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THE EFFECT OF CHRONIC HYPOXIA ON THE CENTRAL NERVOUS SYSTEM OF CHILDREN WITH CYANOTIC CONGENITAL HEART DISEASE

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ABSTRACT

Due to advanced treatments in the field of heart disease, cyanotic heart disease patients have a greater chance of survival, and nowadays many of them live until adolescence or middle age. One of the signs of this disease is blood hypoxia, which has acute and chronic effects on the CNS. In this paper the effect of chronic hypoxia on children affected by cyanotic congenital heart disease (CHD) is evaluated.

For this purpose children aged five to eleven years were divided into three major groups: cyanotic CHD, acyanotic CHD and normal. Then they were compared according to points achieved on the Visual Motor Gestalt Test, which established their intelligence and mental superiority. The average value of cyanotic CHD (mean±SD, 11.78±4.54) in all age groups was less than the other two groups. Furthermore, the average values of acyanotic CHD children (mean±SD, 8.97±4.04) were less than the normal subjects (mean±SD, 6.6±4.18). Statistically, the difference of means between the values of these three groups was significant in all age groups except for the five and nine year old groups.

The statistical insignificance of the values for 5 and 9 year old groups was due to the high variance of normal group point values in these two age groups. The effects of other influencing factors such as the job and education of parents, number of children in the family and the relative filial position of the child in his family were considered. As a result of this study, we have established that patients with CHD–especially cyanotic patients—have a considerable amount of intelligence retardation which the cardiologist and surgeon can prevent or minimize by shortening the period of hypoxia with rapid correction.

Keywords: Intelligence, Congenital heart disease (cyanotic), Hypoxia.

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INTRODUCTION

Almost one-third of the cardiac output has been allocated to the brain while the brain weighs only a little more than 2.5 percent of the total body weight. The blood O_2 content decreases from 19.6 mL/100mL to 12.9 mL/100mL after leaving the brain, indicating high oxygenative metabolism in the brain.[1]

Hypoxia is a case in which O_2 saturation is less than normal. Normally the O_2 saturation of a newborn is 85-90 percent, which later increases to 95-99 percent. This case differs from "anoxia" in which there is arterial O_2 stoppage, and from "ischemia" in which there is incomplete blood circulation to cells or organs which causes disorders in their functions.

In chronic hypoxia the patient has insufficient O_2 for a long period of time and cyanotic CHD patients are in this group. Chronic hypoxia affects organs and different systems of the body. One of these sensitive and important organs is the CNS which is vulnerable in different ways. For example, cerebral apoplexy may occur in children under 2 years of age, especially if they are suffering from iron deficiency and have an arterial blood O_2 saturation of less than 50 percent. If hypoxia is severe or accompanied by periodical peaks it can cause changes in organelle structures and neural central-peripheral conductive axons.

While many cyanotic CHD patients show normal evolution, a minority have motor and mental retardation handicaps.[2] The necessary time for reaction and response to stimuli increases in cyanotic CHD patients, and a meaningful relation with O_2 saturation of blood is observed in them.[3] Growth and development in severe cyanotic CHD and puberty in those who have not been operated on show retardation. In addition, cyanotic CHD children usually start walking later than the other two groups.[4]

The effect of hypoxia on intellectual function and fine function of the CNS in cyanotic CHD patients was also considered in order to decrease the possibility of damage to the level of intelligence by means of new progressive discoveries. Intelligence is a noteworthy topic for different groups such as psychiatrists, psychologists, cultural authorities and parents. Obviously the intelligence, especially of the younger portion of the population, grants the survival of independence and progress of a nation. The manifest importance of intelligence is thus verified.

Consequently, parents and specialists are interested in knowing if cyanotic CHD affects the intelligence of affected children. Hypoxia caused by cyanotic CHD, chronic CHD, and stressful CHD, either cyanotic or acyanotic can affect the child's level of intelligence. This case is more severe and tangible in cyanotic patients and less in acyanotic ones. Perhaps low arterial blood O_2 saturation is the first factor in relation to retardation of mental development in these children. Hence we decided to examine this case in our regional children.

