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New Methods for Surgical Treatment of Perthes Disease in Children

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Abstract—*The treatment of Perthes disease in children and adolescents is a complex and unresolved problem. The various methods of conservative and surgical treatment used in most clinical observations do not allow to obtain the desired results. At the same time, the number of unsatisfactory outcomes of surgical treatment remains very high (18–27%). The consequence of this is the early disability of a significant number of patients of the most working age. In recent years, there has been a clear trend towards the use of surgical methods of treating this pathology. However, inadequate surgical tactics often give a high percentage of unsatisfactory outcomes. The choice of treatment method for patients with Perthes disease is still debatable.*

Keywords— *hip joint, Perthes disease, surgical treatment, osteosynthesis, rehabilitation.*

I. INTRODUCTION

The prevalence of Perthes disease currently has a tendency to increase, accounting for 25-30% among diseases of the hip joint in children [1, 2, 6]. Despite the large number of studies devoted to this problem, there is no single point of view on the etiology and pathogenesis of Perthes disease. At the moment, they continue to consider the traumatic, inflammatory, dishormonal, neurotrophic theory of the occurrence of the pathological process, but none of them has received a high level of evidence [3, 4, 17-20].

The most preference is given to the theory where local ischemia of the proximal femur against the background of hemodynamic disorders is considered the main cause of Perthes disease [4, 5, 15, 18]. In this regard, the actual direction of treatment of this category of patients is to improve the trophism of hip joint by both conservative and surgical methods. There are many methods for the surgical treatment of pathology. In the past, tunneling of the proximal femur was widespread [11, 17, 20]. In addition, a method of revascularization of the head and neck of the thigh using an autograft on a feeding muscle leg containing a neurovascular bundle has gained some popularity [8, 16]. However, the long recovery period and the lack of adequate unloading of the hip joint structures after these surgical interventions forced them to be abandoned as independent treatment methods.

Currently, two groups of surgical interventions for Perthes disease are mainly used. The first group includes decompression operations with the application of spoke-rod apparatuses providing long-term unloading of hip joint [9, 10]. The second group consists of various types of intertrochanteric osteotomies, often in combination with acetabuloplasty or subchondral modeling of the femoral head [11, 12].

It is noteworthy that in the literature there is a lack of information on the application of a specific surgical treatment technique depending on the age of the children, the duration of the disease and the stage of the process, which is due to the lack of clear indications for surgery. In this regard, at present, the problem of

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treating children with aseptic necrosis of the femoral head remains unresolved, which indicates the relevance of scientific research in this area.

The aim of the work was to improve the treatment results of children with dystrophic lesions of the hip joints based on the development of a pathogenetically based algorithm for managing this category of patients.

II. MATERIAL AND METHODS

The study included 56 children (16 girls and 40 boys) with diagnosed Perthes disease aged 4 to 12 years (mean age 7.3 ± 0.8 years). Clinical, CT and radiological methods, dopplerographic study of regional blood flow at the level of the hip joints were used.

The clinical research method was to know an anamnesis about the course of the disease (the time of the first complaints, symptoms, etc.) appeared. During the inspection, attention was paid to the length, axis of the limb and segment, the presence of deformation. An X-ray examination included radiography of the hip joints before and after surgery after 2 months, 6 months and 1 year. An X-ray examination made it possible to determine the presence of osteonecrosis and spatial changes in the affected joint, as well as to assess the degree of regeneration after surgery.

In some cases, CT scan was performed to clarify the location and size of the lesion. The doppler-graphical method of research allowed to determine the state of blood flow in the vessels in the area of the affected joint and identify changes in the joint at an early stage. The regional blood flow indices: systolic blood flow velocity (Vh) and resistance index of the deep femoral artery (DFA) and the lateral envelope femoral artery (LEFA) were evaluated. The comparison group consisted of 20 children without pathology of the hip joints, distributed by sex and age. All obtained data were processed using nonparametric statistics methods. The mean (M), median (Me), 25 and 75% percentiles were determined. The significance of differences was determined using the Wilcoxon test at a 95% probability threshold.

