Effects of low frequency electrical stimulation on monoamine neurotransmitters, cerebral blood flow and hemorheology in children with cerebral palsy

Sai Xun, Jun Chen, Guo-Sheng Jin, Jian-Hui Zhao, Ai-Yun Yuan, Yu-Tang Li, Mei Hou

Department of Rehabilitation, Women and Children's Hospital of Qingdao City, Shandong, Qingdao 266000, China

ARTICLE INFO

Article history:
Received 8 Sep 2017
Received in revised form 12 Sep 2017
Accepted 19 Sep 2017
Available online 28 Sep 2017

Keywords:
Cerebral palsy
Low frequency electrical stimulation
Monoamine neurotransmitters
Cerebral blood flow
Blood rheology

ABSTRACT

Objective: To investigate the effects of low frequency electrical stimulation on monoamine neurotransmitters, cerebral blood flow and hemorheology in children with cerebral palsy.

Methods: A total of 83 children with cerebral palsy were divided into the control group (n=42) and the observation group (n=41) according to the random data table, patients in the control group were treated with routine rehabilitation treatment, on this basis; the children in the observation group were treated with low-frequency electric stimulation. Before and after the treatment, the levels of monoamine neurotransmitter [dopamine (DA) and 5-hydroxytryptamine (5-HT) and norepinephrine (NE)], cerebral blood flow [the average blood flow velocity of anterior cerebral artery (ACA), middle cerebral artery (MCA) and posterior cerebral artery (PCA)] and blood rheology index [high/low shear whole blood viscosity, plasma viscosity and fibrinogen (FIB)] of two groups were compared.

Results: Before treatment, there were no significant difference of the levels of DA, 5-HT, NE, the average blood flow velocity of ACA/MCA/PCA, high/low shear whole blood viscosity, plasma viscosity and FIB between the two groups. After treatment, two groups of DA, 5-HT and NE levels were significantly higher than those in the same group before treatment, and the observation group of DA, 5-HT and NE levels were significantly higher than those of the control group, the difference was statistically significant; The average blood flow rate of ACA/MCA/PCA in the observation group after treatment was significantly higher than those in the same group before treatment; After treatment, the levels of high shear/low shear blood viscosity, plasma viscosity and FIB of the two groups were significantly lower than those in the same group before treatment; The levels of observation group after treatment were significantly lower than that in the control group, the difference was statistically significant.

Conclusion: Low frequency electrical stimulation can effectively increase the level of monoamine neurotransmitter, improve the level of cerebral blood flow and hemorheology, has an important clinical value.

1. Introduction

Children with cerebral palsy (CP) is a more common nervous system disease in pediatric clinical. It is a kind of motor dysfunction and abnormalities in posture of CNS injury, the main clinical manifestations of growth retardation, language function and limb movement disorders.

And it may be associated with mental retardation, seizures and other complications[1,2]. At present, there is no radical cure for the disease. The clinical treatment mainly includes drug treatment, rehabilitation treatment, western medicine treatment and traditional Chinese medicine treatment.

Studies have shown that the biological low-frequency electrical stimulation treatment can effectively improve the brain cell metabolism in children, and enhance brain function, can improve the curative effect of cerebral palsy[3,4]. The purpose of this study was to compare the effects of low frequency electrical stimulation on cerebral palsy in children by comparing the changes of monoamine neurotransmitters, cerebral blood flow and blood rheology indexes before and after treatment.
2. Data and methods

2.1. General information

A total of 83 children with cerebral palsy treated in our hospital from June 2015 to March 2017 were selected as the research objects. All the children were in accordance with the diagnostic criteria of cerebral palsy, which belonged to the range of spasticity and muscle tension. All the children were informed consent and signed informed consent. And exclude: (1) allergic children; (2) the muscle tension of grade 0 or grade V; (3) the influence of CT examination in patients with progressive disease of the nervous system in the near future; (4) the active use of drug treatment, has effect on the stimulation index; (5) there were lesions or with other skin disease; (6) the abnormal coagulation function; (7) 7 poor treatment compliance, failed to cooperate, cannot be treated. The patients were divided into the control group (42 cases) and observation group (41 cases) according to the random data table, 29 cases of male patients and 13 female children in the control group; aged from 5 to 72 months; the duration of 1 to 15 months, the average duration of (5.75 ± 0.63) months. The patients in the observation group were 30 cases of men, 11 females; age 5 months to 72 months; the duration of 1-15 months, the average duration of (5.62 ± 0.74) months.

