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Association Study between Cesarean Section and Attention Deficit Hyperactivity Disorder in Children

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Abstract: Attention Deficit Hyperactivity Disorder (ADHD), characterized by inattention, impulsivity, and hyperactivity, is a common neurobehavioral disorder in children. Some studies suggest that cesarean section increases the risk of ADHD, while others suggest no association between cesarean section and ADHD. This study retrospectively analyzed the maternal pregnancy and delivery conditions of 280 cases with complete records of normal delivery and cesarean section admitted in 2024, and diagnosed ADHD and analyzed the psychological conditions of their children, in order to understand the relationship between maternal pregnancy and delivery conditions, as well as delivery mode, and ADHD in children.

Keywords: Attention Deficit Hyperactivity Disorder; Cesarean Section; Pregnancy and Perinatal Conditions.

1. Introduction

Natural childbirth is an inevitable physiological process for human reproduction, while cesarean section is only a non natural delivery method to solve difficult labor and the need for rapid termination of pregnancy, which is not absolutely safe for both mother and baby. Research has shown that cesarean section may cause neurological and psychological damage to children, affecting their intelligence and intellectual structure, but there is currently controversy[1]. Foreign animal experiments have found that dopamine neural channels are sensitive to changes in birth mode. Clinical research suggests that attention deficit hyperactivity disorder in children, which is related to metabolic disorders of dopamine neurotransmitters in the brain, may have some inherent connection with cesarean section. However, there is currently no report on whether cesarean section affects the attention of healthy school-age children. The development of sensory integration ability is directly related to children's learning ability and mental health. Attention Deficit Hyperactivity Disorder (ADHD) refers to a group of syndromes that occur in childhood and are characterized by significant difficulty concentrating, short attention duration, hyperactivity, or impulsive behavior compared to peers of the same age[2]. More and more scholars have noticed that a large proportion of ADHD children have abnormal conditions during pregnancy and childbirth. This study retrospectively analyzed the pregnancy and delivery status of 280 cases of normal and cesarean section patients with complete records admitted in 2024. The diagnosis and psychological analysis of ADHD in their children were conducted to understand the relationship between maternal pregnancy, delivery status, and delivery methods and ADHD in children.

2. Data and Methods

2.1. Research Subjects:

From over 800 medical records of deliveries from January to December 2024, approximately 300 individuals who lived in Jiaozhou City and had detailed contact information and complete medical records were selected for voluntary examination. After excluding individuals with intellectual disability, childhood obsessive-compulsive disorder, childhood anxiety disorder, and childhood tic disorder, a total of 280 individuals were included in the study. Among them, there were 150 cases of normal delivery and 130 cases of cesarean section.

2.2. Research Methods:

1) Analysis of Maternal Pregnancy and Delivery Factors: A retrospective analysis was conducted on all study cases to understand their delivery methods and complications during pregnancy and childbirth. 2) Screening for ADHD in children: Conduct a Wechsler Intelligence Test on all study children to exclude those with lower intelligence; Using the Conners Parent Scale and SNAP-IV Scale (both filled out by parents of children), understand the general situation of children, the general situation of children's parents, symptoms of hyperactivity, attention deficit, impulsivity, and behavioral problems in children, and screen for suspicious individuals. Communicate and verify with parents who have identified suspicious children, jointly conducted by chief pediatricians and psychiatrists.

2.3. Diagnostic Criteria:

onset before the age of 7; Symptoms for at least 6 months; If the diagnostic criteria for ADHD are met and the IQ is within the normal range, it can be diagnosed as ADHD [3].

2.4. Statistical Methods:

SPSS20.0 software package was used, and statistical methods such as t-test, analysis of variance, chi square test, and multiple logistic regression were employed. $P \leq 0.05$ indicates significant difference, and $P \leq 0.01$ indicates extremely significant difference.

3. Results

3.1. Correlation between Maternal Pregnancy, Perinatal Factors and Children's ADHD

Maternal pregnancy and perinatal complications include pregnancy associated anemia, pregnancy induced hypertension syndrome, pregnancy induced diabetes, fetal intrauterine growth retardation, fetal distress, elderly

primipara, preterm labor, labor process/labor force abnormalities (including prolonged latency, prolonged active period or stagnation, prolonged or stagnation of the second labor process, delayed or stagnation of fetal head decline, labor stagnation, primary or secondary uterine atony). The delivery methods are divided into cesarean section and vaginal delivery.

