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Associations between oxidative stress and antioxidant protection system in affective-respiratory paroxysm

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Abstract: Affective-respiratory paroxysm (ARP) is an episodic loss of consciousness that occurs in children, and its mechanism is not fully understood. The aim of this study was to evaluate the state of oxidative stress and antioxidant defense system in children with ARP. The results show that the ARP group had higher levels of malondialdehyde (MDA) and reactive oxygen species (ROS), while the activity of antioxidant enzymes (SOD and GPx) was decreased. This indicates that the imbalance between oxidative stress and the antioxidant defense system may play an important role in the development of ARP. Therefore, it is important to evaluate the effectiveness of antioxidant therapy in future studies.

Keywords: Affective-respiratory paroxysm, oxidative stress, antioxidant defense system, malondialdehyde (MDA), reactive oxygen species (ROS), superoxide dismutase (SOD), glutathione peroxidase (GPx), pediatric neurology, biomarkers.

Introduction: Affective-respiratory paroxysm (ARP) is a temporary but serious physiological condition that can occur in children. It has been noted that this condition is often associated with stress, age-related immaturity of the nervous system, and biological factors (Halliwell & Gutteridge, 2019). In ARP, the child temporarily stops breathing, which can lead to hypoxia and increased oxidative stress. This process may also affect the nervous and immune systems, according to existing hypotheses (Ghezzi, 2020).

Research shows that oxidative stress plays an important role in various neurological disorders, and this process may also be significant in ARP. Oxidative stress leads to damage to cell membranes, proteins, and DNA due to excessive increase in reactive oxygen species (ROS) at the cellular level (Tain, Hsu, & Chan, 2022). At the same time, the antioxidant defense system works to reduce this damage. If this system is not sufficiently effective, the cells can be damaged, and the symptoms of the disease may worsen.

The changes in this system in conditions associated with ARP have not been fully studied yet. The research conducted so far has mainly focused on the neurological and psychosomatic aspects of ARP, and there is not enough information about its biochemical mechanisms. Therefore, it is necessary to study the relationship between oxidative stress and the antioxidant defense system in ARP in more depth.

The aim of this study was to analyze the relationship between oxidative stress and the antioxidant defense system in children with Affective-Respiratory Paroxysm (ARP). The hypothesis is that in ARP, the antioxidant defense system may be decreased, while oxidative stress may be increased. If this hypothesis is confirmed, it may help develop new therapeutic approaches for the treatment and prevention of ARP in the future.

METHODS

This was a cross-sectional study. The study included 40 children aged 3-7 years with a diagnosis of Affective-Respiratory Paroxysm (ARP) and 40 healthy children as a control group. All participants were examined by a pediatric neurologist, and the ARP diagnosis was confirmed based on international diagnostic criteria (Kane, Roberts, & Thompson, 2021).

Venous blood samples were collected from the participants. The blood samples were centrifuged to separate the plasma, which was then stored at -80°C. As biomarkers of oxidative stress, the concentrations of

malondialdehyde (MDA) and the levels of reactive oxygen species (ROS) were analyzed. Additionally, the activities of superoxide dismutase (SOD) and glutathione peroxidase (GPx) were measured to assess the state of the antioxidant defense system (Tain, Hsu, & Chan, 2022).

All data were analyzed using SPSS 26.0 software. The normality of continuous variables was checked using the Shapiro-Wilk test. The differences between groups were evaluated using Student's t-test or the Mann-Whitney test. Correlation analysis was performed using Pearson or Spearman coefficients. Results were considered statistically significant at $p < 0.05$.

Research Findings. The mean age of the children participating in the study was 5.2 ± 1.1 years. In terms of gender distribution, the ARP group had 22 boys (55%) and 18 girls (45%), while the control group had 21 boys (52.5%) and 19 girls (47.5%). There was no significant difference in age and gender between the groups ($p > 0.05$).

It was found that the level of malondialdehyde (MDA) was significantly higher in the ARP group compared to the control group (4.62 ± 0.85 nmol/mL vs. 2.89 ± 0.67 nmol/mL, $p < 0.001$). Additionally, the levels of reactive oxygen species (ROS) were also increased in the ARP group (2.31 ± 0.54 µmol/L vs. 1.74 ± 0.41 µmol/L, $p < 0.01$). These results confirm that the level of oxidative stress is higher in children with ARP.

