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Ultrasound Evaluation of Neonatal Hip Joint Problems

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Abstract
Background: The assessment in neonates, such as developmental hip dislocation (DDH) and septic hip arthritis, is very important from a clinical standpoint. In this regard, ultrasound imaging has shown to be invaluable due to the fact that it allows for assessment without the use of ionising radiation. The purpose of this research was to evaluate the usefulness of ultrasonography in the diagnosis of DDH and septic hip arthritis in neonates. Methods: Newborns at Benha University Hospital and other private facilities were analysed using a comparative cross-sectional research methodology. The study population was subjected to in-depth interviews, physical exams, and ultrasound assessments. The ultrasound evaluation looked at the shape of the hip, the location of the femoral head, and the strength of the hip joint. The degree of irregularity was determined by a combination of measurements and visual inspections, such as measuring alpha and beta angles. Patients who had favourable ultrasonography results were monitored and referred to specialists as needed. Conclusions Both the positive and negative predictive capacities of ultrasonography were quite high (80% and 100%, respectively). In addition, a high area under the curve (AUC=0.949) and associated 92% diagnostic accuracy rate were found when employing ROC curve analysis to differentiate DDH from normal findings using hip ultrasonography. Furthermore, a positive family history (p=0.007), oligohydramnios (p=0.003), and caesarean section (p=0.008) were all significantly associated with an increased risk of DDH incidence, as determined by the study's analysis into probable DDH causes based on the analysed data. We conclude that ultrasound is a useful and non-invasive method for assessing hip joint issues in neonates, especially DDH. The clinical examination of newborns with suspected hip abnormalities benefits greatly from its accuracy and its capacity to detect related risk factors.

Keywords: Neonatal, Hip Joint Problems, Hip Dysplasia, Septic Hip Arthritis, Ultrasound.

1. Introduction

Developmental Significant problems affecting the newborn population include developmental hip dysplasia (DDH) and septic hip arthritis. Hip dislocation or aberrant development is a hallmark of DDH, a common musculoskeletal condition [1]. If not diagnosed and treated promptly, it may cause serious long-term problems. However, septic hip arthritis is a dangerous form of arthritis that, if left untreated, may lead to joint destruction and functional disability [2].

Evaluation of hip joint issues in neonates has historically relied on a combination of a physical examination and plain radiography. In the early stages of DDH, however, these techniques have low sensitivity and specificity. Because of this, other methods of diagnosis are being investigated, such as ultrasonography because of its benefits [3].

Neonatal hip joint abnormalities are now easier to diagnose with the use of ultrasound. The hip may be imaged in real time, offering invaluable insight into the hip's morphology, anatomy, and stability. In addition, ultrasonography is safe for children since it does not involve needles, radiation, or anaesthesia [4].

Numerous categorization systems and diagnostic criteria have been created for the use of ultrasonography in the examination of newborn hip joints. The Graf classification is a popular option since it uses the alpha and beta angles of the hip joint to identify hip joints. Hip dysplasia may be diagnosed and its severity measured with the use of this approach [5].

When conducted by trained professionals, ultrasonography has been demonstrated to have a high sensitivity and specificity for identifying DDH. To maximise hip joint development and minimise long-term consequences, it enables early diagnosis of hip dysplasia and may lead suitable therapies, such as the use of orthotic devices or surgical procedures [3, 6].

Ultrasound may be used to detect septic hip arthritis in addition to DDH. Joint effusions, synovial thickness, and the existence of abscesses or fluid collections inside the joint may all be detected and evaluated using this method. Septic hip arthritis may be treated with antibiotics, but only if doctors catch it early enough [7, 8].

Ultrasound has becoming increasingly used to evaluate hip joint abnormalities in neonates, leading to better diagnosis accuracy and higher rates of early intervention. In both clinical practise and academic contexts, it has become an integral part of the diagnostic workup. Despite its usefulness, further research and development is needed in several areas [9, 10].

Therefore, the purpose of this research was to determine how useful ultrasonography is for evaluating the hip joint of neonates and for detecting developmental delay and septic hip arthritis.

2. Methods

This Fifty patients were studied in this comparative cross-sectional study from the Benha University Hospital outpatient clinic and other private clinics.