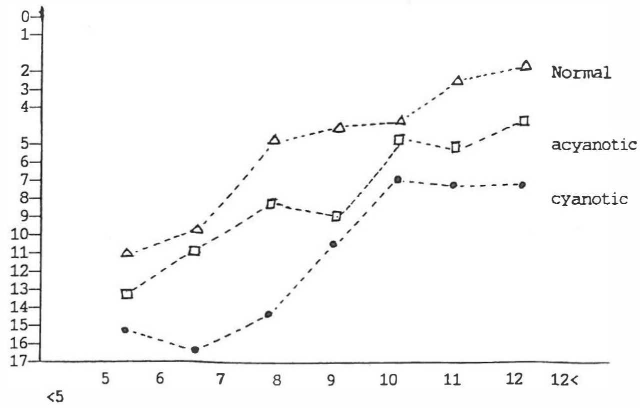

Fig. 1. Mean values of the Bender-Gestalt test in different age groups among cyanotic, acyanotic and normal children (5-11 years of age) who referred to pediatric and cardiac surgery wards and clinics of Shiraz during 1993-1994.

METHODS

After consulting with psychologists and psychiatrists in order to present an enforceable test in clinical centers and hospital wards and considering the facility of learning to grade, the Visual-Motor Gestalt test was adopted. The Gestalt test is the second most esteemed test to evaluate intelligence and mental aspects of children in the world (Wechsler is the first). The Visual-Motor Gestalt test and clinical use article was published in "Psychiatrical Evaluation of Children and Youngsters Magazine" in 1938.[6] Since this test has been invented it has become one of the most common tests in psychology. It was considered the fourth most commonly used test in 1958 and more recently as the second one.

This test includes nine illustrated cards, 4 × 6 inches, which are systematically presented to the subject by the tester. The subject has to draw them on a white page. Bender was the first to prove that it is possible to evaluate

Table I. The study group.

	Group	Subgroup	Number	Total No.
A	Cyanotic	Tetralogy of Fallot (TF) Transposition of great arteries (TGA) Arteriovenous fistula (AVF)	38 10 2	50
B	Acyanotic	Ventricular septal defect (VSD) Atrial septal defect (ASD) Patent ductus arteriosus (PDA)	28 14 8	50
C	Normal	Normal	50	50

child intelligence by these cards.

The maximum grade on the Bender Gestalt test is 30 based upon the child's error, unlike other intelligence tests. The lower grade is better; therefore, we use the terms "better" and "worse" in order to avoid any misinterpretation. Having finished testing the cases, we graded them with the aid of a group of psychological consultants, and then compared their scores.

Clearly we should not claim that it is possible to assess the real intelligence of a child according to the child's responses to this test. Certainly, no test can absolutely evaluate a child's intelligence. However, Pascal and other distinguished scientists such as Suttell, Keller, Stewart, Cunningham, Baldwin, Smith, Keogh and Koppitz proved that the test scores have a meaningful relation to preparedness to enter school, educational progress, reading and writing difficulties, child intelligence tests and his family's social level.[7]

Test scores of children in Europe, USA, and Shiraz did not depend on gender during standardization of the test, so sex was not considered in the choice of subjects of this research. On the other hand, the socioeconomic class of a family, which has a great effect on the child's test score, and in turn, is affected by the job and educational level of the parents, was of utmost consequence. Another prime factor was the position that the child had in relation to his siblings (first, second, last...). As a result, we tried to match the children in viewpoint of their factors, jobs, parents' education, and number of family members in the three groups (cyanotic CHD, acyanotic CHD, and normal).

Two-hundred and eighty children (5-11 years of age) affected by CHD (140 cyanotic type, 140 acyanotic type) were chosen from the internal ward and the pediatric cardiac surgery clinic and ward. They had been referred or admitted for examination, catheterization, palliative surgery or total correction. 140 normal, healthy children (5-11 years of age) who referred to the clinic not for serious illness but for due general evaluation or routine check-ups were also chosen. To complete the cases, we chose some middle to low class students. The patients were mostly from Fars province, but some were from other parts of the country.

