

## Nonlinear Dynamics of EEG in Pilocarpine-induced Status Epilepticus

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**Background:** Pilocarpine-induced status epilepticus (SE) model shows stereotypic EEG changes and behavioral characteristics. Although neuronal damages and therapeutic responses are also dependent on SE stages, the dynamical aspect of underlying neuronal interaction according to the SE stages has not been studied. We applied nonlinear analysis to the EEG recorded from pilocarpine-induced SE model to characterize nonlinear dynamics of different SE stage and to correlate therapeutic response with correlation dimension (D2). **Methods:** Ten male Sprague-Dawley rats weighing 150-250g were used in this experiment. EEG was continuously recorded during SE and was classified into 6 stages as follows: baseline (BS), transitional (TR), discrete seizure (DS), continuous ictal discharges (CID), early periodic epileptiform discharges (EP), and late periodic epileptiform discharges (LP). High dose diazepam (20 mg/kg) was injected at the LP stage. SEs of 5 rats (control group) was controlled by diazepam and those of the rest (failed group) were failed to stop status epilepticus. **Results:** Mean D2 value decreased progressively with fluctuation and was significantly different for SE stage (df=5, F=11.594, p=0.000). Independent t-test showed that the difference of D2 value between the controlled and failed group was significant at CID (df=40, t=2.591, p=0.013) and LP stage (df=49, t=2.425, p=0.019). **Conclusions:** These results suggest that nonlinear dynamical change at the late half of SE stage is one of the contributing factors determining therapeutic responsiveness in pilocarpine-induced SE model.

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**Key Words:** Pilocarpine-induced status epilepticus, EEG stage, Nonlinear analysis, Dimension

(status epilepticus; SE)

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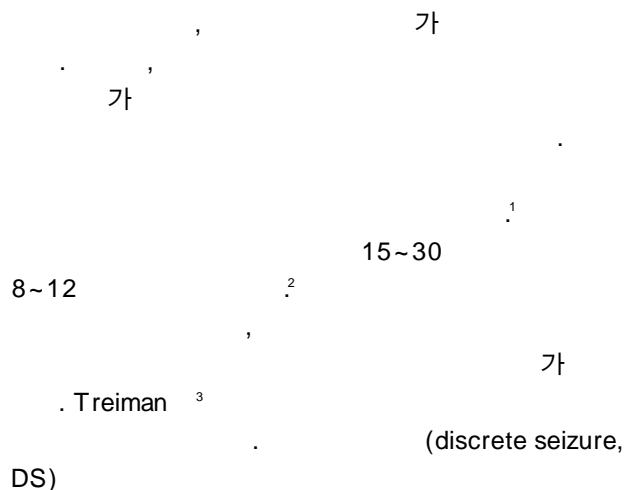
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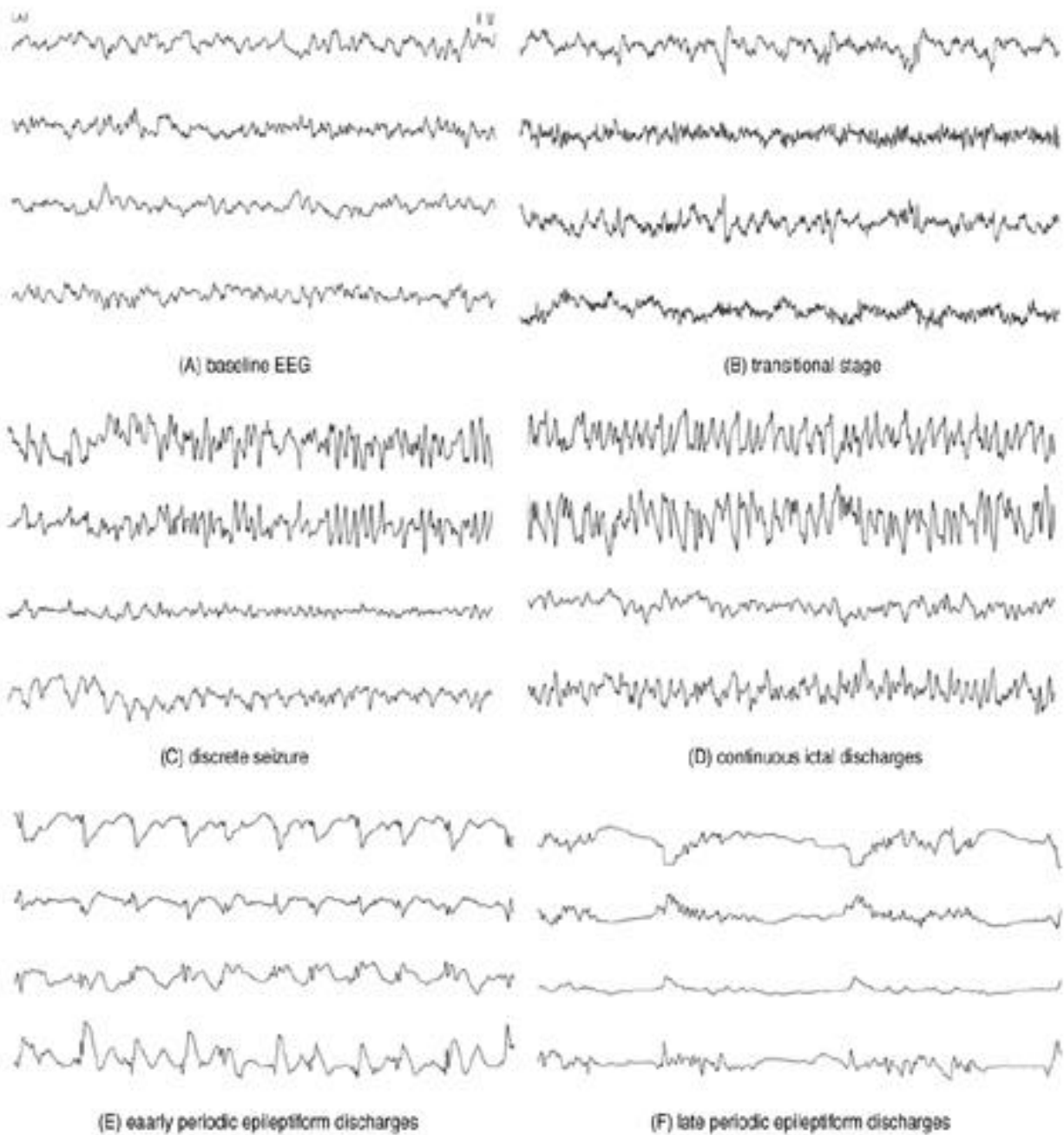
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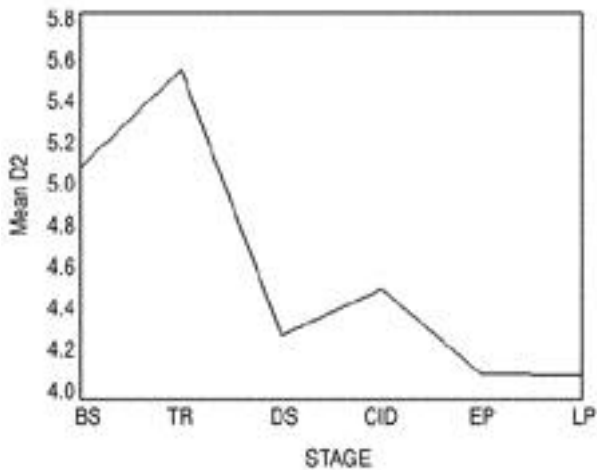