III. RESULTS

All patients were divided into four groups depending on the type of surgical intervention. The 1st group consisted of 12 children who underwent osteoplastic interventions (revascularization of the head and neck of the femur using an autograft on a feeding muscle leg). The 2nd group included 10 patients operated on by the method of formation of a vascularized autograft in the sub - and intertrochanteric region of the femur with its subsequent displacement in external fixation apparatus and the formation of an extended regenerate.The 3rd included 19 patients operated on by the method developed at the Research Institute of Traumatology and Orthopedics of the Republic of Uzbekistan (Patent No. IAP 04200). The 4th group included 15 children after intertrochanteric rotational corrective osteotomy.

Patients of all observation groups presented characteristic complaints of pain in the affected joint, aggravated by physical exertion; gradual restriction of movements in the joint, in particular flexion and abduction in the hip joint of the affected limb. Only in patients of the 3rd group there was a later time of the period for seeking medical help (14-30 days) and the frequency of pain and its reduction.

An X-ray examination of patients of the 1st group found in all cases signs of damage to the epiphysis of the femur. In 7 patients (58%), a partial lesion of the femoral head was noted, and in the remaining 5 patients (41%), a total lesion was observed. To clarify the size of the necrosis focus, these patients in the preoperative

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period underwent X-ray examination in selective projections and CT scan, while the lesion was localized in different parts of the femoral head and made up 25-75% of its area (fig. 1)

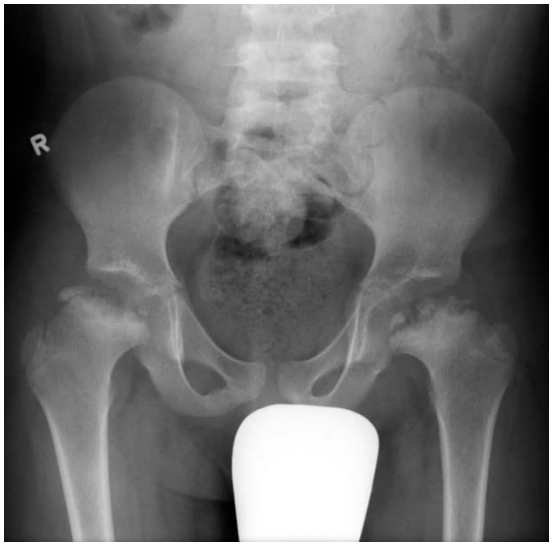

Fig 1. Pelvic x-ray demonstrates late changes of Perthes disease bilaterally with fragmentation of the femoral heads and widening of the femoral neck (coxa magna).

In the 2nd group, a partial lesion of the femoral head was detected in 70% of cases (7 patients) and a total lesion in 30% (3 patients), while the lesion site was localized in various parts of the femoral head, with the exception of the apical zone, and ranged from 25 up to 50% of its area.

In the 3rd group in the preoperative period during the X-ray examination in 100% of cases, a total lesion of the epiphysis of the femur was revealed. In our opinion, this was due to the later terms of treatment of patients and, as a result, the delayed diagnosis of pathology. A CT study was performed in 15.7% of cases (3 patients), while it was conducted not to determine the size of the lesion, but to visualize anatomical changes in the joints with subsequent planning of treatment tactics.

X-rays of children of the 4th group revealed a partial lesion of the epiphysis in all cases. To determine the size and localization of the site of necrosis, X-ray were taken in selective projections, while the lesion site was localized in various parts of the femoral head and comprised 25 to 50% of its area. According to a CT study, it should be noted that in 6 patients (40%), the lesion was localized along the anteroposterior surface of the pineal gland, in 4 (26.6%) on the posterior-outer surface, and in 5 (33.4%) apical zone. Thus, taking into account the localization criteria and the size of the focus of osteonecrosis, as a tactics of treatment, it was planned to make precisely rotational osteotomy.

The results of a dopplerographic study of regional blood flow in the hip joints of patients of all observation groups are presented in the table.

Significant changes in blood flow velocity by DFA and LEFA on patients of all research groups were noted by almost a quarter ($p < 0{,}0004$) comparedwith similar data from the comparison group. A significant decrease in the linear velocity of blood flow in most cases was confirmed by the presence of regional disorders of the peripheral blood supply to the affected hip joint (see table 1).

