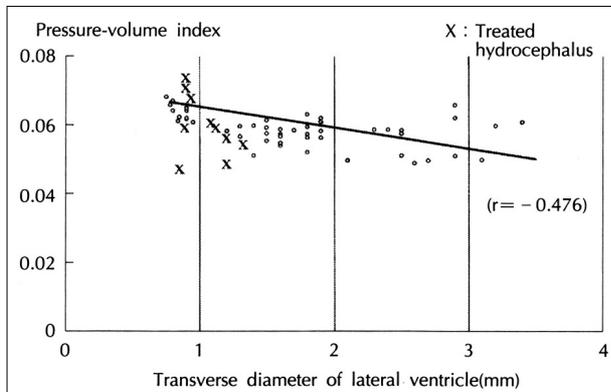


Fig. 5. Change of intracranial pressure-volume index according to the severity of induced hydrocephalus ($r = -0.476$, $p = 0.001$).

bregma 1mm
 40 5 가
 bregma
 2mm, (Fig. 6).
 2 3mm 1mA
 bregma 2mm, 3mA
 2.5mm
 (early latency negative - positive complex wave) (Fig. 7).
 10.0msec 15.3msec
 (N1) (P1) 31.2
 msec N1 P1
 N1 P1 15.4 μ V

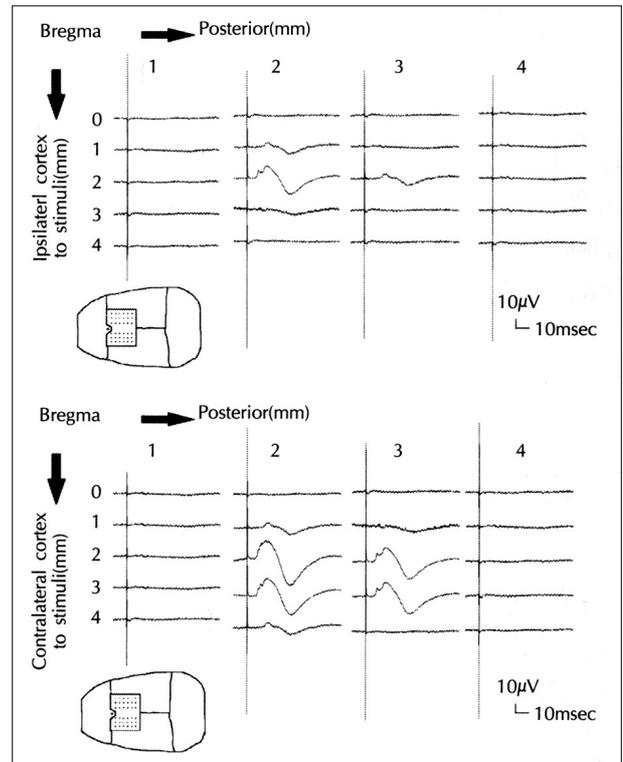


Fig. 6. Typical somatosensory evoked field potential in the control group. N0 : Starting point of negative wave. N1 : Latent period of peak point of negative wave, P1 : Latent period of peak point of positive wave, N1-P1 amplitude : Amplitude between peak points of negative wave and positive wave.

2) 수두증 정도에 따른 체성 감각 유발 전위의 변화

N0, N1, P1, N1 - P1

(Table 2).

10.2msec 10.0msec
가 11.3msec

17.9msec,
19.7msec
34.0msec, 40.6msec

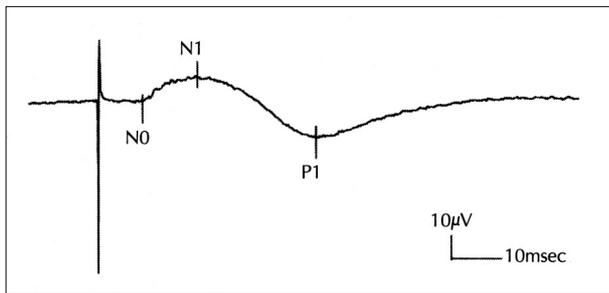


Fig. 7. Localization for recording somatosensory evoked field potential. To find the proper location for recording SSEFP, we recorded 40 SSEFP on the ipsilateral and contralateral hemisphere to stimuli.