Before any patients were included in the trial, their parents gave their informed permission. The Benha Faculty of Medicine Research Ethics Committee gave its permission.

All ages were welcome, all sexes were represented, and referrals came from Orthopedic practises based on clinical suspicion.

On the other hand, certain restrictions were in place. In order to keep a concentrated and relevant sample, patients with neuromuscular problems and those presenting with additional bone abnormalities were not included.

The following was done to every instance we studied:

Taking a complete patient history involves: Age, sex, pregnancy, delivery, and postpartum, as well as any relevant family medical history, should be recorded. Pregnancy complications, such as premature birth or foetal discomfort.

Vital signs, anthropometric measures, and a full body checkup are all part of a comprehensive clinical examination. Hip joint evaluation: All hip joints, both stressed and unstressed, were analysed at Banha University's radiography department. The clinical screening for developmental dysplasia of the hip relied heavily on the Ortolani and Barlow tests, which evaluated hip instability. It is important to check both hips independently [11].

Back dislocations and subluxations may be found with the use of the Barlow test. Dr. Thomas Geoffrey Barlow is widely credited as the creator of this examination. As a provocative technique, the Barlow test may identify hip instability. The examination is carried out by: Placing yourself at the baby's head end on the examining sofa. One hand holds the pelvis still while the other grabs the knee and bends the hip to a ninety degree angle. Fingers should be placed over the greater trochanter and the thumb should rest on the inner aspect of the examinee's thigh. When the thigh is slightly adducted by 10–20 degrees, a posterior force is delivered via the femur. The knee is then gently pressed while the force is directed behind the knee. If the hip can be dislocated by performing the Barlow Test, the patient has a hip dysplasia. The sense of displacement was quite real. With practise, the Barlow technique may have a sensitivity of 87 to 97 percent and a specificity of 98 to 99 percent.

Ortolani Test

The The Italian paediatrician Marino Ortolani initially described the Ortolani Test in 1936.

A supine posture with the baby's hips flexed to 90 degrees is used for the test. The examiner should rest his or her thumb at the child's groyne crease, with the index and long fingers resting laterally on the child's greater trochanter. To do this test, you should grip the child's contralateral hip while gently abducting the hip being examined and applying an upward strain through the greater trochanter on the lateral side. Hearing or feeling a noticeable clunk during the Ortolani test shows that the hip has been successfully repositioned inside the acetabulum after being dislocated.

The Benefits of Hip Ultrasound: The radiologist used US to evaluate the hip at rest and under stress to determine the femoral head position, hip stability, and hip morphology. The child was placed in the supine or lateral decubitus posture for this lateral approach. The scanning was done while the subject was lying on their back with their hips either fully extended or flexed. Images were taken with and without stress while the thighs were extended to 90 degrees in the axial (transverse) plane. The pictures clearly showed the articular cartilage and bone surfaces of the hip joint, and the acetabular covering of the femoral head could be evaluated.

On the opposite side, same procedures were followed. Suitability was tested by applying stress. The next step is a dynamic examination (coronal and transverse views) utilising a hybrid approach, maybe combining a real-time scan with a static analysis. Ultrasound results were evaluated by the same radiologist using both dynamic (based on visual appreciation) and biometric (based on measurement) analysis. Suitability was tested by applying stress. An imaginary line was drawn from the base of the iliac bone, across the femoral head, and back across the base of the acetabulum in a frozen coronal image. After that, the apparent circle of the hypoechoic femoral head was generated and intersected by alpha and beta angles, creating two horizontal sections: the deeper one is like the percentage of femoral head coverage and correlates with the bone (alpha angle), and the other path corresponds to no coverage and correlates with cartilage (beta angle) (beta angle).

Since the alpha angle for a normal scan ranges from more than 50 to 60 degrees, measurements should be reserved for dysplastic hip classification and surveillance, since visual appreciation is a more sensitive approach. Assessment of acetabular morphology, head of femoral sphericity and roundness, and proximal capital femoral epiphyseal ossification centre, as well as stability, are all positive results that may be seen on dynamic ultrasound scans.

Patients who had favourable ultrasound results were checked on again 4–6 weeks later by the same researcher. Concurrently, from the time of the first encouraging results, the patient was sent to a specialist for further care.

