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Musculoskeletal ultrasound: a useful tool for diagnosis of hip developmental dysplasia

One single-center experience

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Abstract

Developmental dysplasia of the hip (DDH) is one of the most common congenital abnormalities of the musculoskeletal apparatus in newborns. The aim of this study was to analyze the contribution of ultrasonography in the detection of DDH in newborns and infants, identifying the regional incidence of this pathology in the central area of Romania, emphasizing the risk factors that underlie DDH etiopathogenicity.

This article represents a retrospective study of 847 newborns and infants examined in the Imagistic Department of a medical center from the central area of Romania, between January 1 and December 31, 2016. The ultrasound examinations were performed for the bilateral coxofemoral joints, using the method and technique described by Graf. For subjects born in the same medical center, data regarding mother's age, birth weights, and type of delivery (natural vs. caesarian section) were statistically analyzed.

In our study group, the frequency of ultrasound diagnosis obtained from the examinations of right and left hips showed that the most frequent stage was type IA, and the rarest stage was III. The IA stage of right coxofemoral joints (87.3%) was higher than in the left coxofemoral joints (87.2%). The incidence of hip dysplasia (type III) diagnosed with ultrasound examinations in subjects from the central area of Romania was 0.2% (0.1% in both hips and 0.1% for the left coxofemoral joint).

The musculoskeletal ultrasound examination is effective in early detection of hip dysplasia. The implementation of national and regional programs that promote indications, risk factors, and the screening age for DDH in both rural and urban areas could be a step forward in the early diagnosis of hip dysplasia for newborns and infants. The low incidence of DDH from our study group is not able to identify the role of advanced age of the mother, high birth weight of the newborn, or caesarean section as risk factors involved in the etiology of hip dysplasia. The implementation of national and regional programs that promote the musculoskeletal ultrasound as a screening imagistic investigation for DDH, in both rural and urban areas, could be a step forward in the early diagnosis of hip dysplasia for newborns and infants.

Abbreviations: DDH = developmental dysplasia of the hip, SD = standard deviation.

Keywords: developmental dysplasia of the hip, newborns, ultrasound

1. Introduction

Developmental dysplasia of the hip (DDH) is one of the most common congenital abnormalities of the musculoskeletal apparatus in newborns, including a range of coxofemoral joint deformities such as: joint instability, articular capsule laxity, articular subluxation, prematurity of coxofemoral joint components, complete dislocation, and dysplasia of the femoral head and acetabulum.[1–5] DDH is an important cause of disability in both children and adults if is not treated in time.[6–9] Anatomical abnormalities of the dysplastic hip can lead to biomechanical changes of the dysplastic hip joint, the shortening of the length of the inferior limb on the affected side, pain, and joint dysfunction. The correct and early diagnosis of this pathology has become a major objective in pediatrics, currently relying on medical history, clinical and imaging examinations—radiological or ultrasound examination.[10–12] The facile accessibility and the lack of exposure to radiation has expanded today the clinical applications of musculoskeletal ultrasonography, making it the gold standard that currently allows qualitative and quantitative assessment of coxofemoral joints in newborns and infants.[13–15]

The aim of the study is to analyze the contribution of ultrasonography in the detection of hip developmental dysplasia in newborns and infants, identifying the regional incidence of this pathology and the risk factors that underlie the etiopathogenicity of this diagnosis. The main reasoning behind this article was the lack of studies in this field performed in our geographical area, with a similar hypothesis and having an increased number of subjects.

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Table 1

Correlation between coxofemoral joints diagnosis and patient gender.

