



Digital Analysis in Hip Circulation and Biomechanical Changes in The Lower Limb in Perthes' Disease

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Abstract

Worldwide, the treatment of Perthes' disease in children and adolescents is a complex and unresolved problem. This is a common pathology that, with timely detection and proper therapy, is successfully treated, but in their absence can provoke the development of severe complications and cause early disability. Improving the results of treatment and rehabilitation of children with Legg-Calve-Perthes disease. Our research is based on archival data and on survey observation using digitalization, the total number of patients is 150 children with Legg-Calve-Perthes disease on inpatient treatment at the pediatric orthopedics clinic of the RSSPMC of Traumatology and Orthopedics of the Ministry of Health of the Republic of Uzbekistan for the period from 2008 to 2022. All patients had previously undergone conservative treatment of congenital hip dislocation. In the early stages of the pathology, 69.6% of children aged 3-6 years complained of fatigue in the hip joint after a long walk or run but did not notice pain. An orthopedic device has been developed to achieve maximum unloading of the hip joint when walking. The proposed device is convenient and when used, maximum unloading of the hip joint is achieved when walking.

Keywords: diseases of Perthes; femoral head; hip joint; venous network; osteochondropathy.

1 Introduction

The applied methods of conservative therapy and surgical treatment do not guarantee success for a cure, and unsatisfactory results and early disability are noted in 18–27% of adolescents. Timely adequate staged rehabilitation of adolescents with Perthes disease increases the effectiveness of therapy, which improves the quality of life of people with this pathology.

However, many questions remain unresolved, there is practically no comparison of the effectiveness of therapy and surgical treatment, aspects of rehabilitation after surgical treatment for osteochondropathy of the femoral head, which dictates the need to create personalized rehabilitation programs in the postoperative period according to the individual characteristics of the pathology of the hip joint.

2 Literature Review

Diagnosis of Perthes disease is based on radiographic signs, which makes it difficult to diagnose the initial stages of the pathology and leads to a late start of therapy [1]. MRI is generally recognized as the “gold

standard” for diagnosing this pathology; however, it is not economically and psychologically applicable in all cases, and the duration of the obligatory absence of movements of the child makes its widespread use even more difficult [2]. Laser Doppler flowmetry, oximetry and myography in some way complement radiological methods in terms of morphological and functional deviations, but their use is not widespread [3,4].

The issues of treatment and the opinions of scientists about their effectiveness are extremely variable and sometimes contradictory in the available literature [5].

Pathogenetically determined therapy of this pathology implies the stimulation of reparative processes in the femoral head, however, the properly proven normalization of local hemodynamics in the scientific literature is not confirmed [6]. At the same time, long-term medical sympathectomy in the form of a dosed neuraxial blockade is promoted, however, it is advised for bilateral pathology in the early stages, it does not have studies with a wide coverage of the contingent of patients and narrow indications [7].

Based on known scientific facts, the development of a more effective method of conservative treatment of Legg-Calve-Perthes disease remains relevant.

Gulyamov S.S. with co-authors give the following data: “... congenital dysplasia, subluxation and dislocation of the hip occur in 5.3 cases per 1000 newborns, congenital hip dislocation occurs predominantly in girls in a ratio of 1:5, left-sided dislocation occurs twice as often as right-sided, the probability of having a child with congenital dislocation of the hip increases with breech presentation, with a positive family history, with other congenital malformations, with congenital pathology of the neuromuscular apparatus (Spina bifida, cerebral palsy, etc.), while impaired blood supply to bone tissue is caused as congenital underdevelopment of the vascular bed in the area of the hip joint, as well as the traumatism of modern operations to reduce the dislocation (osteotomy of the femur, pelvic bones, etc.)” [3].

The etiopathogenesis of hemodynamic disorders in the area of the hip joint (HJ) and Aseptic necrosis of the femoral head (ANBKG) is associated with: networks” [10].