The ultrasound appearance of effusions in septic arthritis is often hypoechoic rather than echo-free, and the absence of fluid accumulation on ultrasound may be indicative of a lack of the diagnosis. Joint asymmetry, fluid presence, and thickened articular capsule are used to diagnose hip problems.

Because of its portability, noninvasive nature, and absence of anaesthesia and radiation exposure, ultrasound (US) has become the modality of choice for imaging paediatric patients. Patients with an irritable hip may require additional evaluation with MRI or possible intervention with arthrotomy, irrigation, and debridement based on the results of these tests. Increased vascularity has been studied for diagnostic certainty using techniques like power Doppler, however this strategy has not met with consistent success.

Although MRI is often used for evaluating the extent of joint effusions and abscesses and tracking treatment progress, US has potential benefits in these areas as well.purposes.

Statistical analysis:

The IBM's 2017 Statistical Package for the Social Sciences (SPSS) was used to analyse the data obtained. Coding and tabulating using IBM SPSS Statistics for Windows, Version 25.0 (Armonk, NY: IBM Corp., 2015). The collected data for each parameter was analysed using the appropriate methods. The Shapiro-Wilk test was used to check for a normal distribution in the data. For numerical data, descriptive statistics included calculating mean, standard deviation (SD), and range; for non-numerical data, frequency and percentage were used. The Chi-Square test was used as part of the analytic statistics procedure for determining the significance of associations between qualitative variables. For quantitative diagnostic tests, the ROC Curve (receiver operating characteristic) helped evaluate sensitivity and specificity by pinpointing the ideal cutoff point that maximised area under the curve (AUC). Accuracy was deemed high when the AUC was more than 0.9, moderate between 0.7 and 0.9, poor between 0.5 and 0.7, and random above 0.5. A p-value less than 0.05 at a 95% confidence interval was used to determine the significance of the findings.

3. Results

The Fifty infants having a clinical suspicion of DDH were included in the present research (Developmental dysplasia of the hip). This group had a mean age of 10.444.5 weeks. Most of the occurrences occurred between the ages of 12 and 16 weeks (38%). There were more women than men, making about 64% of the total. Table 1

Table (1) Demographic data in the studied patients

		Total cases (n=50)
Age (weeks)	**Mean ± SD**	10.44±4.5
	Range	2.0-18.8
Age groups, n (%)	**< 4 weeks**	6(12%)
	4-8 weeks	12(24%)
	8-12 weeks	9(18%)
	12-16 weeks	19(38%)
	> 16 weeks	4(8%)
Gender, n (%)	**Female**	32(64%)
	Male	18(36%)

Data were presented as mean ± standard deviation (SD), frequency (%).

The Cesarean section was the most prevalent risk factor found (present in 86% of cases). The next most prevalent risk factors were oligohydramnios (present in 24%) and a positive family history of DDH (22%). Related birth defects accounted for 6% of the cases investigated, whereas maternal diabetes accounted for 10%, twin gestation accounted for 14%, premature birth accounted for 8%, and breech presentation accounted for 2%. (8 percent). Indicator 1

