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Pulse blood filling of intraosseous tissues in patients with perthes disease

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Abstract
The purpose of the research is a retrospectively study of the features of pulse blood filling of the head and neck of the femur in patients with Perthes disease before surgery with different outcomes of the recovery process. The analysis was done on the results of preoperative studies of pulse blood filling in the head and neck of the femoral bones in 16 children with Perthes disease at the fragmentation stage. Changes in the original indicators of pulse blood filling in the femoral head in patients with Perthes disease during the fragmentation stage might be a sign of an unfavorable course of the revascularization process and may indicate the probability of an unfavorable result.

Keywords: Perthes disease, intraosseous circulation, rheovasography

1. Introduction
Among the prognostic criteria for Perthes disease there are short-term indicators related to the condition of the joint at the end of treatment and long-term parameters suggesting the period of development of the degenerative process in the joint [1]. According to the results of numerous studies, the major short-term criteria include age, gender, the area of the epiphysis lesion and the degree of its extrusion [2, 3, 4].
These indicators make it possible to determine the strategy of the treatment process. However, their predictive capabilities with the framework of regulated treatment options are limited. Therefore, it is important to search for an additional criteria that would allow to predict the outcome of treatment.
The purpose of the research is a retrospectively study of the features of pulse blood filling of the head and neck of the femur in patients with Perthes disease before surgery with different outcomes of the recovery process.

2. Materials and methods
The analysis was done on the results of preoperative studies of pulse blood filling in the head and neck of the femoral bones in 16 children with Perthes disease at the fragmentation stage. The average age of patients at the moment of the operation was 7.8 years (7-9 years). 11 boys and 5 girls. Surgical intervention included hardware decompression, tunneling of the neck and head, varus osteotomy of femur (6 joints), and pelvic osteotomy (10 joints).
Inclusion criteria: stage of fragmentation; group III-IV by Catterall criteria; group B/C, C by the Herring criteria; the period after the surgical treatment is at least four years.
Exclusion criteria: stage of the aseptic necrosis, recovery, outcome; group I-II by Catterall criteria; group A/B according to the Herring criteria.
X-ray results were evaluated based on Stulberg criteria: I class – 3 joints, II class – 9 joints, III class – 3 joints, IV class – 1 joint. Based on the results obtained, the patients were divided into 2 groups.
The first group consists of 12 patients with results matching to the I – II class. 4 girls and 8 boys. The average age is 7.9±0.3 years. Distribution of joints according to Catterall criteria: group III-7, group IV-5. Distribution of joints according to Herring criteria: group B / C-8, group C-4. During the treatment, hip osteotomy was performed in four cases, and pelvic osteotomy was performed in eight cases. The average duration of treatment in the apparatus was 82±0.5 days.
4 joints of class III-IV were included in the second group. One girl and three boys. The average age is 7.5±0.27 years. Distribution of joints according to Catterall criteria: group III-3, group IV-1. distribution of joints according to Herring criteria: group B/C-2, group C-2. During the treatment, hip osteotomy was performed in two cases, and pelvic osteotomy was performed in two cases. The average duration of treatment in the apparatus was 80±0.7 days.
The obtained results were compared with each other and with the control group. The control group include 24 patients at the age of 7-9 years with Perthes disease at the fragmentation stage, corresponding to group III - IV for Catterall, group B/C, and group C for Herring, whose follow-up period was less than 4 years [5].
The research was carried out in the operating room. The patients were under endotracheal anesthesia.
PolyAnalyst of RGPA-6/12"REAN-POLY" (MEDICOM-MTD, Russia) was used to obtain reovassogramme. An electrocardiogram in the II standard lead, the base impedance, volumetric rheovasograms of intraosseous tissues and their first derivatives were being registered simultaneously [6]. The frequency of the probing electric current is 56 Hz.
Spokes for transosseous osteosynthesis with a diameter of 1.8 mm, which were inserted using an electric drill, were used as electrodes. Two spokes were inserted into the neck and head of the femur from the outside. Then a third spoke was inserted into the femoral head from the front. To register the impedance of paraossal soft tissues, a fourth spoke was inserted from the outside into the soft tissues of the femur up to the stop.
The following parameters were output in numerical terms

for analysis.