At the same time, the main causes of these disorders are: “... congenital hypoplasia of the vessels of the femoral head, disorders of neurovascular mechanisms, anatomical and functional features of the blood supply to the hip joint in childhood, due to insufficient vascularization of the femoral head associated with anatomical and functional immaturity of the vascular network” [13,14,15].

Legg-Calve-Perthes disease is a very severe disabling disease of the hip joints, which affects children aged 3-9 years most of all, due to the specificity of the architectonics, microcirculation and reactivity of the hip joint during this period [9]. Changes in the head of the femur after suffering Perthes disease, which predisposes to the development of deforming coxarthrosis, and then disability of the patient, is observed in 50-89.5% of cases [11].

Diagnosis of Perthes disease is based on radiographic signs, which makes it difficult to diagnose the initial stages of the pathology and late initiation of therapy. CT and MRI are generally recognized as the “gold standard” for diagnosing this pathology, however, they are not economically and psychologically applicable in all cases, and the duration of the child’s mandatory absence of movements makes their widespread use even more difficult, which implies the child’s medical sleep.

Recently, the ultrasonic method of research has become widespread in the diagnosis of this pathology, which makes it possible to detect the disease already at the first stage.

The methods of conservative treatment used do not always give the desired result: in 40-80% of patients, the disease ends with the development of deformity of the femoral head.

Therefore, the search for new, active methods and ways of rehabilitation with partial unloading of the hip joint is very relevant today.

3 Research Materials And Methodology

3.1 Purpose of the study

Improving the results of treatment and rehabilitation of children with Legg-Calve-Perthes disease.

3.2 Research methods

Our research is based on archival data and on survey observation using digitalization, the total number of patients is 150 children with Legg-Calve-Perthes disease on inpatient treatment at the pediatric orthopedics clinic of the RSSPMC of Traumatology and Orthopedics of the Ministry of Health of the Republic of Uzbekistan for the period from 2008 to 2022.

As can be seen from the presented data, boys predominated in the study, their ratio was 3.5:1. The percentage of girls was 22.0%.

The peak incidence fell on the age periods from 3 to 6 years and from 7 to 10 years (37.3% and 38.7%, respectively), the average age was 8.7 ± 1.2 years.

4 Analysis And results

The vast majority of sick children were boys (117 people - 78.0%) and 33 patients were girls (22.0%). Right-sided necrosis was observed in 47 cases (31.3%), left-sided - in 89 (59.3%), bilateral - in 14 cases (9.4%) (Fig. 1).