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Table 1. Dopplerographic study of the blood flow of the hip joints

Patient groups	**Arterial blood flow**			
	DFA		**LEFA**	
	Vps (M)	**Ri (M)**	**Vps (M)**	**Ri (M)**
Comparison group (n = 20)	0.62	1.1	0.55	0.99
1st group (n = 12)	0.42 *	0.95 *	0.39 *	0.77 *
2nd group (n = 10)	0.40 **	0.95 **	0.39 **	0.77 **
3rd group (n = 19)	0.38 ***	0.77 ***	0.32 ***	0.72 ***
4th group (n = 15)	0.40 ****	0.90 ****	0.39 ****	0.77 ****

Note: M is the average, p is the confidence level (Wilcoxon sign-rank test) in relation to the indicators of the comparison group (p * = 0.004; p ** = 0.004; p *** = 0.002; p **** = 0.004).

Perhaps the result of worsening trophism was the appearance of zones of local ischemia with an outcome in necrosis. This fact indicates a pronounced violation of the blood supply to the bone-joint structures of the hip joint, which provoked the appearance of a significant lesion of the osteonecrosis of the femoral head.

Thus, the results of the analysis of dopplerographic studies showed a decrease in hemodynamics of the regional blood flow of the hipjoints. Particularly pronounced changes were noted in patients of the 3rd group with verified total lesion of the hip pineal gland. Obviously, there is a direct correlation between the degree of alteration of bone tissue and the level of circulatory disorders.

All patients of the 1st group underwent bone-plastic surgery aimed at improving trophism and regional blood flow in hips joint. At the same time, 9 patients (75%) had plastic surgery with an autograft from the fibula, and 3 (25%) with synthetic bone-plastic materials. In the analysis, good results (absence of pain when moving in hips joint, increase in range of motion in the joint, restoration of normal gait biomechanics) were obtained in 5 patients (41.6%) with stage I and II disease and partial damage to the epiphysis, satisfactory (decrease in pain intensity syndrome, increased range of motion in hips joint, minor violations of the biomechanics of gait) - in 3 children (25%) with stage II disease. Unsatisfactory (retention of pain, restriction of movements in hips joint, impaired biomechanics of gait), the results amounted to a third of all cases - 4 patients (33.4%). Apparently, unsatisfactory outcomes of surgical treatment are associated with a total lesion of the femoral head amid dysplastic changes in the components of the joint.

10 patients of the 2nd group with I-III stages of the disease were operated on with method belongs to the category of osteoplastic surgery. Its purpose was the formation of a vascularized autograft in the sub - and intertrochanteric region of the femur with its subsequent displacement inexternal fixation apparatus and the formation of an extended regenerate.

In addition, in the absence of joint overload, a good trabecular network was formed with the correct orientation of the subchondral bone fibers. Due to the decompression effect, the performed operation allowed to provide long-term unloading of the affected segment with the effect of stimulation of blood circulation. Good treatment results were obtained in 70% of cases (7 patients), this group included patients with both total and partial lesions of the epiphys. It should be noted that the focus of necrosis was located peripherally. Satisfactory

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results were obtained in 2 patients (20%) with a total lesion of the epiphys and apically located partial focus of necrosis. An unsatisfactory result was observed in one child (10%) with the presence of hallux valgus deformity of the proximal femur. The presence of this deformation subsequently required an intertrochanteric osteotomy.

Thus, the use of this method is most justified in patients with both total and partial lesions of the pineal gland, the location of the focus of necrosis in the unloaded zone with anatomically correct relationships in the joint.

Patients of the 3rd group with stages I-III of the disease underwent neck tunneling, two parallel tunnels in the vertical and horizontal directions, the resulting bony sticks are inserted into the neck tunnels, which are fixed with a L-shaped fixative. An analysis of long-term results stated: good results were obtained in 63.1% of cases (12 patients), satisfactory in 15.7% (3), unsatisfactory in 21.2% of cases (4). In all cases, it was possible to correct the existing violations of the anatomical relationships in the joint and at the same time carry out its full unloading. This method of surgical intervention is the best method of treatment in the presence of anatomical changes in the joint and total damage to the femoral head. Good treatment results in the 4th group were obtained in 12 (80%), satisfactory in 2 (13.3%) patients.