P=.03			Gender		Total
			F	M	
Right hip Ultrasound examination Diagnosis	IA	Count	363	377	740
		% within gender	84.6%	90.2%	87.3%
	IB	Count	65	41	106
		% within gender	15.2%	9.8%	12.6%
	IIA	Count	0	0	0
		% within gender	0.0%	0.0%	0.0%
	III	Count	1	0	1
		% within gender	0.2%	0.0%	0.1%
Total		Count	429	418	847
		% within gender	100.0%	100.0%	100.0%
***P*=.02**			**Gender**		**Total**
			F	**M**	
Left hip Ultrasound examination Diagnosis	IA	Count	360	378	738
		% within gender	84%	90.4%	87.2%
	IB	Count	65	40	105
		% within gender	15.2%	9.6%	12.4%
	IIA	Count	2	0	2
		% within gender	0.4%	0.0%	0.2%
	III	Count	2	0	2
		% within gender	0.4%	0.0%	0.2%
Total		Count	429	418	847
		% within gender	100.0%	100.0%	100.0%

2. Methods

This article represents a retrospective study of 847 newborns and infants examined in the Imagistic Department of the Nova Vita Medical Center, Romania, between January and December 31, 2016, where the authors perform their clinical activity. The methodology of the study was approved by the Ethics Committee of the medical center (registration no.-5750/October 3, 2017), signed by the medical manager of the institution, and has also been approved by the Ethics Committee of the University of Medicine, Pharmacy, Sciences and Technology of Târgu Mureş (Registration No. 331/November 17, 2017), signed by the Chairman of the Committee.

The subjects included in this study had been addressed to the Nova Vita Medical Center in order to be examined clinically and with ultrasound by specialist doctors. The ultrasound examinations were performed for the bilateral coxofemoral joints, using the method and technique described by Graf. For the accurate angular measurement, we used the 4 classic reference points (the perichondrium-periost junction, the acetabular bone edge, the lower edge of the iliac bone, and the middle of the acetabular labia) and the 3 reference lines drawn through the 4 points mentioned above.[15] Between the 3 lines, we measured the value of 2 angles: the α angle (the bone cover angle) that originates between the baseline (line of the iliac bone) and the roof line (from the lower edge of the iliac bone to the external bone of the acetabulum) and the β angle (cartilaginous cover angle), which originates between the baseline and the cartilaginous inclination line (from the acetabular angle to the middle of the acetabular labia). According to the classification proposed by Graf, we considered as normal values of α angle above 60° and for angles β all values below 55°.[15]

Ultrasound exploration was performed using General Electric Logiq 7 (General Electric Company (GE)) multifunctional equipment, by the same specialist physician, having 8 years' experience in the field, using a linear probe type M12L (5–13 MHz).

The data for this study were collected using unitary ultrasound examination reports. The parameters monitorized and analyzed were represented by demographic data (age, gender, medical history), ultrasound data (values of αand βangles, ultrasound examination stages of the coxofemoral joints according the Graf classification, and the presence of ossification nuclei). For patients born in the Nova Vita Medical Center, the parameters analyzed were the birth weight of the newborn, the mother's age, and the type of birth (vaginal/caesarean section). These parameters were taken from the birth register of the Obstetrics and Gynecology Compartment of the abovementioned institution.

Data collected from the ultrasound and clinical files were computerized, stored, and processed. The statistical analysis was performed using SPSS (IBM) statistical software. The article reports frequency tables and percentages. Descriptive statistics are based on central trend indicators (average, median) and the dispersion indicators were expressed by the minimum and maximum standard deviation (SD). In analytical or inferential statistics, we used Chi-square and Student tests for Table 1, as well as Spearman correlation in Figures 1–4.

The statistical significance was interpreted according to the significance threshold ($P < .05$). Graphical expression was performed using Box Plot diagrams.

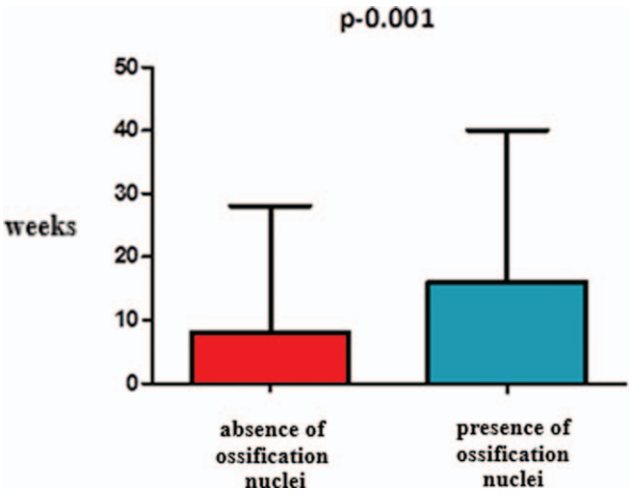

Figure 1. Correlation between patient age and the presence/absence of ossification nuclei during ultrasound examination.