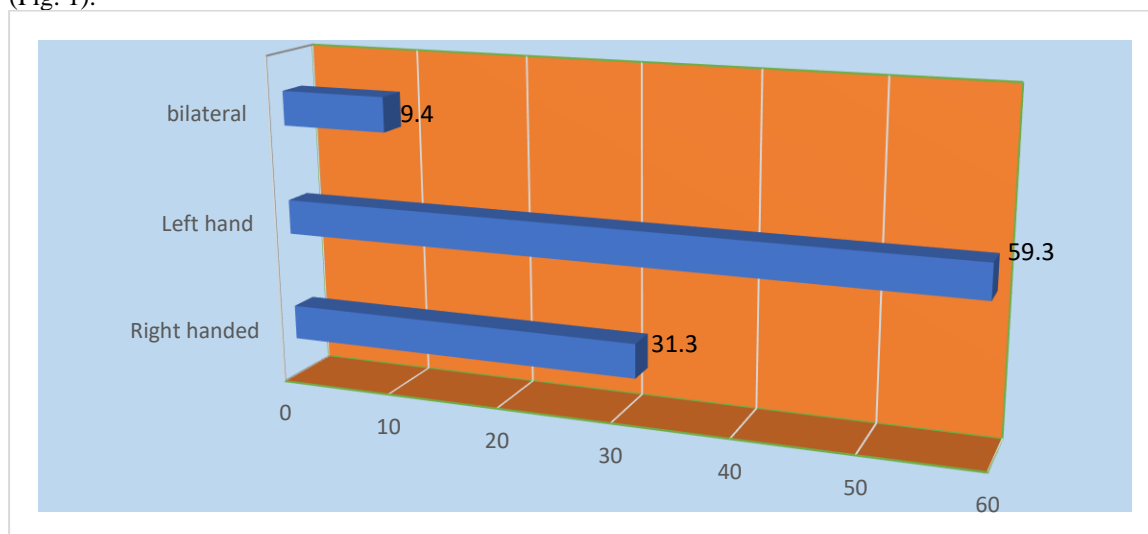


Figure 1: Distribution of examined children depending on the side of the lesion

All patients had previously undergone conservative treatment of congenital hip dislocation.

In the early stages of the pathology, 69.6% of children aged 3-6 years complained of fatigue in the hip joint after a long walk or run, but did not notice pain.

Pain after prolonged exercise was noted in 17 (29.3%) patients aged 7-10 years and in 18 (50%) patients aged 11-16 years, which is explained by initial dysplastic coxarthrosis.

In 128 (85%) patients, changes in gait were noted in the form of lameness, instability when walking and swinging of the body, which is associated with shortening of the leg and weakness of the gluteal muscles due to the convergence of attachment sites and a decrease in tone.

Against the background of bilateral osteochondropathy of the femoral head (OHCB)) in 14 (9.4%) patients, duck gait with increased lumbar lordosis was noted. Positive Trendelenburg sign was diagnosed in 128 (85%) patients.

Shortening of the limb in unilateral pathology in children aged 3-6 years is due to a lag in the growth of the epiphysis of the femoral head, and in older children, an increase in the difference in the length of the lower limbs is associated with "premature closure of the growth zone and underdevelopment of the entire proximal femur."

In children under 6 years old, the amplitude of internal and external rotation was found to be excessive - 90-110°, at 7-10 years old it decreased to 70-80°, at 11-14 years old - up to 69-46°, and over 12 years old - up to 35-45°.

The severity of clinical, radiological and functional disorders progressed with age from 6 to 14 years.

As a result of the analysis of two-projection radiographs of HJ, the stages of the disease were identified, which are shown in Fig. 2.

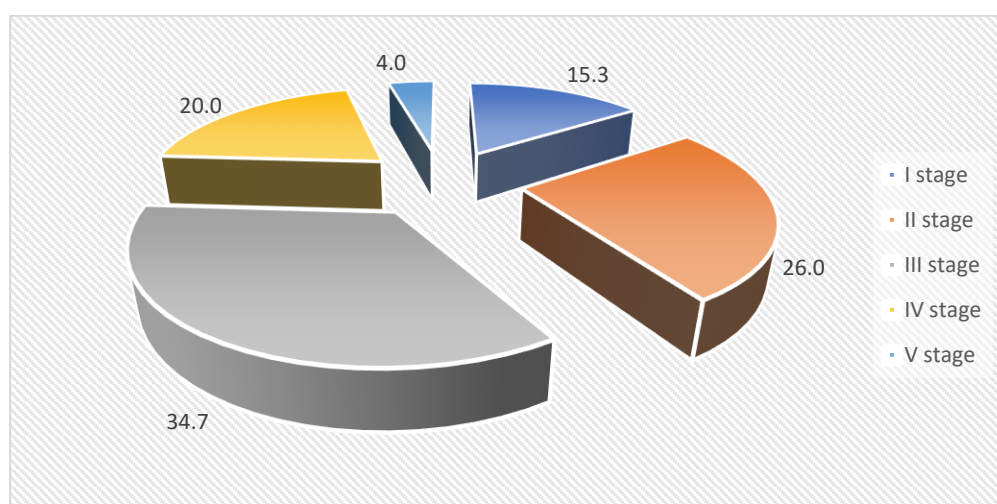


Figure 2: Distribution of patients depending on the stage of the disease

At stage I on the radiograph, the femoral head is unchanged; revealed signs such as deformation of the joint space (expansion). Expansion was more detected in the medial segment of the joint space in 23 sick children. The femoral head (FH) retains its inherent shape, the bone structure is also not changed.