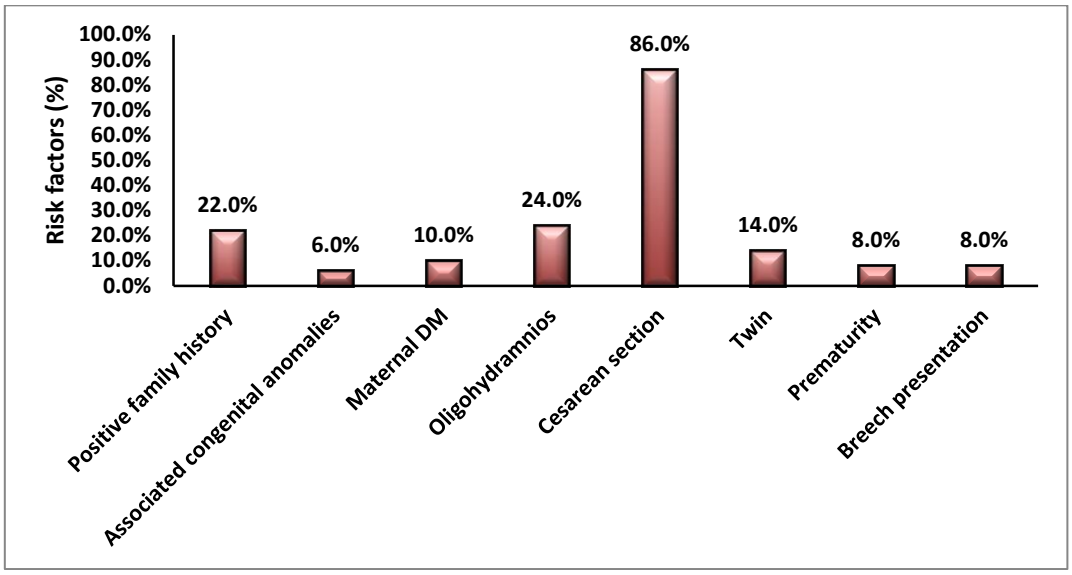

Fig. (1) Risk factors distribution in the studied cases

Among 50 One hundred people's hips were scanned using ultrasound. Thirty percent of hips tested by ultrasonography exhibited signs of DDH, while the other seventy percent were normal. Right-sided ultrasound examination suggested DDH in 13% of the cases analysed, whereas left-sided ultrasound examination suggested DDH in 17% of the cases. Only 10% of instances showed positive effects on both sides.

Seventy-four percent of the right hips and 66 percent of the left hips were categorised as Graf type I (normal) according to the Graf classification system. The percentage of right hips with Graf type II DDH suspicion was 22%, whereas the percentage of left hips was 30%. Four percent of individuals on each side had Graf type III DDH.examined. **Table 2**

Table (2) Graf types among examined hips.

		Right hips (n=50)	Left hips (n=50)
Graf type, n (%)	**I**	37(74%)	33(66%)
	IIa	3(6%)	5(10%)
	IIb	1(2%)	4(8%)
	IIc	5(10%)	5(10%)
	IId	2(4%)	1(2%)
	III	2(4%)	2(4%)
ıspected DDH, n (%)		13(26%)	17(34%)

Data was represented as number (percentage).

According to alpha angle measurements in the studied patients, the mean value of alpha angle on right hip was 59.2±6.5 °. While the mean value of alpha angle on left hip was 58.3±6.7 °. **Figure 2**

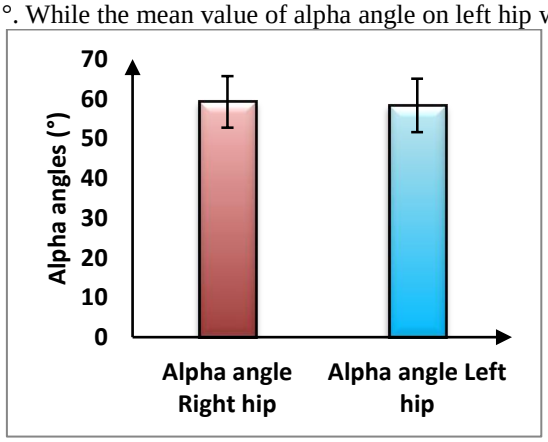

Fig. (2) Alpha angles in both sides

According to beta angle measurements in the studied patients, the mean value of beta angle on right hip was 48.9±8.2 °. While the mean value of beta angle on left hip was 52.1±10.1°. **Figure 3**

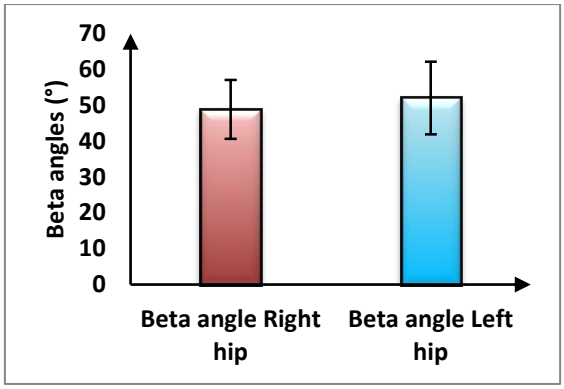

Fig. 3. Beta angles in both sides

Ultrasonography Positive and negative predictive values were determined by comparing the findings to the correct diagnosis of DDH after the follow-up period as true positive, false positive, true negative, and false negative. Positive and negative prediction from ultrasonography were quite high (80% and 100%, respectively).ectively). **Table 3**

Table (3) Validity of hip ultrasonography in predicting accurate diagnosis

	TP	FP	FN	TN	PPV%	NPV%
DDH diagnosis by ultrasonography	22	8	0	70	80.69	100

TP: True positive; FP: False positive; FN: False negative; TN: True negative; PPV: Positive predictive value; NPV: Negative predictive value.