2.2 Therapeutic method

The control group was treated with conventional rehabilitation program, mainly based on the clinical symptoms of appropriate treatment, drug use Cattle Encephalon Glycoside and Ignotin Injection brain cell nutrition (Ou Jilin Sihuan Pharmaceutical Co. Ltd. Dimei, production, Zhunzi H22025046, size 2 mL * 6 branch) intravenous infusion therapy, according to the weight of children 0.1-0.4 mL/Kg every time, adding 250 mL 0.9% Sodium Chloride Injection intravenous injection, 1 times a day, 2 weeks for 1 courses. Rehabilitation therapy includes rehabilitation of upper limbs and rehabilitation of lower limbs. The reflex suppression technique, tapping technique, Bobath suppression method and voita maneuver are performed 2 times a day, 30 min each time. The patients in the observation group were treated with low frequency electrical stimulation on the basis of routine rehabilitation treatment. The CVFT (model CVFT-011M), set the parameters: frequency of 50 Hz, stimulation on the basis of routine rehabilitation treatment. The observation group were treated with low frequency electrical stimulation 2 times a day, 30 min each time. The patients in the observation group were treated for 3 months.

2.3. Index detection

Fasting peripheral venous blood was collected before treatment and 3 months after treatment. The indexes of detection included monoamine neurotransmitter index and blood rheology index. Among them, the index of monoamine neurotransmitters including dopamine, serotonin (DA) 5- (5-HT) and norepinephrine (NE), detection method for the radioimmunoassay kit purchased from Shanghai Xian cotton Biotechnology Co. Ltd.. Blood rheology: high and low shear viscosity of whole blood viscosity, plasma fibrinogen (FIB), using MEN-C100 automatic blood analyzer detection. At the same time the cerebral blood flow of patients before and after treatment were detected by color Doppler ultrasound diagnostic instrument, including the anterior cerebral artery (ACA), middle cerebral artery (MCA) and posterior cerebral artery (PCA) and average blood flow velocity.

2.4. Statistical analysis

Research data were processed and analysed by using SPSS 17.0 statistical software. In the study, monoamine neurotransmitter index, cerebral blood flow and blood rheology levels are accord with the normal distribution, expressed in Mean ± SD. T test was used to compare the intra group and inter group indices, and the difference of P<0.05 was statistically significant.

3. Result

3.1. Comparison of monoamine neurotransmitter markers

The test results of monoamine neurotransmitter levels of two groups of patients before and after treatment were shown in table 1. Before treatment, there was no significant difference in the levels of DA, 5-HT and NE between groups (P>0.05). After treatment, the observation group DA, 5-HT and NE respectively (192.34 ± 22.82), ng/mL (210.18 ± 25.14) ng/L and (98.01 ± 11.82) ng/L, which were significantly higher than that in the group before treatment, and were significantly higher than those in the control group after treatment level (147.17 ± 17.13)ng/mL, (171.99 ± 20.56) ng/L and (83.18 ± 11.26) ng/L, the difference was statistically significant (P<0.05).

Table 1.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Time</th>
<th>DA (ng/mL)</th>
<th>5-HT (ng/L)</th>
<th>NE (ng/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>42</td>
<td>Before treatment</td>
<td>108.46±16.15</td>
<td>138.62±21.48</td>
<td>57.36±7.54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After treatment</td>
<td>147.17±17.13'</td>
<td>171.99±20.56'</td>
<td>83.18±11.26'</td>
</tr>
<tr>
<td>Observation group</td>
<td>41</td>
<td>Before treatment</td>
<td>108.77±16.39</td>
<td>138.89±21.16</td>
<td>57.32±7.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After treatment</td>
<td>192.34±22.82''</td>
<td>210.18±25.14''</td>
<td>98.01±11.82''</td>
</tr>
</tbody>
</table>