At the II stage of the disease in 39 sick children (26.0%), flattening and decrease in the height of the epiphysis of the GBC, compaction of its structure, deformation of the epiphyseal-growth zones and regional osteoporosis were determined. Radiologically, the FH is homogeneously darkened without a structural pattern, the height relative to the healthy side is lower, the joint space is enlarged.

In stage III, 52 sick children (34.7%) had fragmentation of the femoral head, expansion and deformity of the joint space, lateral subluxation of the head, horizontal location of the growth plate, and Gage's symptom.

In the stage of recovery in 16 children (8.3%), we were able to determine: the restoration of the head, which is characterized by the disappearance of necrotic areas, and the formation of a new, but not yet completely formed FH.

In the stage of residual effects in 6 (4.0%) patients, a high standing of the greater trochanter, deformity of the head in the form of flattening and mushroom-shaped, as well as subluxation of the femoral head and coxavara were determined.

Thus, in case of an unfavorable course of AHCH, lateral subluxation of the GB was more often noted, an increased risk of an unfavorable course reveals extremely severe destruction of the GB.

Ultrasonography is an indispensable non-invasive diagnostic method of examination. The cartilaginous covering of the epiphysis usually gives a weak echo; the articular capsule is echogenic. If it is required to determine the joint effusion, then the distance from the border of the femoral neck to the surface of the joint capsule is measured. Through movements in the hip joint, an optimal delineation of individual tissue layers is achieved. Obtaining a sonographic image of the inside of the hip joint is difficult. the medial part of the head is in the sound shadow. It is usually possible to determine the outer 2/3 of the cartilaginous head of the femur. A better image can sometimes be obtained by adducting the hip.

At the same time, the initial pre-radiological signs of the disease were detected in 36 patients. Sonographic examination revealed signs of synovitis, which was characterized by thickening of the joint capsule and widening of the joint space. The flattening and fuzziness of the FH contours were determined.

Ultrasound diagnoses AHB at an early pre-radiological stage, differentiates AHB from other FH diseases, dynamically monitors the state of AH, and reduces the number of radiographic studies.

Pulsed-wave Doppler in the projection of the hip joints in all the subjects visualized 1-3 groups of vessels enveloping the femoral neck (Fig. 3).

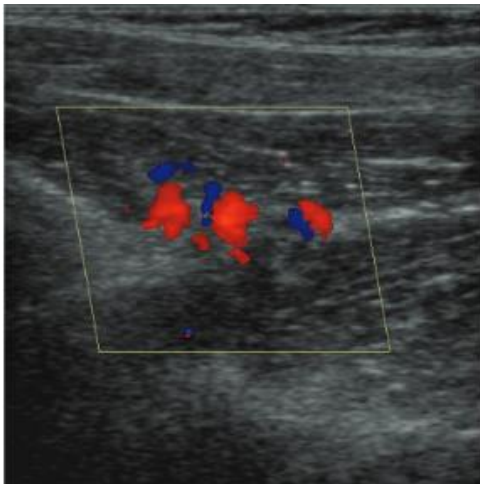


Figure 3: Echogram of the hip joint. 3 groups of vessels enveloping the neck of the femur. CDC

At the same time, in 30% of patients, a loose type of vascular structure was noted (Fig. 4).