ROC The hip ultrasonography DDH discrimination study indicated a high area under the curve (AUC=0.949) and a high percentage of correct diagnoses (92%).of DDH. **Table 4 and Figure 4**

Table (4) Diagnostic accuracy of hip ultrasonography in DDH diagnosis

	AUC	Sensitivity	Specificity	CI	Accuracy %	Kappa	P-value
DDH diagnosis by ultrasonography	0.949	100%	89.74%	0.885-0.983	92	0.794	<0.001*

AUC, Area under curve; CI, confidence interval; *: Significant ≤0.05

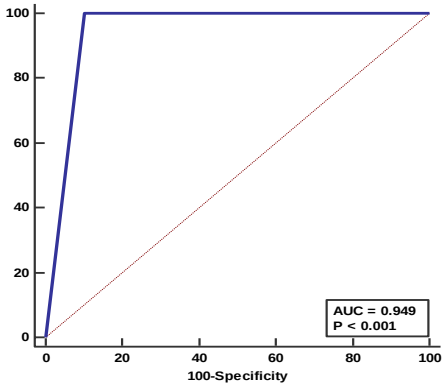

Fig. (4) ROC curve analysis for discrimination of DDH from normal results using ultrasonography

Potential DDH-related causes Positive family history (p=0.007), oligohydramnios (p=0.003), and caesarean section (p=0.001) were all linked with an elevated risk of DDH, as determined by the parameters examined.p=0.008). **Table 5**

Table (5) Association between risk factors an DDH cases

	DDH cases n=22	Normal cases n=28	Test	p
Positive family history	9(40.9%)	2(7.1%)	7.284	0.007*
Associated congenital anomalies	3(13.6%)	0(0%)	3.747	0.053
Maternal DM	4(18.2%)	1(3.6%)	2.585	0.108
Oligohydramnios	10(45.5%)	2(7.1%)	8.860	0.003*
Cesarean section	23(104.5%)	20(71.4%)	6.934	0.008*
Twin	5(22.7%)	2(7.1%)	2.119	0.145
Prematurity	3(13.6%)	1(3.6%)	1.472	0.225
Breech presentation	3(13.6%)	1(3.6%)	1.472	0.225

Test=Chi square test; *: Significant ≤0.05.

4. Discussion

This The purpose of this research was to evaluate the use of ultrasonography for diagnosing DDH and septic hip arthritis in neonates.

Newborns at Benha University Hospital and other private facilities were analysed using a comparative cross-sectional research methodology. The study population was subjected to in-depth interviews, physical exams, and ultrasound assessments. During the ultrasound evaluation, the femoral head position, hip stability, and hip morphology were all analysed. Alpha and beta angles were among the measurements and visual inspections used to establish the degree of irregularity. Patients who had positive ultrasonography results were monitored and referred to specialists as needed.

The average age of the patients was 10.44 4.5 weeks, with 38% of the instances occurring between the ages of 12 and 16 weeks. There were more women than men, making about 64% of the total.

In a similar vein, Amer et al. (2021) conducted a research to emphasise the value of ultrasonography for screening for hip dysplasia in infants. Fifty young patients were included in the study. Ultrasound examinations were performed on all patients, with Graf alpha and beta angles measured. All of the infants were less than 6 months, with 33 females and 17 males included. A mean age of 11.214.81 weeks was found [12], with a range of ages between 2 weeks and 18 weeks and 3 days.

In line with the present research, Abdullah and Zytoon (2015) examined the use of high-resolution ultrasonography in the screening of high-risk babies for developmental dysplasia of the hip. There were 124 men and 146 women in all. They were between the ages of four weeks and six months old [13].

Cesarean section was the leading risk factor found in the cases investigated, occurring in 86% of the time. The next most prevalent risk factors were oligohydramnios (present in 24%) and a positive family history of DDH (22%). Related birth defects accounted for 6% of the cases investigated, whereas maternal diabetes accounted for 10%, twin gestation accounted for 14%, premature birth accounted for 8%, and breech presentation accounted for 2%. (8 percent).