Note: compared with before treatment, *P<0.05, compared with the control group after treatment, **P<0.05.
Table 2.
Comparison of cerebral blood flow related indexes between two groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Time</th>
<th>ACA mean blood flow velocity (cm/s)</th>
<th>MCA mean blood flow velocity (cm/s)</th>
<th>PCA mean blood flow velocity (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>42</td>
<td>Before treatment</td>
<td>33.98±8.82</td>
<td>39.87±8.52</td>
<td>36.54±7.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After treatment</td>
<td>37.39±8.01</td>
<td>41.84±8.42</td>
<td>38.27±7.96</td>
</tr>
<tr>
<td>Observation</td>
<td>41</td>
<td>Before treatment</td>
<td>34.63±7.52</td>
<td>40.01±8.49</td>
<td>36.88±8.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After treatment</td>
<td>46.9±8.83&quot;</td>
<td>59.9±11.29&quot;</td>
<td>49.26±10.05&quot;</td>
</tr>
</tbody>
</table>

Note: compared with before treatment, \( P<0.05 \), compared with the control group after treatment, \( \# P<0.05 \).

Table 3.
Comparison of hemorheological parameters between the two groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Time</th>
<th>High shear whole blood viscosity (mPa.s)</th>
<th>Low shear whole blood viscosity (mPa.s)</th>
<th>Plasma viscosity (g/L)</th>
<th>FIB (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>42</td>
<td>Before treatment</td>
<td>6.77±1.06</td>
<td>10.41±1.28</td>
<td>2.01±0.26</td>
<td>5.62±0.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After treatment</td>
<td>5.78±0.35*</td>
<td>9.17±1.19*</td>
<td>1.72±0.24*</td>
<td>4.36±0.29*</td>
</tr>
<tr>
<td>Observation</td>
<td>41</td>
<td>Before treatment</td>
<td>6.65±0.92</td>
<td>10.46±1.24</td>
<td>2.03±0.29</td>
<td>5.46±0.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After treatment</td>
<td>5.19±0.19&quot;</td>
<td>7.45±1.37&quot;</td>
<td>1.34±0.18&quot;</td>
<td>2.61±0.35&quot;</td>
</tr>
</tbody>
</table>

Note: compared with before treatment, \( P<0.05 \), compared with the control group after treatment, \( \# P<0.05 \).

3.2. Comparison of two groups of cerebral blood flow related indexes

The test results of cerebral blood flow related indicators levels of two groups of patients before and after treatment were shown in Table 2. Before treatment, the mean ACA velocity, MCA average blood flow velocity and PCA mean blood flow velocity of two groups were relatively close, and the difference was not statistically significant \( (P>0.05) \). Compared with the group before treatment, the average blood flow velocity, MCA average blood flow rate and PCA average blood flow rate of the control group were increased in different degrees after treatment, but there was no statistical difference \( (P>0.05) \) between the two groups (ACA). After treatment, the observation group three levels were \((46.99 \pm 8.83) \text{ cm/s}, (59.96 \pm 11.29) \text{ cm/s} \) and \((49.26 \pm 10.05) \text{ cm/s} \), were significantly higher than the treatment group before and after treatment was significantly higher than the control group, the difference was statistically significant \( (P<0.05) \).

3.3. Comparison of hemorheological indexes between the two groups

There is no significant difference compared high/lower shear whole blood viscosity, plasma viscosity and FIB levels of two groups before treatment \( (P>0.05) \). After treatment, high/lower shear whole blood viscosity, plasma viscosity and FIB levels of two groups were reduced to varying degrees compared with the group before treatment, and the difference was statistically significant \( (P<0.05) \). The level of the observation group after treatment and \((5.19 \pm 0.19) \text{ mPa.s}, (7.45 \pm 1.37) \text{ mPa.s}, (1.34 \pm 0.18) \text{ mPa.s} \) and \((2.61 \pm 0.35) \text{ g/L} \) were significantly lower than the control group \((5.78 \pm 0.35) \text{ mPa.s}, (9.17 \pm 1.19) \text{ mPa.s}, (1.72 \pm 0.24) \text{ mPa.s} \) and \((4.36 \pm 0.29) \text{ g/L} \), the difference was statistically significant \( (P<0.05) \). As shown in Table 3.

