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# CEREBRAL HEMODYNAMICS IN CHILDREN WITH LEFT VENTRICULAR FALSE TENDONS

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Connective tissue dysplasia can be a predictor of heart arrhythmia and acute cerebrovascular disease in the future. At the moment, the question of the condition of cerebral hemodynamics in children with dysplasia is open. The purpose of the present work was to study the state of cerebral hemodynamics in children with left ventricular false tendons. The study involved 64 patients with false tendons and 23 apparently healthy children aged 13 to 17 years. Cerebral hemodynamics was assessed using rheoencephalography. In children with false tendons in the arteriae Carotis territory, the tone of large and medium-sized vessels is reduced against the background of satisfactory elasticity of their walls. Venous return is not impaired. No significant hemodynamic disorders were observed in the arteriae Vertebralis territory.

**Key words:** children, connective tissue dysplasia, false tendons, rheoencephalography.

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# ЦЕРЕБРАЛЬНА ГЕМОДИНАМІКА У ДІТЕЙ З АНОМАЛЬНО РОЗТАШОВАНИМИ ХОРДАМИ В ЛІВОМУ ШЛУНОЧКУ СЕРЦЯ

Дисплазії сполучної тканини можуть бути предиктором порушень ритму серця та гострих порушень мозкового кровообігу в майбутньому. У літературі на разі відкрито питання про стан церебральної гемодинаміки у дітей з дисплазіями сполучної тканини. Метою дослідження було вивчити стан церебральної гемодинаміки у дітей з аномально розташованими хордами в лівому шлуночку серця. Обстежено 64 пацієнтів аномально розташованими хордами з та 23 практично здорових дитини контрольної групи віком від 13 до 17 років. Оцінку церебральної гемодинаміки проводили за допомогою реоенцефалографії. Встановлено, що у дітей з аномально розташованими хордами у басейні a.Carotis фіксується зниження тонусу судин великого і середнього калібрів на фоні задовільних показників еластичності їх стінок. Венозний відтік не був порушений. У басейні a.Vertebralis істотних порушень гемодинаміки не було зафіксовано.

**Ключові слова:** діти, дисплазія сполучної тканини, аномально розташовані хорди, реоенцефалографія.

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Today, in the practice of a pediatrician and pediatric cardiologist, the number of young patients with defects in the connective tissue development has increased. This pathology has a significant frequency in the pediatric population – from 26 to 80% [2]. It is known that connective tissue dysplasia syndrome (CTD) is a favorable background for the development of many diseases. Sometimes it can be a predictor of future serious pathologies, such as heart arrhythmia, infective endocarditis and acute cerebrovascular accidents [3]. Now there are two main groups of CTD: 1) differentiated diseases – hereditary connective tissue dysplasias; 2) hereditary connective tissue dysplasia with visceral manifestations. The first group includes the systemic hereditary syndromes of Ehlers – Danlos, Marfan, Grönblad – Strandberg, Holt – Oram, and the pachydermatocele – "Cutis laxa". The second group includes diseases with a set of phenotypic traits that do not fit into any of the previously described syndromes and are referred to as undifferentiated connective tissue dysplasia (UCTD). According to the latest data, UCTD occurs in 4.0—85.0% of the population, and it takes up to 40.0% in the structure of pathologies associated with the cardiovascular system. Dysplastic changes can be local or widespread. Changes, which are localized in only one organ are called isolated [9]. The most important visceral phenotypic manifestations of UCTD include prolapse of the mitral and other heart valves, false tendons (FT) of the ventricles, and a number of other manifestations [3, 6].

Cerebral hemodynamics provides a full brain blood supply in various conditions of the body's life. This became possible due to a complex system of regulation of cerebral circulation, which is aimed at changing the cerebral vascular tone [11, 12]. The basis of the functional stability of cerebral blood flow is the vascular reactivity: the ability to respond promptly and adequately to various types of stimuli in order to ensure the normal brain activity. Today, it is known that even non-severe cerebral vascular disorders in childhood affect the occurrence of cerebral accidents in adulthood. Clinical manifestations may not appear in adolescents immediately, due to large compensatory capabilities (collateral circulation, a high degree of vascular elasticity, initial degenerative and dystrophic manifestations). But in adulthood, with even a slight compensation breakdowns, serious hemodynamic changes, including strokes, may occur [7]. Therefore, the relevance of early detection of cerebral hemodynamic disorders in adolescents is beyond doubt.