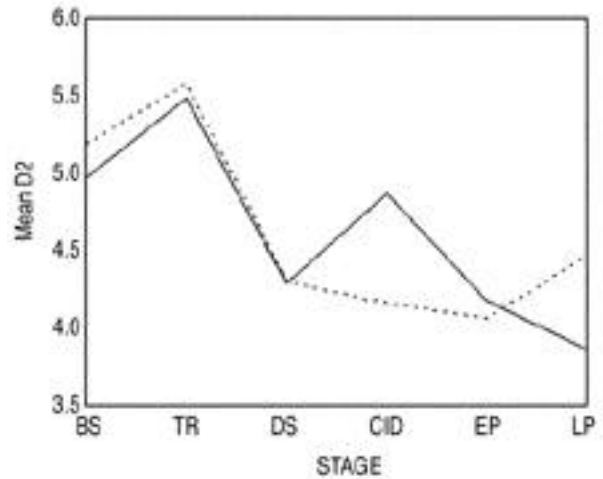
4 discrete seizure 30 1 epoch 3 epoch  
 (DS), continuous ictal discharge (CID), early PEDs baseline EEG (BS) DS가 (D2)  
 가 transitional stage (TR) 가 가  
 (Fig. 1).



**Figure 1.** Baseline EEG and status epilepticus evolving stage including transitional stage. SE begins with discrete electrographic seizures which end abruptly and simultaneously in all channels, with a low-voltage slow postictal pattern. This pattern is followed by one in which continuous, high-amplitude, rapid spiking occurs. Periods of isoelectric EEG may occur at any time during the continuous spiking. These flat periods gradually increase in frequency and duration until the final pattern appears-periodic epileptiform discharges (PEDs) on a relatively flat background. Early PEDs represent monotonous periodic discharge with relatively short flat period and late PEDs showed complex discharges in shape with longer flat period.



**Figure 2.** Mean correlation dimension (D2) during the progression of status epilepticus. BS; baseline, TR; transitional stage, DS; discrete seizure stage, CID; continuous ictal discharges, EP; early periodic epileptiform discharges (PEDs), LP; late PEDs.