Interestingly, Amer et al. (2021) discovered that caesarean section (44%), oligohydramnios (22%), and limiting of abduction (11%) were the most prevalent reasons (16 percent). Variables accounting with between 4% and 16% of cases included a positive family history, concomitant congenital abnormalities, maternal diabetes mellitus, an atypical skin crease, positive Barlow tests, and twin pregnancies [12].

The most common risk factor in our cohort was caesarean section birth (52%), followed by breech presentation (14%), and oligohydramnios (14%). [13] This finding is consistent with that of Abdullah and Zytoon (2015).

According to Loder and Skopelja's 2011 study, the different risk factors were as follows: oligohydramnios (13.7%), caesarean section delivery (52.2%), clinical suspicion (6%), breech presentation (14.4%), twins (6%), first-born child (2%), first-born child + CS (6%), and positive family history (6%).

Breech presentation, oligohydramnios, female sex, and primiparity were identified as risk factors for DDH in a research by akr uhac et al. [15]. According to a meta-analysis conducted by Chan et al. [16], the most significant risk variables for DDH include breech presentation, female sex, a positive family history, and clicking hips on physical examination.

Consistent with the findings of another research by de Hundt et al. (2012), [17] we find that infants delivered through caesarean section had an increased risk of related instability and dislocations. According to Lord and Skopelja (2011), the most common risk factor among our sample was C-section delivery (52.2%; 14).

Sutton (2003) has discovered that infants delivered through caesarean section had

an increased risk of dislocations and related instability [18].

However, Sutton (2003) found that a history of oligohydramnios was the second most common risk factor, behind a familial history [18].

However, Dante et al. [19] found that a family history of the condition was the most common risk factor, followed by oligohydramnios.

Note that oligohydramnios raises the risk of DDH by a factor of four, most likely as a result of the same processes. In comparison to patients without a family history, those with a positive family history are 12 times more likely to develop DDH. Infants with a positive family history of DDH have been proven to have a higher chance of developing the disorder. Primiparity, oligohydramnios, postmaturity, and a high birth weight have all been identified as risk factors for DDH [20].

Fifty people were scanned, and 100 hips were analysed using ultrasonography. Thirty percent of hips tested by ultrasonography exhibited signs of DDH, while the other seventy percent were normal. Right-sided ultrasound examination suggested DDH in 13% of the cases analysed, whereas left-sided ultrasound examination suggested DDH in 17% of the cases. Only 10% of the instances showed positive outcomes on both sides.

16 percent of the right hips in the study group had Graf type-II, according to Abdullah and Zytoon (2015).

Hip dysplasia, when unilateral (as in 80% of cases), is up to four times more likely to harm the left than the right hip [13]. This explains why 7% of the left hips in the study group had Graf type II (left hip more impacted than right hip). Adduction of the left hip is more prevalent because the left side of the foetus is closer to the mother's sacrum while in the more common foetal posture (left occiput-anterior) [21].

Consistent with the findings of Guille et al. (2000), who found that the left side is involved in 60% of children, the right side in 20%, and 20% had bilateral involvement [22], the current investigation showed that the left hip was impacted more than the right hip.

Sixty percent of babies, according to one research [23], have hip dysplasia, with the left hip being more typically afflicted than the right.

Seventy-four percent of the right hips and 66 percent of the left hips were categorised as Graf type I (normal) according to the Graf classification system. The percentage of right hips with Graf type II DDH suspicion was 22%, whereas the percentage of left hips was 30%. Graf type III DDH was found in 4% of the tested individuals.

Our results on the asymmetry between the sexes in the distribution of Graf Types in the hips are consistent with those of Amer et al. (2021). Graf type I was seen in 26 individuals, or 52% of the total, for the right hip. Twenty-two individuals, or 44% of the total, were found to have Graf type II. Only 4% of patients had Graf type III. These two individuals account for the whole percentage. Fifty percent of left hip cases were classified as Graf type I, which was seen in 25 individuals. Twenty-three individuals, or 46% of the total, had Graf type II. Only 4% of instances (two people) [12] were found to have Graf type III.

