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Sonographic Criteria for Ultrasound Diagnosis of Hip Dysplasia

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Abstract *Introduction.* The analysis of the effectiveness of ultrasound diagnostics in the seroscale two-dimensional B-mode, in children under the age of 6 months with suspected hip dysplasia of varying severity. *Purpose of the research*. To evaluate the effectiveness of ultrasound sonography in the diagnosis of various hip dysplasia in children under 6 months of age, as well as to determine the relationship of pathology with risk factors. *Materials and methods*. A screening examination of 300 children undergoing inpatient treatment at the Samarkand Regional Multidisciplinary Children's Medical Center was conducted. Of these, 70 had hip dysplasia of varying severity, as well as 20 healthy children as a control group. Sonography according to the method of R. Graf was carried out using a linear sensor with a frequency of 5-7 MHz on the device "Toshiba XARIO-200" (Japan). *Results.* Of the risk factors in our study, the most significant were pelvic or leg presentation of the fetus, female sex and tight swaddling. After ultrasound sonography using the R.Graf technique, all patients, depending on the parameters of angle α (development of the acetabulum bone dome) and angle β (development of the acetabulum cartilage zone), were divided into 7 groups. The first group consisted of healthy children with normal hip joint indicators from the control group. The second and third groups included children with the so-called "immature hip joint", but differed in age. In the second group – children under 3 months, in the third - from 3 to 6. Children from these groups require only observation by an orthopedist. The fourth group of children already had "instability" of the hip joint and requires the initiation of therapeutic treatment. We identified children from the fifth group as patients with "subluxation", which requires active treatment and monitoring of the condition in dynamics. The sixth and seventh groups consisted of children already with a "complete dislocation" of the hip, one differing in the orientation of the acetabulum lip. In group 6, it was above the femoral head, and in group 7 – below it, which in turn has a greater chance of developing complications after treatment and a longer recovery stage. According to the results of the study, it was revealed that the smaller the angle α, the greater the degree of underdevelopment of the joint. *Conclusion.* Ultrasonographic assessment of qualitative and quantitative parameters of hip joints allows differentiating different stages of their dysplasia. From the group of patients with identified hip dysplasia, patients with early immature joint changes that do not manifest clinically prevailed. Based on this, it is necessary to include ultrasound of the hip joint in the seroscale two-dimensional sonography mode in the standard examination of newborns to objectify the pathological process.

Keywords Ultrasound, Sonography, Hip joint, TBS, Dysplasia, R.Graf

1. Introduction

Dysplasia of the development of the hip joint includes a wide range of abnormalities of the development of the hip joint of varying severity. In addition to physical examination, ultrasound is the preferred imaging method for screening for hip dysplasia in children under six months of age. The Graph method is the most widely used method of ultrasound examination of the hips of infants; a step-by-step approach will be shown in this article [1].

Hip dysplasia of varying degrees in newborns According to various authors, this group of pathologies occurs in 3-5% of newborns, and in some countries, such as Italy, Czechoslovakia, Hungary, Georgia, 5-6 times more often [2].

The methods and goals of treatment have not changed dramatically over the past 20 years, although recent developments over the past 5-10 years have focused on optimal observation methods, imaging methods to guide treatment, evaluating the results of treatment methods and clarifying indications for treatment. It is important for both doctors and families to understand that the treatment of hip dysplasty can be complicated and accompanied by complications [3].

According to 2013 studies, this pathology occurs on average 3 times more often in girls than in boys.

In the most well-known and frequently used Tonnis classification, two degrees of subluxation and dislocation of the hip are distinguished. These systems allow, first of all, to establish indications for performing extra-articular and

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intra-articular interventions. Hartofilakidis et al. proposed a classification based on the allocation of joints by the nature of underdevelopment of the acetabulum and the ratio between the true and false articular fossa [4].

From population studies, it was concluded that about 75-85% of newborns have morphologically normal hips, 13-25% are immature, while 2-4% have dysplastic hips. In most cases, dysplasia is observed, and only 10% of patients have complete dislocation, i.e. approximately 1:1000. The incidence of hip dysplasia varies depending on geographical, genetic and cultural factors, but generally ranges from 0.006 in Africans to 7.6% in Native Americans.

Hip dysplasia should be checked in all newborns, but especially in those who have risk factors, including pelvic presentation, in those with a positive family history of first-line relatives, in female children, primogeniture (the mother's first child), lack of water, birth weight more than 4 kg in full-term children. The only postpartum risk factor is tight swaddling, in which the baby is wrapped so that the hips and knees are fully stretched and brought together, which is a common practice.