Planning of surgical interventions was carried out taking into account the results of the examination, the calculated hip joint skygram and the features of the anatomy of the affected joint according to 3D reconstruction of a CT scan. The removal of the lesion from under the load was carried out not only by reducing the cervical-diaphyseal angle, but also due to the rotational displacement of the proximal femur. In 60% of cases (9 patients), an extensional (pre-non-rotational) osteotomy was performed, which made it possible to remove the lesion focus, located mainly on the front surface of the femoral head.

In 6 patients (40%), flexion (posterior rotational) osteotomy was used. The chosen tactics of the operation was determined by the position of the focus of osteonecrosis, refined by CT data. The high efficiency of this method is due to the simultaneous removal of the focus from under the load, which helped to maintain a sufficient level of local blood supply, the absence of additional stress forces in the bone.

IV. DISCUSSION

Osteoplastic surgical interventions, which were performed for patients of the 1st group, were effective only in children with stage I disease and a small lesion of the epiphys. Most likely, this is due to the low efficiency of these types of surgical interventions and the lack of restoration of congruence of articular surfaces. In addition, the recovery period of patients after this surgery was extended by 15-23% compared with other groups. Thus, it is advisable to use osteoplastic surgery as an additional method of stimulating blood circulation in the osteonecrosis zone at the final stage of treatment.

Treatment in the form of osteoplastic surgery performed by the developed method also showed good results only with partial damage to the epiphys and the anatomically correct location of the bone components of hip joint.

In patients of the 3rd group, good results were obtained both in stage I and stage III of Perthes disease. This is due to the radicalism and high efficiency of this operational manual. It should be noted that this type of surgical intervention is the method of choice for total damage to the pineal gland of the femur and the presence of violations of the anatomical relationship in the joint.A method of treating Perthes disease in children, including performing an intertrochanteric osteotomy and implantation allows to increase the effectiveness of

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treatment, reduce postoperative complications and trauma, since during the three stages of the operation, repeated operations and hospitalizations are simultaneously excluded, and when using the closest analogue, joint overload and aggravation of necrosis of the femoral head can occur. The method allows to reduce the invasiveness, since during the three stages of the operation three incisions are made, which affects the healing of postoperative wounds and the appearance of gross keloid scars.

In most patients of the 4th group, reliably good results were obtained with the restoration of the anatomical parameters of hip joints. During the operation, along with the full relief of the affected joint, the necrosis site was excreted into the non-loaded part of the femoral head. The terms of restoration of the femoral head in these patients were 12-18% less than in patients who underwent intertrochanteric osteotomy. This is due to the careful selection of patients for surgery, the main criterion of which was the peripheral position of the osteonecrosis focus.

V. CONCLUSION

An analysis of previous surgical interventions showed that good results are observed in patients with the initial stage of the disease and partial lesion of the pineal gland when choosing any method of surgical treatment. Currently, the group of osteoplastic surgical interventions is of retrospective importance and cannot be used as an independent method of treatment due to lack of effectiveness, lack of influence on the anatomical relationships in the affected joint, and long term rehabilitation in the postoperative period. However, they can be used as an additional measure to stimulate blood circulation in the femoral head.

The operation of forming a vascularized auto graft has good efficiency, but in the absence of violations of the anatomical relationship in the joint and the nonapical location of the osteonecrosis focus.

A method of treating Perthes disease in children, including performing an intertrochanteric osteotomy and implantation allows to increase the effectiveness of treatment, reduce postoperative complications and trauma, since during the three stages of the operation, repeated operations and hospitalizations are simultaneously excluded, and when using the closest analogue, joint overload and aggravation of necrosis of the femoral head can occur. The method allows to reduce the invasiveness, since during the three stages of the operation three incisions are made, which affects the healing of postoperative wounds and the appearance of gross keloid scars.

Intertrochanteric osteotomy as an operative treatment method has several advantages. So, rotational-variating intertrochanteric osteotomies, the essence of which is to remove the focus of necrosis in the unloaded part of the hip joint due to the displacement of the neck and femoral head, contribute to the complete restoration of the biomechanically correct shape of the femoral head, normalization of its trophism. In turn, rapid reconstruction of the articular surfaces provides a reduction in the rehabilitation time for patients with Perthes disease [10-12].

Thus, the creation of a differentiated approach to the treatment method would significantly reduce the treatment time for children, in most cases get good results, and also reduce the risk of postoperative complications [1, 6, 11-14, 21].

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