4. Discussion

Cerebral palsy refers to the central nervous system damage caused by multiple factors before or after birth. Premature birth and low birth weight in infants are considered as the most important pathogenic factors of cerebral palsy[6]. Modern medical research has pointed out that the pathological changes of cerebral palsy mainly include the decrease of the number of neurons, the atrophy of cortex and the increase of non-neuronal cells[7]. In clinical treatment, drug treatment can effectively improve brain metabolism and promote the repair of nerve damage in children with cerebral palsy. Rehabilitation therapy is mainly the use of children’s cranial nerves are in the developmental stage and plasticity is stronger. It is currently one of the effective means of treatment of cerebral palsy in children that through repeated stimulation and training, so as to achieve the purpose of restoring normal movement[8,9]. In recent years, studies have found that chemical stimulation and electrical stimulation can effectively increase the regional cerebral blood flow, creating a prerequisite for improving the brain circulation[10]. Studies have found that the bilateral mastoid processes of low frequency electric stimulation can increase the activity of superoxide dismutase (SOD) in brain tissue after ischemia-reperfusion, reduce the level of free radicals, reducing edema, in addition to the expansion of cerebral blood vessels, accelerate regional cerebral blood flow and improve microcirculation[11,12]. On the basis of conventional drug treatment and rehabilitation treatment combined with low frequency electrical stimulation, the clinical effect of low frequency electrical stimulation is discussed from three aspects: monoamine neurotransmitter, cerebral blood flow and blood rheology.

DA, 5-HT and NE are important monoamine neurotransmitters, and they are also important neurotransmitters in the central nervous system. They are mainly involved in somatic activities, learning, memory, endocrine activities and spiritual activities[13,14]. DA has some effects on the brain nerve and emotional parts, and it is mainly involved in mental and emotional activities. 5-HT and NE are neurotransmitters with multiple physiological functions. The former is closely related to emotion regulation, sleep and appetite status, while the latter plays a more important role in cognitive function, especially attention and arous[15,16]. The results of this study pointed out that the DA, 5-HT and NE levels of two groups
after treatment were significantly increased, and the combination of low frequency electric stimulation treatment group were more significantly elevated. Which indicate low frequency electric stimulation can improve the level of monoamine neurotransmitter in brain tissue of children with cerebral palsy, decrease the excitability of neurons, and thus promote the recovery of neurological function.

In recent years, a large number of studies at home and abroad have confirmed that the cerebral hemodynamic related indexes in children with cerebral palsy are significantly lower than that of healthy children[17,18]. The results indicate that, After the stimulation of low-frequency electrical stimulation, the level of cerebral blood flow related indexes was significantly increased compared with before treatment and was significantly higher than the control group after treatment. The results consistent with previous reports of the content[19,20]. It is further proved that low frequency electrical stimulation can effectively speed up the cerebral blood flow and improve the microcirculation of the brain, whereas the reasons for this need to be further explored. Studies have shown that when children with cerebral palsy is in a high viscosity, high shear whole blood viscosity, low shear whole blood viscosity, plasma viscosity levels were higher, FIB deposition and erythrocyte aggregation increased. There was a significant correlation between the changes in the levels and severity of cerebral palsy[21]. The results of this study indicate that both rehabilitation therapy and combined with low frequency electric stimulation therapy can effectively reduce blood rheology level index, and low frequency electric stimulation treatment on index improved more significantly. It shows that combined with low frequency electrical stimulation treatment can improve the hypercoagulable state of the blood on the basis of routine drugs and rehabilitation therapy. It is more conducive to the recovery of the disease to reduce the concentration of FIB and improve the cerebral microcirculation. The level changes may be related to the electric stimulation of the biological conduction pathway, the release of neurotransmitters and the inhibition of platelets on the adhesion of the vascular endothelium[22].

In conclusion, low frequency electrical stimulation can effectively increase the level of monoamine neurotransmitter in children with cerebral palsy, enhance local cerebral blood flow, reduced blood rheology level and improve microcirculation. Which has important clinical value.

Reference