3. Results

During the year 2016, in the Nova Vita Medical Center 847 infants and newborns, aged 4–40 weeks (average 10.59 ± 5.55 weeks) were completely examined. The study group comprised 429 girls (50.6%) and 418 boys (49.4%); 630 (74.4%) of the subjects came from an urban area.

Applying the Graf classification, the ultrasound examination of the bilateral coxofemoral joints identified in the study group was at the following stages: IA, IB, IIA, and III. The synthetic data on their frequency according to subjects' gender are presented in Table 1.

The median age of subjects who registered the presence of bilateral ossification nuclei during the ultrasound examination was 15.51 ± 6.51 weeks, and those who did not have ossification nuclei were 8.74 ± 3.76 weeks (Fig. 1).

The mean age of subjects who presented as stage IA during ultrasound examination of the right hip was 11.01 ± 5.68 weeks, and those with type IB were 7.708 ± 3.58 weeks (Fig. 2). Stage III was diagnosed using ultrasound in a single patient of 11 weeks of age.

The mean age of patients presenting with stage IA during ultrasound examination of the left hip was 11.03 ± 5.68 weeks, and those with type IB were 7.712 ± 3.617 weeks (Fig. 2). Stages IIA and III were diagnosed with ultrasound in only 4 patients whose ages were 4 and 9 weeks (IIA), respectively at 6 and 11 weeks of age (III).

Of 847 patients, 259 were born in the Nova Vita Medical Center Târgu Mureş, as follows: 171 (20.2%) by caesarean section and 88 (10.4%) by vaginal delivery. For these subjects, the medical data were processed using files monitored in the Department of Obstetrics and Gynecology of the Medical Center. The mean birth weight of patients born in the Nova Vita Medical Center was 3439.6 ± 460.7 g, and the mean age of mothers was 30.9 ± 4.4 years.

For patients who presented type IA for the right hip during ultrasound examination, the mean birth weight was 3434 ± 457.9 g, and for those with type IB 3471 ± 481.5 g (Fig. 3).

For patients who presented with type IA during left coxofemoral joint examination, the average birth weight was 3444 ± 401.7 g, and for those with IB type 3475 ± 487.7 g (Fig. 3). Stages IIA and III were diagnosed only in two patients, who weighed 3340 and 3680 g, respectively.

The average age of mothers whose children were born in the Nova Vita Medical Center and had presented during right hip ultrasound examination with the IA type was 31.09 ± 3.95 years, respectively, 29.47 ± 6.00 years for those whose newborns presenting with type IB (Fig. 4).

The average age of mothers whose children were born in the Nova Vita Medical Center and presented during ultrasound examination of the left hip with the IA type was 31.08 ± 3.96 years, respectively, 29.95 ± 4.28 years for those whose newborns presenting with type IB (Fig. 4). Stages IIA and III were only diagnosed using ultrasound in 2 subjects whose mothers were 30 and 32 years old, respectively.

4. Discussion

The DDH is one of the most common congenital skeletal abnormalities in newborns and infants, with multiple variations in incidence rates due to different diagnostic methods and the time of diagnosis.[16,17] In the literature, it is estimated that the