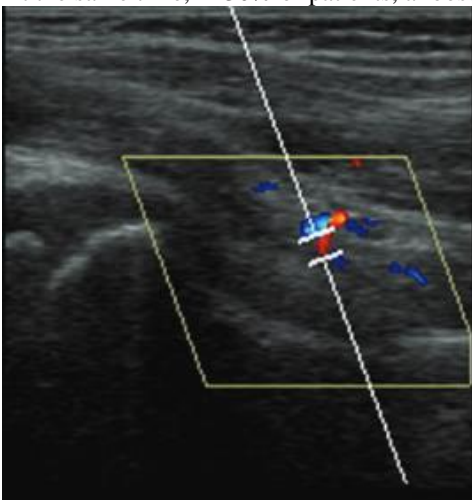


Figure 4: Echogram of the hip joint. Loose type of structure of the vascular bed. CDC

In all patients, Doppler sonography revealed an increase in the peak velocity of arterial blood flow (V_s (art.)) in the circumflex arteries of the femur on the side of the pathology up to 19.2 ± 0.1 cm/s (Fig. 5).



Figure 5: Echogram of the hip joint. CDK. Arterial blood flow rate

Against this background, a decrease in the resistance index (IR) to 0.595 ± 0.01 was noted with preserved IR (0.82) on the healthy side, a decrease in the rate of venous pulsation (V (b)) on the affected side to 6.53 ± 0.1

(normally 10.15), which states the suppression of venous outflow due to the architectonics of the vascular bed on the affected side TBS at OGBC.

Dopplerographic markers of stage I ANGBC were: decline V_s (art.) and IR in the lateral envelopes of the femoral arteries (Table 3.1), PSV in a.femoralis and a.circumflexa statistically significantly ($P < 0.05$) lower on the affected side compared with healthy TB.

The marker of the transition of the III stage of ANGBC to IV was a decrease in the number of pathological vessels in the FH in EDC, it served as a differentiating assessment of the necessary duration of immobilization of patients with Perthes' disease.

It should be noted that in some patients in the initial stages of the disease, in most cases, normative indicators of HJ blood flow were recorded. With the aggravation of the stage of the disease, there is a decrease in the blood flow of the HJ arteries. Moreover, it should be noted that with a bilateral lesion of the joints, a decrease in blood flow was recorded in all the envelope arteries of the HJ, whereas with a unilateral lesion, an asymmetry of blood flow through the vessels of the HJ is observed.

Table 1: Indicators of Doppler studies in patients with Perthes' disease

Total number of patients (n=150)	PSV	Ri
a.femoralis		
Healthy limb	144,21±5,12	0,97±0,01
A diseased limb	124,41±5,14	0,99±0,01
a.femoralisprofunda		
Healthy limb	77,15±4,38	0,98±0,02
A diseased limb	70,15±5,12	0,96±0,02
a.circumflexamedialis		
Healthy limb	40,95±1,89	0,90±0,01
A diseased limb	37,45±1,95	0,90±0,01
a.circumflexialateralis		
Healthy limb	36,98±1,87	0,92±0,02
A diseased limb	31,98±2,34	0,96±0,01

Consequently, circulatory and nutritional disorders play an important role in the development of this disease in children.

Thus, the vessels in the FH area and its neck have weak velocity characteristics, which indirectly states high intra-articular pressure, high peak arterial velocity, coupled with a decrease in venous outflow, indicates venous stasis in the HJ area.

5 Conclusions

Differentiation of the stages of Legg–Calve–Perthes disease on spectral Dopplerography is based on a decrease in the resistance index (IR) of the lateral envelopes of the femoral arteries in stages I-III and its restoration in stages IV-V of the disease, and energy Doppler mapping revealed a marker of the transition of stage III of Legg–Calve–Perthes disease in IV – a decrease in the number of pathological vessels in the epiphysis of the femoral head.

In the III and IV stages of Legg–Calve–Perthes disease, the performed subtelicderotation-varicative osteotomy of the hip with a bone-muscle graft on the feeding leg has high efficiency and functional and anatomical results: a good result was achieved in 51.6%, satisfactory – in 36.5% of the subjects.

An orthopedic device has been developed to achieve maximum unloading of the hip joint when walking. The proposed device is convenient and when used, maximum unloading of the hip joint is achieved when walking.

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