Early diagnosis and treatment of such pathologies are important to ensure the best possible clinical outcome. Hip dysplasia includes a whole range of physical and visualization data that allows diagnosing pathology of varying degrees, from mild instability and developmental abnormalities to outright dislocation. Hip dysplasia is asymptomatic in infancy and early childhood, and, therefore, screening of infants is carried out to identify this unusual condition. Traditional screening methods include newborn examination and periodic physical examination, as well as selective use of radiographic studies.

In recent years, ultrasound has become increasingly popular, allowing infants with varying degrees of dysplasia to undergo early diagnosis and treatment, thereby reducing the frequency of manifestations at a later stage, especially conducting a general examination of infants with a high risk of developing pathology.

2. Purpose of the Research

To study monographic aspects of hip dysplasia in children under 6 months of age and to determine the relationship of pathology with risk factors.

3. Material and Methods of the Research

Table 1. Hip joint criteria during sonography

Groups	General condition of the hip	Condition of the acetabulum		
		Bony Roof	Bony rim	Cartilagenous roof
Type I	Mature thigh	Well developed	Angular/Blunt	Covers the femoral head
Type IIa	Physiologically immature hip (age <3 months)	Development deficit	Rounded	Covers the femoral head
Type IIb	Ossification delay (age >3 months)	Development deficit	Rounded	Covers the femoral head
Type IIc	Critical hip	Significant development deficit	Rounding to flat	Partially covers the femoral head
Type D	Decentering hip	Significant development deficit	Rounding to flat	Shifted
Type III	Hip dislocation	Not developed	Flattened	The cartilage is compressed upwards, tilted cranially
Type IV	Hip dislocation	Not developed	Flattened	The epiglottis is pressed down, horizontal or inclined caudally

Table 2. Quantitative criteria of hip joints during sonography

Groups	Angle α°	Angle β°
Type I	≥60	<55
Type IIa	50-59	>55
Type IIb	50-59	>55
Type IIc	43-49	<77
Type D	43-49	< 77
Type III	<43	> 77
Type IV	<43	> 77