Today it is possible to diagnose cerebral disorders in children using rheoencephalography (REG), which indices are still relevant. The method is based on the graphical registration of changes in the value of the variable electrical resistance (impedance) of the head tissues, which is caused by the pulse fluctuations of their blood filling. This provides indirect information about the intensity of blood filling in the brain vessels; about the state of tone and elasticity of cerebral vessels; about the state of venous return from the cranial cavity. It is also possible to get reliable information about vascular dystonia and hemispheric asymmetry [1].

Considering that the issues of cerebral hemodynamics in children with UCTD are controversial, we decided to perform our own study.

**The purpose** of the study was to study the intensity of blood filling in the brain vessels, the state of tone and elasticity of cerebral vessels, and venous return from the cranial cavity in children with left ventricular false tendons.

**Materials and methods.** The study was carried out on the basis of the Vinnytsia City Hospital "Center for Mother and Child" in the city of Vinnytsia, Ukraine. The inclusion criteria for the study were children with UCTD and the presence of FT in the left ventricle as its cardiac manifestations. The study included 64 patients aged 13 to 17 years. Among them there were 40 boys and 24 girls. The control group included 23 practically healthy children of the same age as the study group of children.

Cerebral hemodynamics was studied using REG. We studied its main quantitative indicators using the hardware-software rheographic complex DX-NT "Regina". It was analyzed: 1) index — rheographic index (RI), which displays the pulse volume and blood flow in the whole body; 2) dicrotic index (DCI), which shows the state of the small-sized vessels tone; 3) diastolic index (DI) – it shows the venous tone; 4) the state (tone) of vessels of medium and large caliber was analyzed using the A/T parameter (the ratio of the ascending phase time to the entire pulse wave time); 5) vascular elasticity was determined by the anacrot time.

Data processing. The mean values, which were presented in the form of M±m, where M is the arithmetic mean, m is the standard error of the mean, were estimated. We evaluated the differences between the results of the two samples using the parametric Student's test (t). All calculations were performed using a special program Microsoft Excel Windows-2007, license number 00426-OEM-8992662-00400, which are included in the Microsoft Office 2003 software package.

**Results of the study and their discussion.** We began the analysis of cerebral hemodynamics with an assessment of the state of a. Carotis territory in children from the study group. First of all, we determined the value of pulse volume, namely, blood flow. This was generally carried out using the REG RI index, which was significantly increased in the left territory of a. Carotis (1.88±0.06 versus 1.65±0.03, $p<0.05$) and in the right territory (1.83±0.07 versus 1.66±0.03, $p<0.05$), respectively. These indices characterize the blood flow in the a. Carotis territory as hypervolemic one. The state of microcirculatory bed in patients remained unchanged, with a slight tendency to increase in tone in small-sized vessels on both sides (an insignificant increase in DCI). The venous outflow in both hemispheres was generally satisfactory, according to the mean DI values. Another picture was recorded with the tone of large-caliber vessels. According to the results of the mean A/T values, children with FT had the vascular tone hypotension in large and medium-sized vessels on both sides, compared with the control group data (13.75±0.33 vs. 14.67±0.36, $p<0.05$) on the left side and (13.75±0.31 vs. 14.64±0.3, $p<0.05$) on the right side, respectively. The vascular wall elasticity in children with FT was generally satisfactory, respectively to the index of anacrota time (table 1).

Table 1

**The state of cerebral hemodynamics in the a. Carotis territory in children with FT**

| Index REG | Children with FT, n=64 | | Control group, n=23 | |
|---|---|---|---|---|
| | a. Carotis territory | | | |
| | Left side | Right side | Left side | Right side |
| RI | 1.88±0.06* | 1.83±0.07* | 1.65±0.03 | 1.66±0.03 |
| DCI | 66.5±2 | 67.74±1.72 | 63.79±1.75 | 63.46±1.84 |
| DI | 72.86±1.98 | 74.4±1.75 | 71.73±1.29 | 71.57±1.21 |
| A/T | 13.75±0.33* | 13.75±0.31* | 14.67±0.36 | 14.64±0.3 |
| Anacrota | 0.1±0.004 | 0.1±0.004 | 0.1±0.002 | 0.09±0.002 |

Note: (*) denotes significant differences relative to the control group ($p<0.05$).

