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aEEG monitoring analysis of lesion degree and long-term prognosis in newborns with HIE

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Abstract. – OBJECTIVE: To conduct monitoring analysis of lesion degree and long-term prognosis using ambulatory electroencephalography (aEEG) in newborns with hypoxic-ischemic encephalopathy (HIE).

PATIENTS AND METHODS: 48 cases of newborns with HIE (aged 37 to 41 weeks) as the observation group and another 50 cases of full-term infants with non-traumatic brain illness as the control group were chosen from March 2012 to March 2013. The aEEG were observed, and the continuity and sleep-wake cycle (SWC) between the two groups were compared. The relevance of aEEG monitoring results and HIE, as well as the long-term prognosis, were analyzed.

RESULTS: 33.33% (16/48) of EEG results appeared to be continuous and 20.83% (10/48) of the SWC results were mature for observation group. These EEG and SWC results are conspicuously lower than the control group 100% (50/50) and differences were statistically significant ($p<0.05$). The maximum voltage of observation group was 56.54±19.33 LV, notably higher than the control group (37.77±2.79 LV). The minimum voltage of the observation group was 4.26±1.25 LV, markedly lower than the control group (7.75±0.67 LV) and these differences were statistically significant ($p<0.05$). Correlational analysis based on the Spearman approach showed that the monitoring results are positively correlated with clinical classification of HIE. After six months of follow-up, 11 of the 48 cases (22.92%) were found to be disabled (including mental retardation and cerebral palsy).

CONCLUSIONS: aEEG enjoys easy operation, effective diagnosis, supports continuous monitoring and reflects the lesion degree as well as long-term prognosis of newborns with HIE and is, thus, highly recommended in clinical practices.

Key Words: aEEG, Newborns with HIE, Lesion degree, Long-term prognosis.

Introduction

The incidence of HIE (Hypoxic Ischemic Encephalopathy) among newborns is rather high clinically, with as much as 15% of newborns die of this disease, and approximately 25% of those who survive are diagnosed with neurodevelopmental sequela, mainly characterized by lower intelligence, dyskinesia and epilepsy, etc.[1,2]. According to Fang et al[3], the brain injury could be identified at an early stage of EEG, thus making earlier interventions and treatments possible. The simplified form of EEG, aEEG has enjoyed rapid development in recent years, and has made great contributions to the test and analysis of brain functions in newborns with severe diseases[4-7]. Since HIE can be diagnosed, and consequently its severity determined at an earlier stage, it is conducive to adjuvant therapy[8]. In this paper we attained following conclusions by monitoring newborns with HIE, using aEEG and analyzing the long-term prognosis.

Patients and Methods

Patients

From March 2012 to March 2013, there were 48 cases of newborns with HIE (aged between 37 to 41 weeks) in NICU of our hospital. Average gestational age was 39.2±1.3 weeks, and the diagnostic criteria in this group of newborns met the requirements of relevant standards set by Society of Pediatrics, Chinese Medical Association. These 48 cases of newborns (26 boys, 22 girls) were chosen as the observation group. At the same time, another 50 cases of full-term infants (28 boys, 22 girls) with an average gestational age of 40.1±0.8 weeks and with non-traumatic brain illness as detected according to the B-ultrasonic results and the brainstem evoked potential, were chosen as the control group. The entire study was conducted with the knowledge and consent of parents of all newborns involved. The difference in terms of gender, age and gestational age between the two groups had no statistical significance ($p>0.05$).

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Table I. Comparison of continuity and SWC between two groups (n = %).

Groups	Cases (n)	EEG		SWC	
		Continuity	Discontinuity	Maturation	No Maturation
Observation group	48	16 (33.33)	32 (66.67)	10 (20.83)	38 (79.17)
Control group	50	50	(0)	50 (100.00)	0 (0)
x^2-value	-	49.495	64.653		
p-value	-	<0.05	<0.05		

Note: compared with the control group, $^*p<0.05$.

Methods

Leads were achieved with NicoletOne Monitor8, plus three reference electrodes, results were then monitored and recorded. All images grasped by aEEG were analyzed by professionals in our hospital. The specific monitoring period was from 12 to 24 hs. No sedatives, narcotic drugs and antiepileptic drugs were used 12 hours before and during the adoption of aEEG.

Observation Index

(1) Continuity: The continuity was assessed based on the advantages of aEEG. EEG was divided into (a) continuous EEG: which is accompanied with continuous brain activities with a minimum voltage of about 5-7-10 LV, and a maximum voltage of 10-25-50 LV; the variation was lowered before equal potential was achieved. (b) Discontinuous EEG: which was accompanied with discontinuous brain activities with a minimum amplitude less than 5 LV, yet a maximum amplitude of more than 10 LV and the variation was lowered after equal potential was achieved.

(2) Sleep-wake cycle (SWC): The EEG was presented with a regular sine wave with the cycling for > 20 mins. The broad band corresponds to the sleep cycle while the narrow one to the wake cycle.

(3) Minimum voltage: namely brain activities at the minimum level or the lower limit of the curve.

(4) Maximum voltage: namely brain activities at the maximum level or the upper limit of the curve. Results were collected with the assistance of software provided by Nicolet and measured with specific rulers.

Statistical Analysis

The analysis was conducted with the software SPSS 13.0 (SPSS Inc., Chicago, IL, USA). The comparison of statistics was examined with x^2 and verified by t-test. Differences with $p<0.05$ were considered of statistical significance.