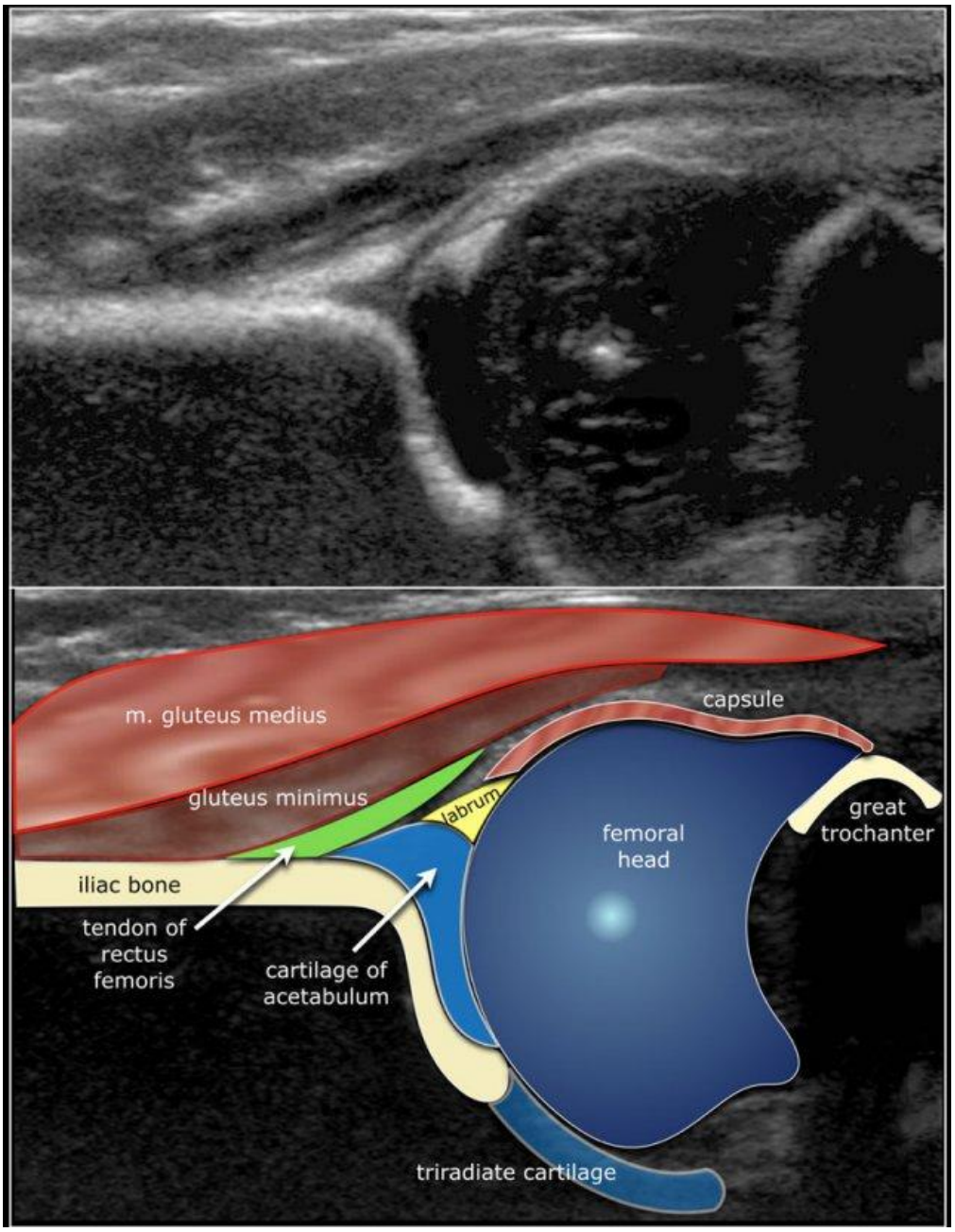

Figure 1. Ultrasound markers for determining the angles α and β (middle gluteus muscle, small gluteus muscle, joint capsule, large condyle, femoral head, acetabulum, acetabular cartilage, tricuspid cartilage, tendon of the thigh-lifting muscle, ilium)

The analysis of ultrasound of the hip of 300 children who were on inpatient treatment at the Samarkand Regional Multidisciplinary Children's Medical Center was carried out, of which 70 patients were found to have various degrees of severity of the corresponding symptoms of dysplasia. All patients were examined by sonography using an ultrasound device "Toshiba XARIO-200 with a linear sensor with a frequency of 5-7 MHz. The quantitative and qualitative indicators of hip joints performed according to the method of R. Graf (tab.1, tab.2) were studied in the work. The essence of this technique is to assess the development of the bone dome of the acetabulum (angle α), as well as the development of the cartilaginous zone of the acetabulum (angle β) (Fig.1).

4. Results of the Research

At the first stage of the study, risk factors for the development of hip dysplasia in the examined children were determined. According to our research, the most significant was the pelvic or leg presentation of the fetus, noted in 28 children (40%). This is due to the fact that obstetric errors could have been made during childbirth. Next in frequency of occurrence is the female sex, identified in 23 girls, which was 32.8%. The world community has not yet reached a consensus on this risk factor. The most likely reason for this ratio of boys and girls is the influence of the mother's female sex hormones on the pelvic muscles in girls. The third most

important factor was the regional factor of incorrect too tight swaddling, established in 12 children (17.1%). The so-called "beshiki" (national cradles with too tight swaddling) are the reason for frequent visits to pediatric orthopedists in our region. In the remaining 7 children, namely in 10.1% of cases, a combination of several of the above factors was observed (Fig.2).

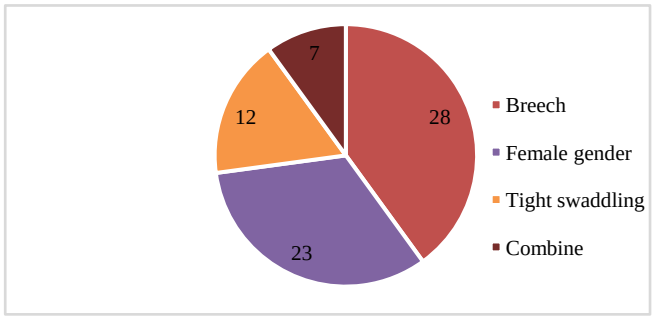

Figure 2. Distribution of examined children with hip dysplasia by risk factors

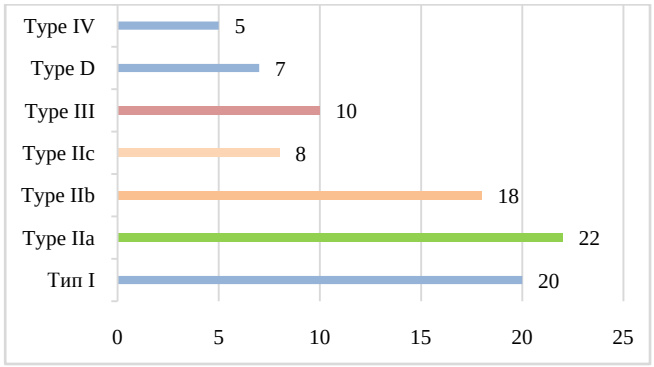

Figure 3. Distribution of examined children depending on Type a of TBS dysplasia according to the results of the study

At the second stage, after ultrasound sonography using the R.Graf technique, all patients were divided into 7 groups (Fig.3).