According to the mean values of cerebral blood flow indices, we did not receive any significant deviations in the a. Vertebralis territory relative to the control group. On the other hand, there was a tendency to RI increase (pulse blood flow), an increase in the small-caliber vessels' tone, but to a decrease in the tone in large and medium-sized ones, according to the results of DCI, DI and A/T. The elasticity of all vascular walls in children with FT was increased in both hemispheres (0.1±0.004 versus 0.09±0.003, $p<0.05$) on the left and right (0.1±0.004 versus 0.09±0.002, $p<0.05$), respectively (table 2).

Table 2

**The state of cerebral hemodynamics in the a. Vertebralis territory in children with FT**

| Index REG | Children with FT, n=64 | | Control group, n=23 | |
|---|---|---|---|---|
| | a. Vertebralis territory | | | |
| | Left side | Right side | Left side | Right side |
| RI | 1.68±0.18 | 1.62±0.17 | 1.46±0.06 | 1.46±0.05 |
| DCI | 69.4±1.91 | 68.73±1.8 | 65.88±1.85 | 65.83±1.34 |
| DI | 75.8±3.42 | 74.8±2.92 | 72.5±1.19 | 73.1±1.71 |
| A/T | 13.88±0.56 | 13.95±0.56 | 14.72±0.25 | 14.74±0.29 |
| Anacrota | 0.1±0.004* | 0.1±0.004 | 0.09±0.003* | 0.09±0.002 |

Note: (*) denotes significant differences relative to the control group ($p<0.05$)

Qualitative analysis of rheogram data included an assessment of its types. We took into account the vascular tone of all calibers and the state of the venous system. At the same time, three types of rheographic curves were identified: normotonic, hypertonic and hypotonic one. The tone of the arteries and veins was also divided into 3 types, namely: normal, increased and decreased.

Analyzing qualitative REG results in children with FT in a. Carotis territory, we obtained the following results. Thus, the most common type of rheogram in the above patients was hypotonic and amounted to 56.3% (36/64 children). The hypertonic type was recorded in a slightly smaller number of patients – 35.9% (23/64). The remaining 7.8% (5/64) of children had a satisfactory normotonic rheogram.

The tone of large vessels in 62.5% (40/64) of children with FT was decreased, in 14.1% (9/64) of patients it was increased, and in 23.4% (15/64) – the tone of large vessels remained unchanged. Almost a similar picture was recorded with the tone of medium-sized vessels, where almost a half — 48.4% (31/64) of children had a decrease in tone, and 29.7% (19/64) – an increase. Satisfactory tone was characteristic only for 21.9% (14/64) of children.

The tone of small-caliber vessels did not have a clear direction, and its variability dominated. A large number of children – 40.6% (26/64) had an increased vascular tone, and a large number of patients had normal tone – 32.8% (21/64). We recorded a decrease in the tone of small-caliber vessels in 26.6% (17/64) of children.

Venous return was increased more than in a half of the studied patients – 51.6% (33/64). A slight difference was observed between the frequency of satisfactory tone — in 28.1% (18/64) and the reduced one — in 20.3% (13/64) of patients. Dystonia occurred in 25% (16/64) of children.

Describing the qualitative indices of REG results in the a. Vertebralis territory, the following changes should be noted. Thus, the hypotonic type of rheogram also prevailed in these children — 42.2% (27/64) of patients. Also, a large number had a hypertonic type – 37.5% (24/64) of children, and the remaining 20.3% (13/64) had a normotonic type of rheogram. The tone of large vessels was decreased in almost half of the patients – 51.6% (33/64). Almost the same number of patients had satisfactory – 23.4% (15/64) and increased – 25% (16/64) had large-caliber vascular tone. In medium-sized vessels, we often recorded an increased tone – 43.8% (28/64) of children with FT. This proves the very high frequency of recorded rheograms with hypertonic type. Decreased tone in these medium-sized vessels – in 31.2% (20/64) and normal tone – in 25% (16) of patients, respectively. Almost the same number of children had both normal – 40.6% (26/64) and increased small-caliber vascular tone – 43.8% (28/64) of patients. Reduced tone was observed only in 15.6% (10/64) of children. Venous disorders have also occurred. We recorded an increase in venous tone in 51.6% (33/64) of the subjects. Venous hypotension was noted in 17.1% (11/64) of adolescents. The remaining children did not have venous return disorders – 31.3% (20/64) (table 3).