Abdullah and Zytoon (2015) corroborated our findings when they reported that Graf type degree Ia was the most common degree in both hips, followed by IIa in the right hip and IIb in the left hip, respectively [13].

The average value of the right hip alpha angle was 59.26.5 degrees across the study population. However, the average alpha angle at the left hip was 58.36.7 degrees. The average beta angle on the right hip of the study population was 48.9 8.2 degrees. The average beta angle for the left hip was 52 degrees, plus or minus 10 degrees.

Amer et al. (2021) discovered that the mean alpha angle for the right hip was 60.047.71 degrees and the left hip was 57.427.30 degrees, while the mean beta angle for the right hip was 56.0810.51 degrees and the left hip was 58.249.95 degrees [12].

Consistent with our results, Abdullah and Zytoon (2015) found that the right hip had a higher mean value of Alpha than the left hip, but the left hip had a higher mean value of Beta. For the right hip, the average Alpha angle was 64.9% (SD = 8.19), with a range of -42% to 83%. The average angle of the left hip was 62.41 degrees (standard deviation = 6.63 degrees), with a range of 47 degrees to 80 degrees. Right hip Beta angles ranged from 20 degrees to 71 degrees, with a mean value of 36.34 degrees (SD = 13.14). Left hip Beta angles averaged 41.45 degrees (SD = 15.78) [13], with a range of 18.

After a period of follow-up, the ultrasonography findings were compared to the definitive diagnosis of DDH, and the results were classified as either true positive, false positive, true negative, or false negative (NPV). The positive predictive value of the ultrasonography findings was 80.69 percent, and the negative predictive value was also quite high at 100 percent. High accuracy

(92%) and high area under curve (AUC=0.949) for diagnosis of DDH were found in the present research employing hip ultrasonography for discriminating of DDH from normal outcomes.

Clinical evaluation and hip ultrasound were performed on 3,541 newborns as part of a research by Swarup et al. (2018). When compared to ultrasonography, clinical examination has a sensitivity of 97% and a specificity of 13.68% [24].

DDH is more common because Amer et al. (2021) focus on high-risk newborns [12].

Due to the normal physiologic laxity that resolves spontaneously by 6 weeks of age, ultrasound screening should not be performed before 3-4 weeks of age in infants with clinical signs or risk factors for DDH [25]. The American Institute of Ultrasound in Medicine reported that screening all newborns with ultrasonography led to a high rate of reexaminations.

According to Omeroglu (2014), hip ultrasonography is the gold standard for diagnosing DDH in infants. Furthermore, the incidence of DDH patients that are discovered late and surgically treated has dropped significantly thanks to either universal or selective ultrasonographic neonatal hip screening programmes [26].

Possible causes of DDH based on the characteristics investigated reveal that a positive family history (p=0.007), oligohydramnios (p=0.003), and caesarean section (p=0.008) are all related with an elevated risk of DDH.

Oligohydramnios was studied by Manoukian et al. (2019) to see whether it could be considered a risk factor for DDH. According to their findings, oligohydramnios has been linked to an increased risk of DDH [OR = 3.9, 95 percent confidence interval (CI): 2.1-7]. .3] [20].

The cost of care rises when diagnosis and treatment are delayed, leading to undesirable consequences. Additionally, complete hip arthroplasty may be required if coxarthrosis progresses. The therapy for this problem takes far longer than necessary, and the resulting workforce loss is substantial. Surgical intervention may be avoided or at least delayed with early diagnosis and conservative therapy [27].

This is why several nations have made hip ultrasonography part of their national screening programmes and health policies. Performing regular hip examinations on newborns, identifying high-risk and clinically-suspected groups, and starting appropriate therapy as soon as possible are all goals of the national early diagnostic and treatment programme for DDH in the United States [6, 28].

5. Final Thoughts

Neonatal hip examination with ultrasound is a reliable technique. It is a reliable method for identifying DDH, including information on the hip's anatomy, femoral head position, and stability. Quantitative grading of DDH severity is possible with the use of the Graf classification and angle measurements. Ultrasound is clearly reliable as a diagnostic tool due to its excellent predictive values and ability to accurately distinguish abnormal situations. Risk factors may be identified, which helps with early intervention. In the end, ultrasonography is a major factor in bettering neonatal hip I outcomes.ssues.

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