Thus, the 1st group consisted of children with a normal hip joint from the control group, namely 20 (22.2%) healthy children. The alpha angle in children of this category was 61± 1.28° (Fig.4).

The 2nd group included children with an immature hip joint under the age of 3 months, the number of which was 22 (24.4%) and with an alpha angle value of 55.1±3.08°.

Next, children with similar values of the alpha angle were identified in group 3, namely 52.5 ± 1.09° (Fig.5), but the age of these children was already in the range of 3-6 months. Both of the above groups are clinically related to an "immature joint" and require observation by an orthopedist. The number of such patients was 18 (20%) of all examined children.

Children with alpha angle values of 45.7±1.97° were assigned to the 4th group (Fig.5). In this group of patients, there was an acute deficiency of the bone roof, which was clearly flattened. Such children require therapeutic treatment by an orthopedist. According to various sources, this type of hip is classified as "instability of the femoral head". Among the examined children, the number of patients with similar indicators was 8 (8.9%).

The 5th group, of the examined children, consisted of 10 (11.11%) patients with an alpha angle of 45.6 ± 2.2°. This Type refers to serious violations of the integrity of the hip joint, classified as "subluxation" and requires dynamic observation by an orthopedist, using minimally invasive and non-invasive methods of treatment.

The children included in the 6th group had an alpha angle of 40.3 ± 1.15°, and the lip of the acetabulum in this case was shifted upwards. This group consisted of 7 (7.8%) children. Patients with similar indicators refer to "complete hip dislocation", which is a direct indication for surgical treatment.

Patients from group 7 who had angle values of 39.25±0.95 were also classified as "complete hip dislocation", however, in this group of children, the acetabulum lip was shifted downward, which is a more dangerous and serious indicator of pathology. The number of children with the above indicators was 5 (5.6%).

Figure 4. Healthy child K., 3 months old. Normal hip joint (Type I – α =60°, β=55°)

Figure 5. Patient N., 5 months of age. "Immature" hip joint (Type IIa – α =54°, β =>63°)

Figure 6. Patient M., 2 months of age. "Subluxation" of the hip joint (Type III. α =48°, β = 68°)

Figure 7. Patient I., 3 months of age."Complete hip dislocation" (Type IV. α=<45°, β >71)

5. Discussion of the Results of the Study

Thus, ultrasound examination of the hip joints is advisable to be carried out in young children to identify signs of hip dysplasia of varying severity. Ultrasound examination should begin with B-mode. The smaller the angle α and the larger the angle β, the greater the degree of underdevelopment of the joint. If minor changes in the hip joints are detected, it is recommended to consult a traumatologist or a pediatric orthopedist.

Early diagnosis of hip dysplasia in children is the key to effective therapy. In case of hip dysplasia of Turea II, follow-up up to a year is recommended. If the pathology does not resolve itself, then physiotherapy is recommended. With Turei III, conservative treatment should be carried out, and Type IV is a direct indication for surgical treatment.

Ultrasonographic assessment of qualitative and quantitative parameters of hip joints allows differentiating different stages of their dysplasia. From the group of patients with identified dysplasia, patients with early changes in the immature joint prevailed (57.5%), which do not manifest clinically, based on this, it is necessary to include ultrasound of the hip joint in the sonography mode in the standard examination of newborns to objectify the pathological process.

Assessment of the hip joints in B-mode does not require significant time and the results of ultrasound examination make it possible to prescribe pathogenetically based treatment, monitor the effectiveness of the therapy in dynamics, without exposing the child to radiation.

Conclusion. Ultrasound sonography of the hip joint is an effective method of rapid non-invasive detection of hip dysplasia of varying severity in young children. The main advantages of the methods are the absence of radiation exposure, speed, non-invasiveness, the possibility of repeated studies, as well as higher efficiency compared to classical radiography in the case of children aged 1-6 months. This, in turn, increases the chances of early detection and the appointment of effective treatment without surgery.

Conflict of Interest

The authors declare that there is no conflict of interest.

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