Firstly, a univariate analysis was conducted to compare the above factors with ADHD. The P-values for delivery mode, fetal distress, and intrauterine growth retardation were all<0.05, while other pregnancy and childbirth complications were not correlated with ADHD. See Table 1.

Table 1. Univariate regression analysis of maternal pregnancy and childbirth factors and ADHD

Maternal factors during pregnancy and childbirth	B value	OR value	P value
Pregnancy with anemia	-0.085	0.872	0.883
Pregnancy induced hypertension syndrome	-6.842	0.002	0.704
Diabetes in pregnancy	-4.542	0.015	0.746
Fetal intrauterine growth retardation	1.324	3.462	0.042
Fetal intrauterine distress	0.845	2.364	0.035
First delivery at advanced age	-1.354	0.280	0.216
Premature birth	0.946	2.715	0.248
Abnormal labor process	1.213	3.210	0.058
Delivery method	0.765	2.146	0.014

Further multivariate regression analysis was conducted on delivery mode, fetal intrauterine distress, fetal intrauterine growth retardation, and abnormal labor process/force with P values<0.1 and ADHD. The results showed that the P values for delivery mode, fetal intrauterine distress, and fetal intrauterine growth retardation were all<0.05, and the OR values were all greater than 1. The above three factors are all independent risk factors (P values<0.05), and they can significantly increase the risk of ADHD. See Table 2.

Table 2. Multivariate regression analysis of maternal factors during pregnancy and childbirth and ADHD

Factor	Bvalue	ORvalue	Pvalue
Delivery method	0.801	2.214	0.015
Fetal intrauterine distress	1.385	3.842	0.030
Fetal intrauterine growth retardatio	1.052	2.856	0.006
Abnormal production process	0.096	2.003	0.058

3.2. The Relationship between Delivery Methods and ADHD in Children

In this survey, there were 130 cases of cesarean section infants, including 22 cases of ADHD, with a detection rate of 16.9%; There were 150 normal newborns, including 12 cases of ADHD, with a detection rate of 8.0%. According to the chi square test, there was a significant difference between the two (P=0.015). It shows that the incidence rate of ADHD in children with cesarean section is significantly higher than that in children with normal delivery.

4. Discussions

Attention Deficit Hyperactivity Disorder (ADHD) is a common neurobehavioral disorder in children, characterized by inattention, impulsivity, and hyperactivity. The global prevalence of ADHD is approximately 7.2%, while the prevalence of ADHD in children and adolescents in China is 6.26%. ADHD is highly heritable, with a twin study in China showing that 72% of ADHD cases are related to genetic factors, and 20% are related to environmental factors. Some studies suggest that cesarean section increases the risk of ADHD, while others suggest that cesarean section is not associated with ADHD. Zhang et al. reported a 17% increased risk of ADHD in children who underwent cesarean section. Xu et al. analyzed previous research data and found that cesarean section only mildly increased the risk of ADHD. However, Zachariassen et al. did not find any ADHD like symptoms in the cesarean section group mice by comparing the distance, speed, and time of activity in the open field experiment between naturally delivered mice and cesarean section mice. Currently, there are no animal experiments on the correlation between delivery mode and mouse attention and impulsive behavior. The fear of natural childbirth among pregnant women is one of the reasons for the increase in cesarean section rates. Some scholars speculate that pregnant women who choose cesarean section may carry ADHD susceptibility genes. However, Leppert et al. established a cohort of 7921 pregnant women and 7925 newborns for long-term follow-up and compared ADHD related polygenic risk scores. However, researchers found that cesarean section is not related to neonatal PRS. A large prospective cohort study in Denmark found that after adjusting for confounding factors, cesarean section did not increase the risk of ADHD compared to natural delivery. Further analysis found that the presence of fetal membrane rupture before cesarean section was not related to ADHD. The researchers believe that although the microbial community structure of newborns is affected by cesarean section, cesarean section does not increase the risk of ADHD by affecting the microbial community structure. In addition, some researchers have pointed out that considering the high correlation between cesarean section and atopic diseases, as well as atopic diseases and ADHD, the two diseases may have the same pathogenesis. Current evidence suggests that cesarean section does not increase the risk of ADHD through genetics or affecting microbial community structure [4].