Analyzing the results obtained, we found that in children with FT in the a. Carotis territory, a decrease in vascular tone dominates, as indicated by both quantitative and qualitative indices. So, among the quantitative values, there is an increase in blood flow, i.e. its hypervolemia, according to RI data, relative to the control group ($p<0.05$). This can be associated with a decrease in the tone of large and medium-sized vessels on both sides, corresponding to A/T values ($p<0.05$). The statistically insignificant increase in the tone of small vessels and a satisfactory elasticity of the vascular wall explain the compensatory changes in the above disorders to ensure normal blood flow in general. The marked results are also displayed in detailing the quantitative composition of rheograms. According to the qualitative characteristics, we noted similar results among the state of the tone of vessels of large and medium calibers in the form of their decrease. The number of children with such results was dominant 62.5% (40/62) and 48.4% (31/64), respectively. A similar situation applies to small vessels, in the form of a tendency to an increase in their tone, both according to the data of quantitative indicators and qualitative ones – in 40.6% (26/64). We have registered that the main group of children is dominated by a decrease in vascular tone in the a. Carotis territory and a tendency to decrease in the a. Vertebralis territory, respectively. This is due to the greater variability of the influence of the autonomic

nervous system links on the vascular tone in children with FT, in the form of sympathetic and parasympathetic tension [4], with the dominant sympathetic in general, which has been proven in other studies [6, 10]. In addition, an important role in these changes in hemodynamics may be associated with the pathology of the elastic vascular frame, which is typical for CTD [8].

Table 3

**Qualitative indices of rheoencephalography in children with FT**

| Rheoencephalography indices | | FT, n=64 | | | |
|---|---|---|---|---|---|
| | | Territory of a. Carotis | | Territory of a. Vertebralis | |
| | | Abs. | % | Abs. | % |
| Rheogram type | Normotonic | 5 | 7.8 | 13 | 20.3 |
| | Hypertonic | 23 | 35.9 | 24 | 37.5 |
| | Hypotonic | 36 | 56.3 | 27 | 42.2 |
| Tone of large caliber arteries | Normal | 15 | 23.4 | 15 | 23.4 |
| | Reduced | 40 | 62.5 | 33 | 51.6 |
| | Increased | 9 | 14.1 | 16 | 25 |
| Tone of medium-caliber arteries | Normal | 14 | 21.9 | 16 | 25 |
| | Increased | 19 | 29.7 | 28 | 43.8 |
| | Reduced | 31 | 48.4 | 20 | 31.2 |
| Tone of small-caliber arteries | Normal | 21 | 32.8 | 26 | 40.6 |
| | Increased | 26 | 40.6 | 28 | 43.8 |
| | Reduced | 17 | 26.6 | 10 | 15.6 |
| Venous blood flow | Normal | 18 | 28.1 | 20 | 31.3 |
| | Increased | 33 | 51.6 | 33 | 51.6 |
| | Reduced | 13 | 20.3 | 11 | 17.1 |

Variability in the tone of medium-and small-caliber vessels, despite their joint tone, is generally associated with the adaptation of tone to changes in blood flow. Probably, this mechanism serves to prevent the hypervolemia development, which had a tendency to develop in the a. Carotis system, according to REG, on both sides relative to the control group ($p<0.05$). Venous return was generally impaired due to increased venous tone.

## Conclusions

1. Children with FT have a hypervolemic type of blood flow in the a. Carotis territory and normovolemic one in a. Vertebralis territory in both hemispheres of the brain.

2. The tone of large and medium-sized vessels is reduced in the territories of cerebral blood flow arteries. The elasticity of their walls was satisfactory in the a. Carotis territory and increased in the a. Vertebralis one.

3. Venous return both in a. Carotis and a. Vertebralis territories is not impaired.

4. Children with FT should be under the supervision of narrow specialists.

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