Results

Comparison of Continuity and SWC Between the Two Groups

The EEG results for 33.33% (16/48) of observation group appeared to be continuous and 20.83% (10/48) of the SWC results were mature, both of these were notably lower than the control group 100% (50/50) as well as statistically significant ($p<0.05$). EEG results of newborns with HIE were mainly discontinuous, and SWC results were mostly immature as shown in Table I.

Comparison of the Maximum and Minimum Voltage Conditions Between the Two Groups

The maximum voltage of the observation group was 56.54±19.33 LV, notably higher than that of the control group at 37.77±2.79 LV; and the minimum voltage of the observation group was 4.26±1.25 LV, markedly lower than the control group, which was 7.75±0.67 LV and these differences were of statistical significance ($p<0.05$). The maximum voltage of newborns with HIE increased while the minimum voltage decreased (Table II).

Table II. Comparison of maximum and minimum voltage conditions between two groups (LV, x±s).

Groups	Cases (n)	Maximum voltage	Minimum voltage
Observation group	48	56.54±19.33*	4.26±1.25
Control group	50	37.77±2.79	7.75±0.67
t-value	-	6.794	17.322
p-value	-	<0.05	<0.05

Note: compared with the control group, $^*p<0.05$.

Analysis of aEEG for Degree of Lesion in Newborns with HIE

Among 48 cases of newborns with HIE, 17 were of mild level, 19 of moderate level and 12 with severe level. aEEG results showed that 16 cases were normal, 20 mildly abnormal, and 12 were severely abnormal. While aEEG results of all 50 cases in the control group were normal. Correlational analysis based on the Spearman approach showed that monitoring results were positively correlated with HIE clinical classification ($r=0.878$, $p<0.05$).

Long-term Prognosis Analysis of the Observation Group

Eleven of the 48 cases (22.92%) were found to be disabled (including mental retardation and cerebral palsy) after six months of follow-up.

Discussion

Clinical practice of aEEG has a history of over 20 years and has been concluded that it is fairly consistent with EEG, especially in the aspect of brain function monitoring, and as a result has a huge clinical application value[9,10]. To monitor EEG mainly records the spontaneous discharging of corresponding neurons in the brain hemispheres of the subjects. Regular EEG is clinically more demanding, and the operation is rather complicated as well, making it less suitable to monitor brain functions of newborns with HIE; however, aEEG helps fill that gap[11-14].

In this paper, we monitored newborns with HIE via aEEG, and studied relevant diagnosis and prognosis. The number of continuous EEG and mature SWC results were lower in the observation group compared to the controls which indicate that the EEG of newborns with HIE are mainly discontinuous, and SWC are mostly immature. The maximum voltage was notably higher and the minimum voltage was markedly lower in the observation group compared to the control group, demonstrating that the maximum voltage increases, whereas the minimum voltage decreases in newborns with HIE. These results are consistent with the reports by Reinke et al[15], and could be due to the fact that aEEG is a simplified form of EEG and works through continuous recording. The EEG signal comes from the two parietal bone electrodes of subject, gets amplified, filtered through frequency, goes through compression and integration of amplitude, and is finally recorded on the semi-logarithmic thermal paper. Since the paper speed is as slow as 6 cm/h, adjacent waveforms successfully manage to overlay and integrate. The overlap area can be observed clinically. While under the influence of the sleep cycle, aEEG results of normal full-term infants, appear to be a spectrum band that is alternately broad and narrow. The broad band corresponds to a quiet sleep, while the narrow band is more closely related to active sleep and the waking state. However, aEEG results of newborns with HIE change abnormally, and are likely to present relevant symptoms more accurately.

In the aspect of continuity, it was reported that the continuity normally falls into three categories, respectively continuous, discontinuous and threshold[15-17]. Yet, given that the threshold type is essentially of less maturity, it was classified as discontinuous in this paper. With regard to SWC, it was reported that it can also be classified into three types, respectively non-SWC (aEEG-related background activities have no cyclic changes), immature SWC (with initial formation of SWC, yet EEG cyclic changes are of low amplitude and no typical sine wave changes) and mature SWC (with discontinuous and relatively continuous sine wave changes during the period of 20 mins). In this paper, immature SWC were classified as non-SWC to simplify the statistical analyses. Since the SWC results in the control group are typical, it is rather easy to conclude that the absence of SWC indicates poor neurological prognosis of newborns with HIE[18-21].

Also, the monitoring results of aEEG are positively related to the clinical classification of HIE, as reported by Jellema et al[22]. Further verification of the monitoring results of aEEG could also reflect the clinical symptoms of newborns with HIE, thus contributing to an effective diagnosis and treatment[23,24]. Comparison of the monitoring results and the normal data enables evaluation of the severity of brain injuries of newborns with HIE. With the increasing clinical practice of hypothermia treatment, aEEG is also capable of assessing the effect of this treatment. Given the advantages above, aEEG has grown to be a regular monitoring indicator of newborns in NICU[25-28].

Conclusions

aEEG shows several advantages such as simple operation, effective diagnosis supporting continuous monitoring and reflects the lesion degree as well as long-term prognosis in newborns with HIE and is thus highly recommended in clinical practices.

Conflicts of interest

The authors declare no conflicts of interest.

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