4.1. The Relationship between Delivery Mode and Maternal Complications During Pregnancy and Childbirth

The cause of ADHD in children is not yet clear. Most scholars believe that ADHD in children is a syndrome caused by multiple factors. At present, there is no clear report on the relationship between ADHD and delivery methods both domestically and internationally. The results of this study indicate that among various pregnancy and childbirth factors, cesarean section, intrauterine fetal distress, and intrauterine growth retardation are significantly associated with the occurrence of ADHD in children. BoksaP, El KhodorBF's research has shown that the dopamine system is highly sensitive to perinatal factors. Cesarean section or cesarean section with intrauterine hypoxia can cause changes in the dopamine system and function, leading to changes in the amount and pathways of neurotransmitter release in newborns, making children more susceptible to ADHD during their growth process. This suggests that reducing unnecessary cesarean section rates is beneficial for reducing the occurrence of ADHD in children. There is a significant

correlation between fetal distress and intrauterine growth retardation and the incidence of ADHD. The incidence of ADHD in children with maternal fetal distress or intrauterine growth retardation is significantly higher than that in children without this factor. Ya koulev believes that this is related to brain damage or impaired frontal lobe function, suggesting that ADHD is caused by delayed development of the prefrontal cortex. All sensory and motor functions are analyzed, synthesized, and regulated in the prefrontal cortex, which develops the latest and undergoes myelination of nerve fibers later. Under normal circumstances, myelination can only be completed during adolescence, and the connections between many parts are more complete. The clinical symptoms of ADHD gradually decrease with age and can completely disappear after puberty, which may be related to delayed maturation of the prefrontal cortex and myelin sheath in children [5]. Therefore, actively correcting intrauterine growth retardation and fetal distress during pregnancy and childbirth can reduce the incidence of ADHD in children.

4.2. Possible Mechanisms of The Relationship Between Delivery Methods and ADHD in Children

4.2.1. Intestinal Brain Axis.

The bidirectional communication regulation between the gut and the central nervous system, known as the gut brain axis, has been a research hotspot in the past decade. In addition to affecting the intestinal environment, gut microbiota also has an impact on distant organs, including the brain. The first year after birth is an important period for the formation of neuronal synapses and the growth of dendritic axons, which coincides with the establishment of a stable gut microbiota in children. The gut microbiota of newborns may affect the development of the central nervous system through the brain gut axis. Some gut microbiota can produce neurotransmitters, such as Bacteroides, Lactobacillus, and Bifidobacterium, which can produce gamma aminobutyric acid. Cenit et al. believe that neurotransmitters produced by gut microbiota can stimulate intestinal epithelial cells to secrete hormones or cytokines, transmit signals to the brain through the enteric nervous system, and affect behavior. Ikeda et al. compared the levels of neurotransmitters in the brains of mice born naturally and those born by cesarean section, and found that the levels of dopamine, norepinephrine, and serotonin in the brains of mice born by cesarean section were lower, and there were also behavioral changes. Short chain fatty acids, which are metabolites of gut microbiota, also participate in gut brain interactions. Common SCFAs include acetic acid, propionic acid, and butyric acid; Foley et al. found that subcutaneous injection of propionic acid in rats can lead to behavioral changes related to neural development. The gut microbiota can affect the development of innate and adaptive immunity. Erny et al. found that gut microbiota affects the maturation, differentiation, and function of microglia by comparing gene expression and surface markers in germ free and germ free mice. Microglia are immune cells that reside in the central nervous system and participate in innate immunity, playing an important role in the normal development of the brain. Some researchers found that there were fewer regulatory T cells in the lymph nodes and spleen of caesarean birth mice compared with natural delivery mice. Researchers have found a significant correlation between cytokine levels and ADHD symptoms. Buske Kirschbaum et al. reported that peripheral cytokines can directly cross the blood-brain barrier or bind to receptors on the vagus nerve to transmit signals. Ceylan et al. believe that cellular immunity and oxidative stress damage neurons and promote the formation of ADHD.