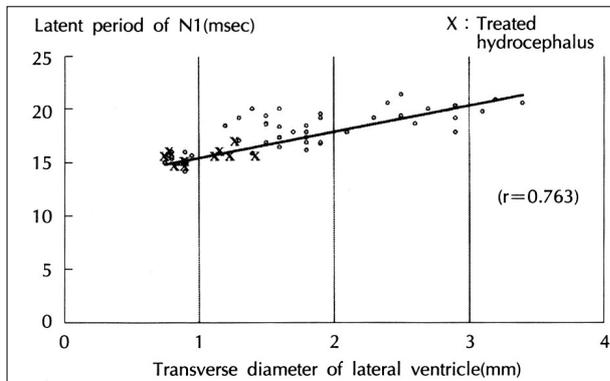


Fig. 8. Change of N1 according to the severity of induced hydrocephalus($r = 0.763$, $p = 0.001$).

(Fig. 8, 9).

가

70%

(Fig. 10).

30%

N1 - P1 15.4 µV

15.6 µV

가

13.7 µV

(Table 2).

3) 수두증 치료군에서 체성 감각 유발 전위의 변화

10.2msec,

15.6msec,

30.8msec,

N1 - P1

15.2msec, N1 - P1

14.7 µV

(Table 2).

가

1mm

70%

1

가

1mm

30%

2

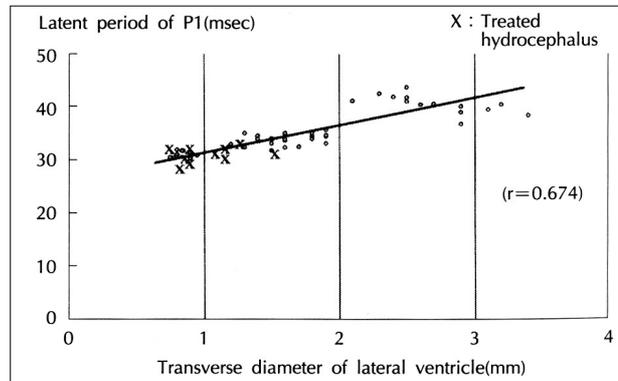


Fig. 9. Change of P1 according to the severity of induced hydrocephalus($r = 0.674$, $p = 0.001$).

Table 2. Changes of SSEFP according to the severity of hydrocephalus

Classification	Control	Mild hydrocephalus	Severe hydrocephalus	Treated hydrocephalus
Number of animals	12	24	14	10
N0(msec)	10.0 ± 0.5	10.2 ± 0.9	11.3 ± 1.3	10.2 ± 1.2
N1(msec)	15.3 ± 1.4	17.9 ± 2.1	19.7 ± 2.5	15.6 ± 1.6
P1(msec)	31.2 ± 2.8	34.0 ± 4.1	40.6 ± 3.8	30.8 ± 2.4
N1 splitting	none	70%	30%	30%
N1-P1 amplitude(µV)	15.4 ± 2.4	15.6 ± 5.6	13.7 ± 2.7	14.7 ± 6.4

N0 : Starting point of negative wave

N1 : Latent period of peak point of negative wave

P1 : Latent period of peak point of positive wave

N1-P1 amplitude : Amplitude between peak points of negative wave and positive wave

The data are mean ± standard deviation

가

(Fig. 11).

3. 압력-부피 계수와 체성 감각 유발 전위의 상관 관계

가 가
 regression test $N1 = 28.340876 +$
 $(-179.421 \times PVI)(r = -0.451, p = 0.001), P1 = 61.065$
 $+ (-440.227 \times PVI)(r = -0.557, p = 0.001)$
 가
 N1 - P1

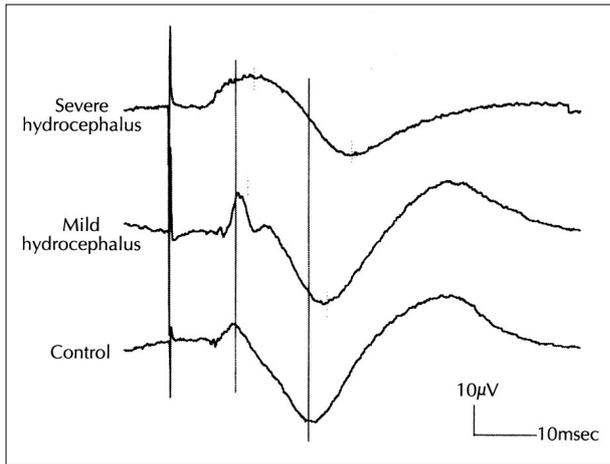


Fig. 10. Change of somatosensory evoked field potential according to the severity of induced hydrocephalus. As hydrocephalus progressed, N1 and P1 were delayed. In severe hydrocephalus, the N1-P1 amplitude decreased.