1. BI pst - basic impedance (equivalent of the blood filling of vessels) of paraossal soft tissues.
2. BI ot - basic impedance (equivalent of the blood filling of vessels) of intraosseous tissues.
3. TRFPW-the time of rapid blood filling of the pulse wave (opening of the organ artery).
4. TSFPW - time of slow blood filling of the pulse wave (opening of intra-organ arteries).
5. TMSFPW - the time of maximum systolic blood filling of the pulse wave (the summa of TRFPW and TSFPW).
6. RVP-relative volume pulse (equivalent to a portion of blood that provides pulse blood filling, RI / BI*1000).
7. ARFPW-the amplitude of rapid blood filling of the pulse wave (equivalent to blood filling of the organ arteries).
8. RI - rheographic index (the equivalent of blood supply to part of the vascular channel).
9. ASRFOA - the average speed of rapid blood filling of the organ arteries (ABKN/IBKN).
10. ASFPW - the average speed of blood filling of the pulse wave (RI/ TMSFPW).
11. PVR - indicator of peripheral vascular resistance (amplitude of the lower incisure point/ ARFPW.
12. DI-diastolic index (indicator of the predominance of blood inflow over outflow, vein tone, amplitude of the dicrotic wave RI).

Unweighted variational series were created from collected quantitative data. The differences between the averages were estimated based on the statistically significant level of significance of the differences, which was determined using the nonparametric Wilcoxon-Mann-Whitney test for independent samples. The analysis was done using Microsoft Excel 2013. The results were interpreted based on the standard techniques for reovassogramme decoding.

3. Results

The impedance in the intraosseous tissues of the head and neck of the femur was less pronounced than the impedance in the paraossal tissues (tables 1, 2).

Table 1: Parameters of pulse blood filling in intraosseous tissues of the femoral head.

№	Parameters	group 1 (n=12)			group 2 (n=4)			group к (n=24)		
1	BI pst, Om	160,3	±	39,9	111,4	±	11,5	101,1	±	5,3
2	BI ot, Om	78,8	±	11,6	61,2	±	2,5	68,7	±	5,6
3	TRFPW, s	0,0498	±	0,0016	0,0523	±	0,0025	0,0505	±	0,0010
4	TSFPW, s	0,0523	±	0,0057	0,0603	±	0,0025	0,0566	±	0,0032
5	TMSFPW, s	0,1020	±	0,0067	0,1125	±	0,0071	0,1071	±	0,0038
6	RVP, Om	0,4171	±	0,0966	0,2259	±	0,0558	0,3687	±	0,0657
7	ARFPW, Om	0,0145	±	0,0036	0,0037	±	0,0012	0,0104	±	0,0017
8	RI, Om	0,0301	±	0,0052	0,0138	±	0,0034	0,0245	±	0,0035
9	ASRFOA, Om/s	0,2841	±	0,0685	0,1155	±	0,0286	0,2026	±	0,0317
10	ASFPW, Om/s	0,2910	±	0,0459	0,1203	±	0,0254	0,2291	±	0,0372
11	PVR, %	55,4	±	9,2	97,0	±	6,4	64,0	±	3,8
12	DI, %	73,8	±	13,5	50,3	±	12,7	58,5	±	5,8

Table 2: Parameters of pulse blood filling in intraosseous tissues of the femoral neck.

№	Parameters	group 1 (n=12)			group 2 (n=4)			group к (n=24)		
1	BI pst, Om	112,3	±	12,6	72,6	±	12,0	101,1	±	5,3
2	BI ot, Om	70,5	±	8,2	52,4	±	13,4	70,8	±	4,9
3	TRFPW, s	0,0516	±	0,0030	0,0504	±	0,0005	0,0518	±	0,0009
4	TSFPW, s	0,0558	±	0,0048	0,0518	±	0,0041	0,0598	±	0,0020
5	TMSFPW, s	0,1073	±	0,0074	0,1022	±	0,0041	0,1116	±	0,0025
6	RVP, Om	0,3785	±	0,0731	0,1765	±	0,0319	0,4059	±	0,0381
7	ARFPW, Om	0,0178	±	0,0061	0,0036	±	0,0017	0,0130	±	0,0022
8	RI, Om	0,0250	±	0,0044	0,0099	±	0,0029	0,0284	±	0,0034
9	ASRFOA, Om/s	0,3521	±	0,1285	0,1103	±	0,0334	0,2514	±	0,0425
10	ASFPW, Om/s	0,2348	±	0,0368	0,0931	±	0,0267	0,2579	±	0,0323
11	PVR, %	81,9	±	6,8	84,2	±	20,4	90,6	±	2,9
12	DI, %	67,1	±	16,9	75,0	±	9,6	65,5	±	4,7