The clinical diagnosis was determined by cardiac catheterization and echocardiography. Pediatric cardiologists did the clinical evaluation. After thorough explanation to their parents, the children were tested according to the Bender-Gestalt test. Children affected by Down's syndrome, Turner's syndrome or mental retardation were excluded from the list of test subjects. In addition, even though the necessary time for the test has no direct effect on the child's score, the cases who gave the test during a time more than the standardized period were also excluded. Children who were incapable of relative cooperation with the tester were also excluded. Finally, children aged 5-11 were sorted into different groups of normal, cyanotic CHD, and acyanotic CHD as shown in Table I.

RESULTS

The mean value of cyanotic CHD children (mean±SD, 11.78±4.54) in all age groups was worse than acyanotic (mean±SD, 9±4.04) and normal subjects (mean±SD, 6.6±4.18). The mean score of the acyanotic group was better than the cyanotic and worse than the normal group (Fig. 1). Table II indicates a scale representation of mean values, standard deviation, degree of freedom, and the P values of the different groups. After indicating the mean value of the groups, analysis of variance (ANOVA) was carried out. According to the Table, the P values in the five and nine year old groups were 0.1170 and 0.4870, respectively, which statistically indicates that the score difference between cyanotic, acyanotic and normal has no significance in these two age groups. However, it is interesting to notice the great variance between the score of normal groups which results in a variance which is not significant. The P values in all other groups is under 0.05, so the mean score of cyanotic, acyanotic, and normal groups has a significant variance.

DISCUSSION

The main purpose of this paper was to investigate the effect of hypoxia on the CNS with more emphasis on the development of intelligence and fine motor function. Considering the results of Table II and the mean value figure, we can conclude that mental and intelligence retardation of children affected by cyanotic CHD is influenced by the following factors:

1. Because of the significant relation between the Bender-Gestalt test and intelligence, hypoxia as a pathologic factor can cause intelligence retardation in cyanotic CHD children in comparison with acyanotic and normal subjects.

2. The heart is a vital organ, affecting the whole body, and people are usually sensitive to its involvement with disease (both children and adults). So, in addition to the hypoxic problem, heart disease itself is another cause of intelligence development retardation in these children. This can be proven by observing intelligence retardation in them, though it is less in the acyanotic group.

3. In comparison with the normal group, we can mention some factors causing intelligence retardation, such as the behavior of parents and educators toward CHD patients

(especially those with cyanotic CHD). A great deal of overprotectiveness, pampering, and the prevention of constructive group play has been observed. This might be caused by the lax effort in art instruction in Iranian schools. This phenomenon shows more effect on the intelligence scores of children affected by cyanotic CHD and acyanotic disease.

4. Parents and school educators pamper these children and give them no occasion to come in contact with natural stimuli, which can be the foundation for personality and intelligence development in children. It is recommended that physicians who care for such children advise their parents to secure a free environment in which normal social contacts can be established by such children. This can be greatly beneficial in the mental development of the child.

As a result of testing the subjects and comparing the mean score of the afore-mentioned groups, we have established that cyanotic CHD patients have a considerable amount of intelligence retardation in comparison with the two other groups. Furthermore, acyanotic CHD patients display more intelligence retardation than normal healthy children.

In this respect, not only is hypoxia as a pathologic consequence a main factor, but also other factors such as parental coddling and overprotection play a role. Moreover, such conduct is also observed in the educational setting. Pediatric cardiologists and surgeons can eliminate the main factor by shortening the period in which the child is obliged to suffer from chronic hypoxia. This is possible by early total correction or palliative cardiac surgery. On the other hand, psychological consultations are necessary for the parents of such children and the children themselves in order to provide stimuli essential to establish the development of intelligence and understanding.

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