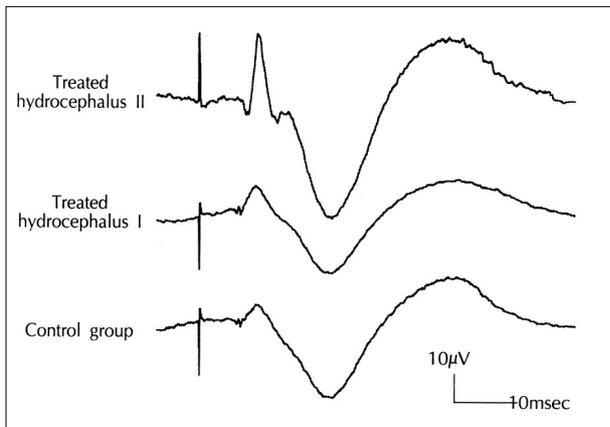


Fig. 11. Change of somatosensory evoked field potential after shunting. SSEFP in 70% of the treated group was similar to those in the control group. However, SSEFP in 30% of the treated group showed N1 splitting.

고 찰

가
 가 7)12)16)21)22)24). Positron emission tomog-
 raphy, magnetic resonance spectroscopy, diffusion mag-
 netic resonance

APT

5)13)28)

brain turgor(Kb)

1)10)23)29)

. 1970

가

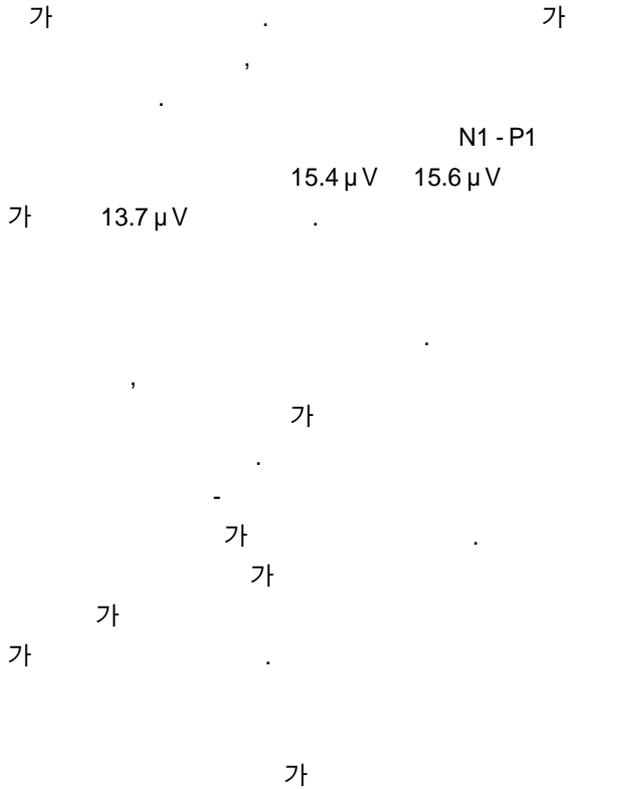
가 6)25).

가

가

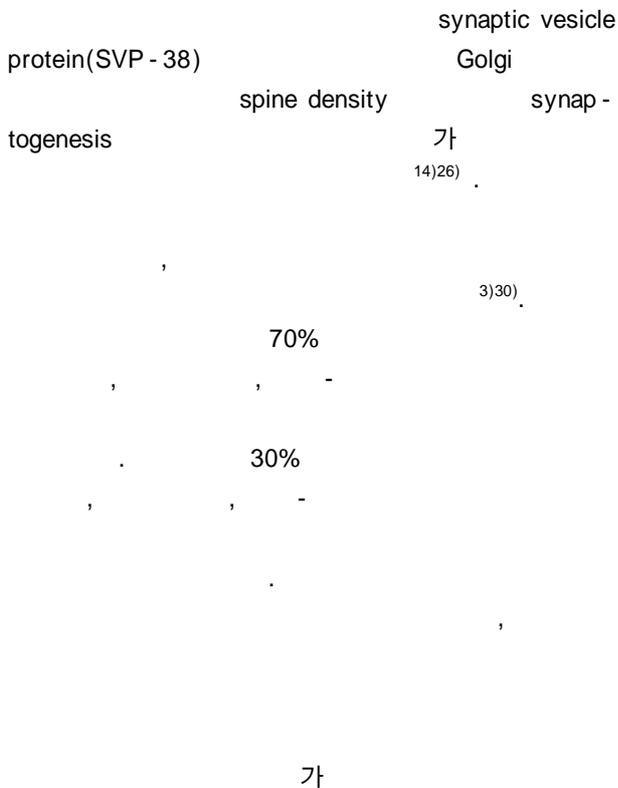
가

3)4)8)9)30). BAEP



결론

가



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- :

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