As can be seen from the data in tables 1 and 2, the parameters of pulse blood filling in the head and neck of the hip do not differ significantly for patients from the first and control groups.

There were no statistically significant differences in the indicators of IBCN, BMCN, VMSN and DSI among all groups. Differences in other parameters in the second group were statistically significant (table 3).

Table 3: Correlation of parameters of pulse blood filling in intraosseous bone tissues.

№	Parameters	femoral head				femoral neck			
		groups 2/к		Groups 2/1		groups 2/к		Groups 2/1	
		p <	%	p <	%	p <	%	p <	%
1	RVP, Om		61		54	0,001	43	0,05	47
2	ARFPW, Om	0,05	57	0,05	41	0,05	43		31
3	RI	0,05	56	0,05	46	0,001	35	0,05	40

4	ASRFOA, Om/s	0,05	57	0,05	41	0,05	44		31
5	ASFPW, Om/s	0,05	53	0,05	41	0,001	36	0,05	40
6	PVR, %		115	0,01	175		93		103

The amplitude and speed of pulse blood filling in the head and neck of the femoral bones for patients from the second group were less than for children from the control group. Relative volume pulse in the hip neck was also smaller. The relative volume pulse, pulse blood filling and the speed of pulse blood filling of the arteries in the head and neck of the hip in children of the second group were reduced compared to the indicators from the first group.

Significant increase of the PSS index in the femoral head was registered in the group II. Specific character of changes in rheological parameters suggest that the main reason for the decrease in blood filling indicators of the head was the occlusion of vessels of the microcirculatory bed against the background of an increase in peripheral vascular resistance (resistive vascular tone). Blood inflow to the intraosseous tissues of the neck was presumably limited at the level of the extracostal arteries.

4. Discussion

Perthes disease is a form of idiopathic necrosis of the femoral head in children. A distinctive feature of this pathology is the ability to spontaneously restore blood supply independently. The process of revascularization can occur by recanalization of obturated vessels or by the formation of new vessels. The second option is observed in case of Perthes disease and lasts for several years [7]. According to Conway, the revascularization process can be evaluated by scintigraphy the results of scintigraphy. The author identifies scintigraphic signs indicating a good or bad outcome of the disease [8].

This paper represents an attempt to identify the specific characters of the pulse blood filling in the femoral head that would, indicate the possibility of an unsuccessful outcome, based on the analysis of rheovasographic data. Significant deviations of individual indicators of blood filling in the head and neck of the hip were detected in the group of patients with a poor outcome. Analysis of the data obtained and the results of previous studies [9, 10] suggest that decrease in AVCN by less than 0.005 ohms and, in SsCN by less than 0.15 ohms/s, PPS increase in the femoral head by more than 90%, as well as OOP decrease in the femoral neck by less than 0.2 ohms indicate an unfavorable course of the revascularization process. A small number of observations doesn't give us grounds to draw firm conclusions, however, it allows us to suggest that changes in these parameters predict the possibility of an adverse outcome of the rehabilitation process.

The invasive nature of the used technique limits the possibility of its usage for cases where operational approach is advised. Apparently, the appearance of the above-mentioned deviations in rheological indicators reveal the necessity to increase the time of rehabilitation treatment and use additional methods to stimulate blood flow in the femoral head.

5. Conclusions

Changes in the original indicators of pulse blood filling in the femoral head in patients with Perthes disease during the fragmentation stage might be a sign of an unfavorable course of the revascularization process and may indicate the probability of an unfavorable result.

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