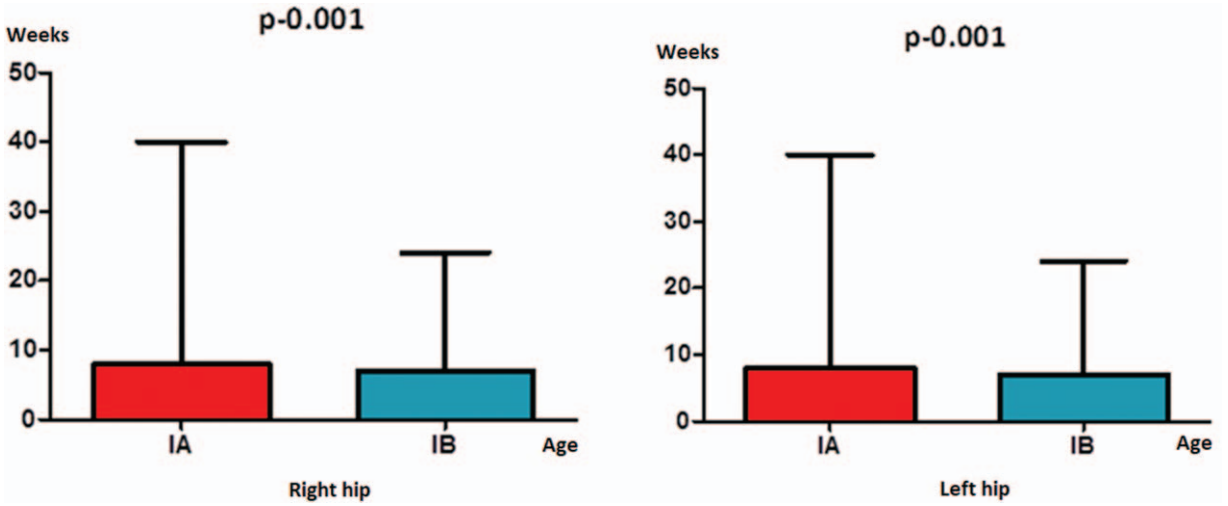

Figure 2. Correlation of patient age with ultrasound diagnosis for right hip.

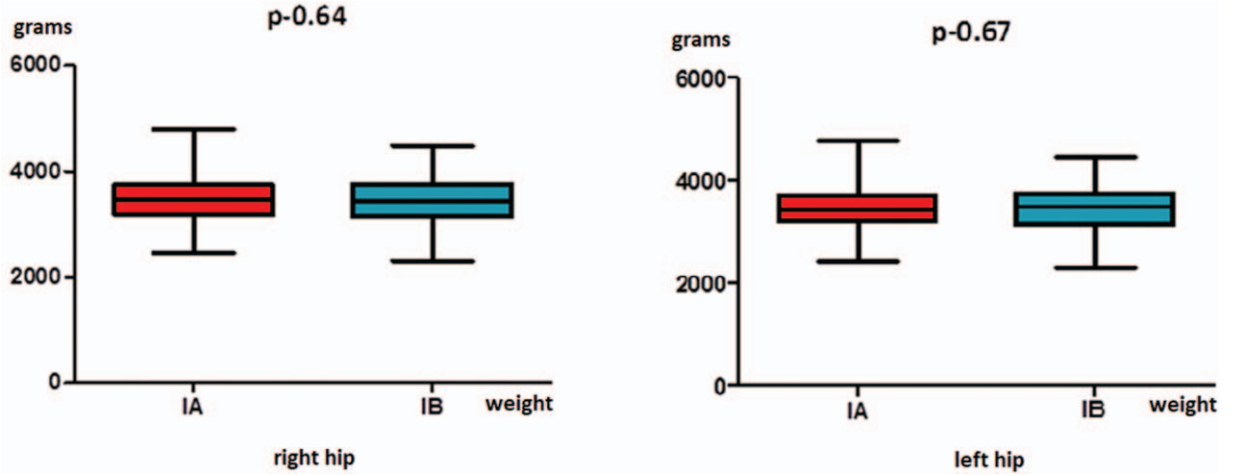

Figure 3. Correlation between birth weight of subjects and ultrasound stages IA and IB in right left hips examination.

incidence of DDH is between 1.5 and 20/1000 newborns, being 4 to 8 times more frequent in females than males.[18–21]