**Figure 3.** Mean correlation dimension (D2) during evolving status epilepticus according to treatment response. Line means controlled group whose SE was terminated by diazepam injection at LP stage. Dotted line indicates failed group whose SE persisted after diazepam injection. BS; baseline, TR; transitional stage, DS; discrete seizure stage, CID; continuous ictal discharges, EP; early periodic epileptiform discharges (PEDs), LP; late PEDs.

가

가

independent t - test

p 0.05

가

18

(D2)

$$D_2 = \lim_{r \rightarrow 0} \frac{\log C(r)}{\log r}$$

$$C(r) = (1/Np) \sum_{i=1}^k \sum_{j=i+1}^k H(r - |X(i) - X(j)|)$$

$$D_2 = \frac{r}{Np} \frac{k(k-1)}{2}$$

X(i), X(j)

$$H(X(i) - X(j))$$

1

0

D2

logC(r)/log(r)

가

가

D2

SPSS for Windows (Ver 10.0)

267±38.5

TR

4

가

가

가

가가

1.

(df=5, F=11.594, p=0.000).

가 가

(Fig. 2). , BS

DS

가

가, DS

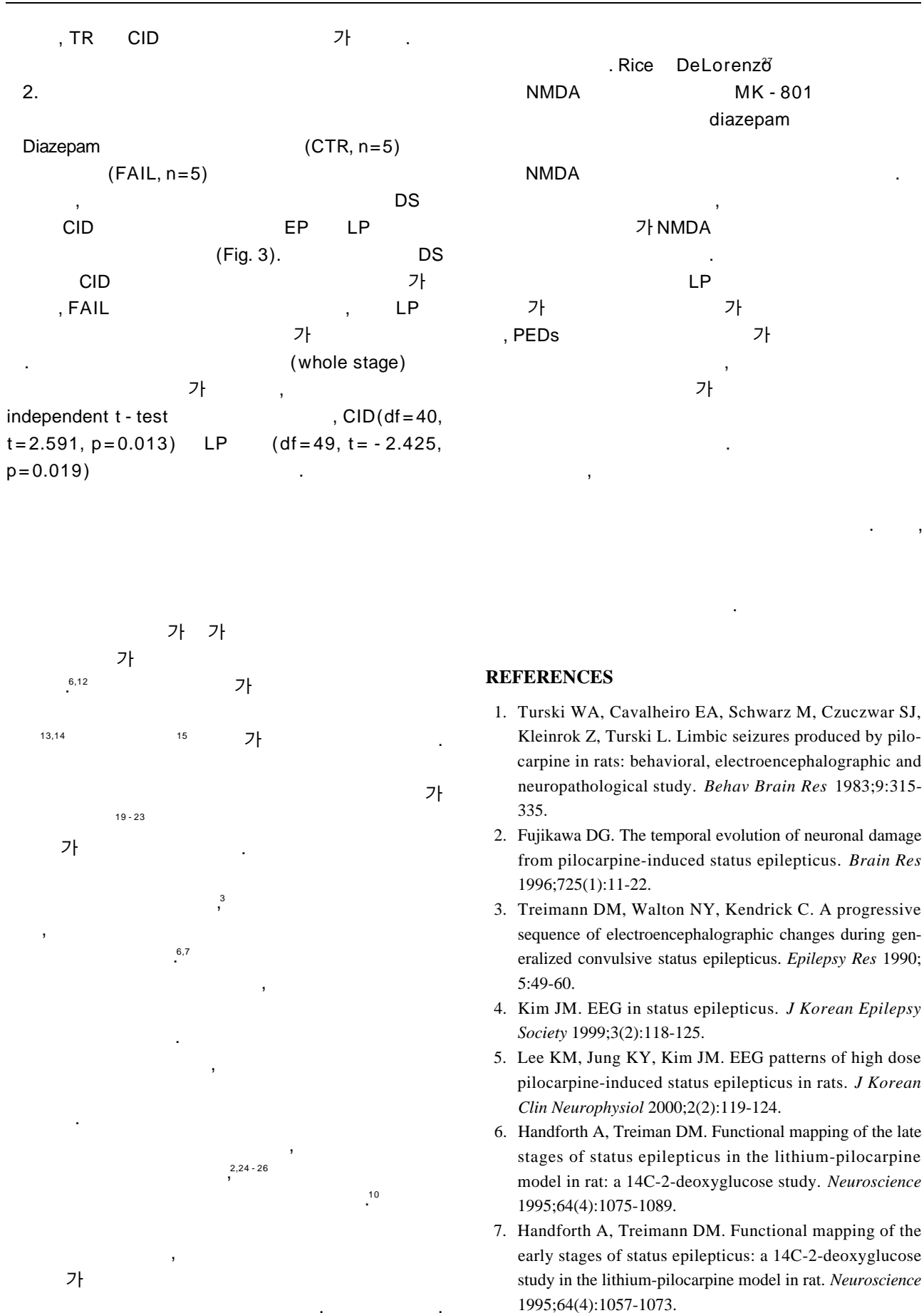
CID

. PEDs

가

DS (p=0.012) EP, LP (p=0.000)

가



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