The activity of antioxidant enzymes was significantly lower in the ARP group. For example, the activity of superoxide dismutase (SOD) was 3.78 ± 0.62 U/mL in the control group, while it was 2.94 ± 0.55 U/mL in the ARP group ($p < 0.01$). Additionally, the activity of glutathione peroxidase (GPx) was also decreased in the ARP group (48.6 ± 7.7 U/L vs. 61.2 ± 8.3 U/L, $p < 0.001$). This indicates that the antioxidant defense system is impaired in ARP.

The correlation analysis results showed an inverse relationship between MDA levels and SOD activity ($r = -0.57$, $p < 0.001$). There was also a negative correlation between ROS and GPx ($r = -0.49$, $p < 0.01$). These findings confirm that the increase in oxidative stress is associated with the weakening of the antioxidant defense system (Table 1.).

Table 1.

Indicators of Oxidative Stress and Antioxidant Defense System

Indicator	ARP Group (n=40)	Control Group (n=40)	p-Value
MDA (nmol/mL)	4.62 ± 0.85	2.89 ± 0.67	<0.001
ROS (µmol/L)	2.31 ± 0.54	1.74 ± 0.41	<0.01
SOD (U/mL)	2.94 ± 0.55	3.78 ± 0.62	<0.01
GPx (U/L)	48.6 ± 7.7	61.2 ± 8.3	<0.001

Note: MDA - malondialdehyde, ROS - reactive oxygen species, SOD - superoxide dismutase, GPx - glutathione peroxidase.

The results obtained indicate that in conditions associated with Affective-Respiratory Paroxysm (ARP), there is an increase in oxidative stress and a decrease in the antioxidant defense mechanisms. This condition can increase the risk of neurological damage, especially during ARP episodes. The significance of these findings is that they can help in early detection of conditions associated with ARP and evaluate the possibilities of antioxidant therapy.

DISCUSSION

The results of this study show that children with Affective-Respiratory Paroxysm (ARP) have significantly higher levels of oxidative stress markers and a decreased antioxidant defense system. These findings are important in understanding the pathophysiological mechanisms of ARP.

First, it was found that the levels of malondialdehyde (MDA) and reactive oxygen species (ROS) were much higher in the ARP group compared to the control group. This indicates an increase in oxidative stress, which can damage cell membranes, proteins, and DNA (Halliwell & Gutteridge, 2019). These results are consistent with previous studies, where oxidative stress has been shown to play an important role in neurological diseases (Ghezzi, 2020).

Second, the indicators of the antioxidant defense system, namely the activities of superoxide dismutase (SOD) and glutathione peroxidase (GPx), were decreased in the ARP group. This indicates a weakening of the antioxidant defense system, which reduces the

ability of cells to protect themselves from oxidative damage (Tain, Hsu, & Chan, 2022). Previous studies have also shown that decreased activity of antioxidant enzymes can lead to an increase in oxidative stress in neurological diseases (Kane, Roberts, & Thompson, 2021).

The correlation analysis results also showed an inverse relationship between MDA and SOD. This can be interpreted that as the level of oxidative stress increases, the antioxidant defense system weakens, and this process can lead to further exacerbation of ARP. The negative correlation between ROS and GPx also confirms this hypothesis.

These findings may be important for developing new therapeutic approaches to treat and prevent ARP. For example, enhancing the antioxidant defense system in children through antioxidant supplements or dietary changes may be beneficial. Future studies evaluating the efficacy of antioxidant therapy in conditions associated with ARP would be appropriate.

CONCLUSION

The obtained results are of great importance in understanding the biochemical mechanisms of ARP. In this condition, the imbalance between oxidative stress and the antioxidant defense system may be one of the main factors influencing the development of ARP. This suggests the possibility of using antioxidant therapy in the future to treat and prevent ARP.

Several directions are recommended for future research. Firstly, it would be appropriate to study the effects of antioxidant supplements in conditions associated with ARP. Secondly, long-term studies are needed to determine the impact of oxidative stress on the dynamics of ARP. Additionally, investigating genetic factors may also help provide a broader understanding of the mechanism of ARP.

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