In our study group, the frequency of ultrasound diagnosis obtained from the examinations of right and left hips showed that the most frequent stage was type IA, and the rarest stage was III. The IA stage of right coxofemoral joints (87.3%) was higher than in the left coxofemoral joints (87.2%). As for type III, it was more common in the left coxofemoral joints (0.2%) compared with the right coxofemoral joints (0.1%). The statistical analysis of the database indicated the presence of only 2 cases (0.2%) of type IIA identified in the left coxofemoral joints. Frequency of type IB in the right coxofemoral joints (12.6%) was higher than in the left coxofemoral joints (12.4%). All these results are in accordance with other literature studies published between 2012 and 2017 in different countries as: the Netherlands (5170 patients), Saudi Arabia (276 patients), Turkey (1690 subjects), and Brazil (222 patients).[21–24]

DDH is presented in the literature as a multifactorial disease.[3] This complex developmental disorder is the result of genetic and nongenetic risk factors.[6,16–17] The latter factors include the female gender of the child.[25–28] Regarding ultrasound examination of the right hips, in the present study we obtained for stage IA a higher frequency with statistical significance for males (90.2%), comparing with females (84.6%), with a *P* value of .03. For stage III, the frequency was higher for females (0.2%) comparing with males (0%), all data being in accordance with the literature. After ultrasound examinations of the left hip, we obtained for type IA a statistically significant higher frequency for males (90.4%) comparing with females (84%), with a *P* value of .02. A statistically higher frequency for female (0.4%) versus male gender (0.0%) was recorded in the diagnosis of type III ($P < .01$). In the present study, ultrasound stage III was present only for girls, a result which confirms the idea from literature that the newborn gender could be a risk factor for DDH due to increased capsular and ligament laxity and the presence of the hormone relaxin—a maternal hormone produced by the ovaries during pregnancy.[22,29,30]

In our study group formed of 847 newborns, only 27.4% (232 subjects) presented ossification nuclei during ultrasound examination of bilateral hips. As a result of the Chi-square test, we obtained a statistically significantly higher incidence of ossification nuclei in females (141 cases) than in males (91 cases), with

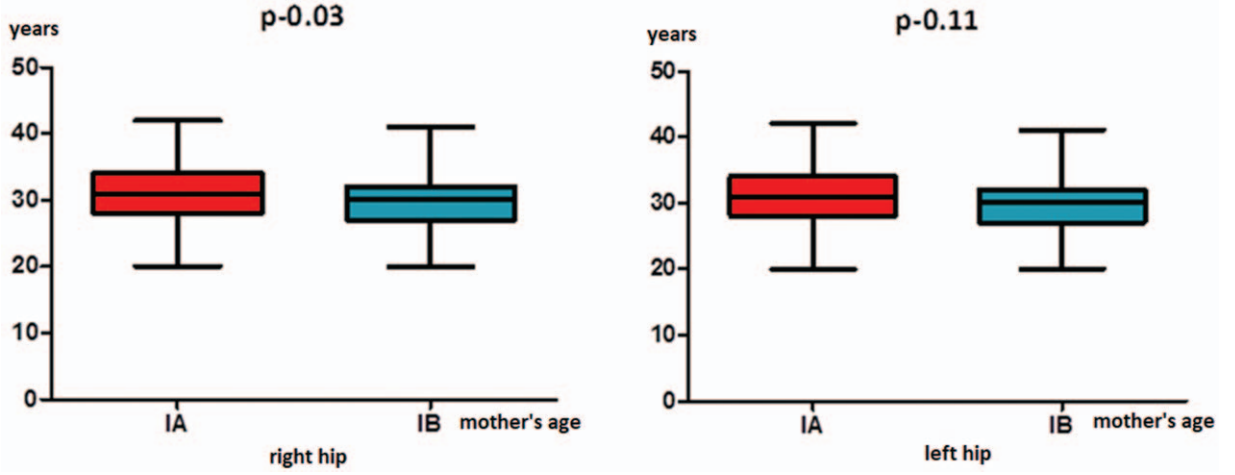

Figure 4. Correlation between mother's age and ultrasound examination diagnosis for right and left hips.