4.2.2. Hormonal Environment

Fill Malfertheiner et al. found that the level of arginine vasopressin in umbilical cord blood of newborns born naturally was significantly higher than that of newborns born by cesarean section. Bamberg et al. observed the natural delivery process through magnetic resonance imaging and found that the brain of the fetus was strongly compressed during delivery. Postpartum stress can lead to the release of a large amount of neurohormones, and some scholars speculate that this stressor has epigenetic effects on specific genes and is beneficial to health. Another study supports this hypothesis, and the investigation found that compared with selective cesarean section, the DNA methylation level in the placenta of natural delivery is significantly increased. Martinez et al. detected baseline and post stress salivary cortisol levels in healthy infants at 6 months of age and found that infants who underwent cesarean section had lower baseline and post stress salivary cortisol levels, indicating that cesarean section may affect hypothalamic pituitary adrenal axis function. In animal experiments, Sala et al. found that mice lacking oxytocin receptors exhibited impaired social behavior, while Hoffiz et al. found that AVP levels in the plasma of naturally delivered mice were 30-50 times higher than those of cesarean section mice, and had neuroprotective effects. Chang et al. found that the cortisol levels in the saliva of ADHD adolescent patients were lower than those in the control group. Therefore, it is speculated that changes in the neuroendocrine system during the perinatal period can affect neurological development.

4.3. Reducing the Cesarean Section Rate

Since the 1950s, due to the increasingly improved anesthesia, blood transfusion, cesarean section techniques, and anti infection measures, coupled with the development of perinatal medicine, cesarean section has become an important surgery to save the lives of pregnant women and fetuses. On a global scale, the cesarean section rate increased from around 5% in the 1950s to around 20% in the 1990s. However, in recent years, the cesarean section rate in China has been abnormally high, especially in big cities, with some reaching 40% to 50%. Major hospitals in China have reported that the proportion of social factors in indications for cesarean section is gradually increasing. There are multiple reasons for the increasing proportion of social factors, such as the increasing proportion of elderly primiparous women, precious infants, and macrosomia. With China's family planning policy of late marriage and late childbirth, coupled with the pressure of modern women's work and study, many women have missed the optimal childbearing age, leading to an increase in elderly primiparous women; With the improvement of people's living standards, excessive pursuit of high nutrition and high calorie during pregnancy has led to a significant increase in the incidence of macrosomia and a corresponding increase in cesarean section rates; In addition, with the development of ovulation induction technology and reproductive technology, there has been an increase in precious babies and multiple pregnancies, which has also increased the cesarean section rate; Some pregnant women insist on cesarean section to avoid pain, ensure the intelligence, safety, and auspicious day of the child.

In addition, in recent years, with the continuous improvement of anesthesia methods, the application of

antibiotics, and the advancement of cesarean section techniques, the safety of cesarean section has been greatly improved, avoiding the damage caused to mothers and infants by some complex vaginal delivery methods in the past, making cesarean section widely used and the cesarean section rate increasing accordingly. The increase in cesarean section rate to a certain extent marks the progress of medical level and the improvement of people's cultural quality. As an important method for dealing with difficult labor and high-risk pregnancy delivery, cesarean section has indeed played a significant role. There is data indicating that within a certain range, the increase in cesarean section rates has reduced maternal and infant mortality rates, saved the lives of many critically ill pregnant women, and reduced diseases such as vaginal wall prolapse and uterine prolapse. But when the cesarean section rate exceeds 20%, the perinatal mortality rate does not decrease with the increase of cesarean section rate. However, the postpartum hemorrhage, infection, organ adhesion, chronic lumbosacral pain, incision endometriosis, neonatal pneumonia, and neonatal asphyxia caused by cesarean section far exceed those caused by vaginal delivery. The above facts indicate that the decrease in perinatal mortality, especially neonatal mortality, cannot be achieved solely by increasing cesarean section.

5. Conclusion

In short, Delivery is a physiological phenomenon. During vaginal delivery, the compression of uterine contraction on the fetal chest can greatly reduce the incidence rate of neonatal respiratory diseases, and can also significantly reduce maternal injury, bleeding, infection and other serious complications. It is unnecessary to inappropriately relax the indications for cesarean section or to have no indications for cesarean section. After a sharp increase in cesarean section rates in developed countries for about 10-15 years, the upward trend was suppressed, and the significant decline in cesarean section rates became a sign of the development of perinatal medicine. Therefore, it is necessary to strengthen health education in prenatal schools for pregnant women, enhance communication with patients, make them aware that childbirth is a natural process, reduce their psychological burden, and lower the incidence of cesarean section caused by social factors, thereby reducing the incidence of ADHD.

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