$P < .01$. Using the same method, the present study reveals the fact that the average age of the patients who presented bilaterally with ossification nuclei, was 15.51 ± 6.51 weeks, and those who did not present with such nuclei were aged 8.74 ± 3.76 weeks. Thus, our results are synchronized with data from the literature, which state that ossification nuclei occur in infants of 4 to 6 months of age (16–24 weeks).[2]

For all 259 subjects born in the Nova Vita Medical Center, we were able to access information regarding the type of birth (natural vs. caesarean), birth weight, and mother's age, with all of these parameters being considered in the literature as nongenetic risk factors for DDH.[2,8,25–28] By statistical analysis, we determined in our study that stage IA is the most common stage for both coxofemoral joints, regardless of the type of birth (cesarean section or vaginal delivery). The existence of only 1 case of hip dysplasia in the entire group, with the birth by caesarean in history cannot support the idea that newborns delivered via caesarean section have a higher risk of unstable or dysplastic hips.[29] The mean birth weight of newborns was 3439.6 ± 460.7 g. Analyzing the correlation between the mean birth weights of these patients and stages IA and IB during ultrasound examinations, we obtained no statistically significant differences between right ($P = .64$) and left coxofemoral joints ($P = .67$). Stages IIA and III were diagnosed by ultrasound only for left hips and only in two subjects whose mean weight was 3340 g and, respectively, 3680 g. The existence of only one stage IIA and one case with type III in our study cannot support the supposition that high birth weight is a risk factor for DDH, or that low birth weight (<2500 g) has a protective role for hip developmental dysplasia.[8,30]

The mean age of mothers monitorized in our study was 30.9 ± 4.4 years. The study also revealed a statistically significant difference ($P = .03$) in the mean age of mothers whose children presented with hip ultrasound examination stages IA (31.08 ± 3.96) comparing with those with stages IB (29.95 ± 4.28). In contrast, for the left coxofemoral joints, we did not find any significant difference ($P = .11$). Stages IIA and III were diagnosed using ultrasounds only in the left hips and only 2 patients whose mothers were 30 and 32 years of age, respectively, confirming the hypothesis that the incidence of DDH increases in children whose mothers are more elderly (30–34 years) compared with mothers under the age of 20 years.[30]

Since ultrasound examination is an operator-dependent technique, the musculoskeletal ultrasound procedure for the diagnosis of DDH should eliminate error sources as much as possible. Adequate communication skills in relation to children and their relatives, the existence of an adapted examination environment (calm atmosphere, optimal temperature, support systems for maintaining the position of the child), and appropriate management of the time dedicated for these types of examinations, could lead synergistically to reducing childrens' movements, the main source of error.[15,31] A modern ultrasound device equipped with a high-frequency linear transducer, and the examiner's experience in eliminating artifacts and establishing the correct orientation of the ultrasound planes could guarantee a safe exploration of the hip joints in newborns and infants.[15]

5. Conclusions

The musculoskeletal ultrasound examination is effective in early detection of hip dysplasia, being preferred for the diagnosis of this pathology due to the lack of radiation, low costs, and facile accessibility. The Graf method could provide a qualitative and quantitative assessment of the coxofemoral joints of newborns and infants if it is performed by an experienced physician, in a center with increased addressability.

The incidence of hip dysplasia (grade III) diagnosed with ultrasound examinations in subjects from the central area of Romania was 0.2% (0.1% in both hips and 0.1% for the left coxofemoral joint).

The study group cannot support the proposal that advanced age of the mother, high birth weight of the newborn, or caesarean section represent risk factors involved in the etiology of hip dysplasia. The low incidence of DDH from our study group is not able to identify the role of advanced age of the mother, high birth weight of the newborn, or caesarean section as risk factors involved in the etiology of hip dysplasia.

The implementation of national and regional programs that promote indications, risk factors, and the screening age for DDH in both rural and urban areas could be a step forward in the early diagnosis of hip dysplasia for newborns and infants. The implementation of national and regional programs that promote the musculoskeletal ultrasound as a screening imagistic investigation for DDH, in both rural and urban areas, could be a step forward in the early diagnosis of hip dysplasia for newborns and infants.

Author contributions

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