Radiological screening for DDH among risky infants in Abha Maternity & Children Hospital from 2019-2021

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Abstract

Background: Developmental Dysplasia of the Hip (DDH) is the most common musculoskeletal condition diagnosed in neonates. Different timings and approaches to screening for DDH are used in the orthopedic community.

Objectives: To provide evidence that DDH can be screened using sonarograph at the age of 2 months to decrease the risk of misdiagnosed DDH and determine the most common method of treatment regarding the radiological screening the infants underwent.

Methods: This is a retrospective observational study that targeted all infants at risk of DDH who were born between 01-01-2019 to 31-12-2020 at Abha Maternity and Children Hospital (AMCH), Abha, Saudi Arabia. Included in the study were newborns who underwent radiological screening for hip with known risk factors for DDH. Demographic and clinical data were collected from the hospital electronic system. These data included subjects' age and sex, documented ultrasonography screening, documented X-ray diagnosis of DDH, and type of treatment.

Results: A total of 201 infants (101 female, 100 male) aged from one day to six months (mean age 51.46 days, standard deviation 19.21 days) were included in the study. Ultrasonography screening revealed 40 subjects (19.9%) with positive DDH findings. X-rays done at age 4 to 6 months confirmed 26 (12.9%) DDH cases. Ultrasonography correctly detected 24 (11.9%) and excluded 159 (79.1) patients with DDH. However, two cases (1.0%) were not detected by ultrasonography and were later detected by X-ray, and 16 cases (8.0%) were falsely detected as positive DDH.

Twenty-five subjects (12.4%) were treated conservatively, and one subject (0.5%) was treated surgically. Twenty-four cases of DDH showed hip abnormalities on ultrasound, giving a sensitivity rate of 92%. On the other side, 159 subjects who did not have DDH were screened negative with ultrasound (specificity rate 91%).

Conclusions: The present study reveals that early US screening for DDH has high sensitivity and specificity and was associated with a lower rate of invasive intervention. Further research is needed to confirm these findings and examine potential factors influencing the accuracy of US-based screening programs in Saudi Arabia.

Keywords: DDH; Ultrasound; Radiological screening

Introduction

Developmental dysplasia of the hip (DDH) represents a spectrum of hip joint disorders, ranging from hip dysplasia to irreducible hip dislocation, in which some can spontaneously resolve or deteriorate. There is no accepted gold standard in the diagnosis of early DDH [1].

Risk factors for DDH that may prompt targeted screening include breech presentation, female gender, first degree relative with DDH, metatarsus adducts, congenital torticollis, talipes, high birthweight and oligohydramnios, also there are racial differences in the incidence [2].

The potential spontaneous resolution and impreciseness of the diagnosis of DDH makes the assessment of screening in DDH difficult to evaluate accurately. Pathological DDH is more common in females (75%) and on the left side. The rate of unilateral irreducible hip dislocation in the UK is in the order of 0.5-1.00 per 1000 live births. The inheritance of DDH is considered polygenetic and multifactorial. In England and Wales, screening traditionally followed the recommendations of the Standing Medical Advisory Committee (SMAC), originally introduced in 1969 and updated in 1986. This was superseded by the 2008 policy of the NHS Newborn and Infant Physical Examination (NIPE) programmed, in which selective 'at risk' screening was added to the existing universal neonatal and general practitioner clinical hip screening guidelines. The NIPE programme recommends that a strong family history or breech presentation is an important risk factor in the development of DDH. Presently, those with 'true' risk factors of a strong family history of pathological DDH or those born by breech presentation should be screened sonographically [1].

Different timing and approaches to screening for developmental dysplasia of the hip (DDH) are used in the orthopaedic community. Thus, ultrasonographic screening programs and reports based on clinical examinations produced differing incidence rates of DDH. Furthermore, different risk factors and a change of incidence of DDH in the last decades were discussed [3].

Developmental dysplasia of the hip (DDH) is one of the most frequent congenital abnormalities in newborns [4,5]. In the screening of infants for developmental dysplasia of the hip (DDH), clinical examination and hip ultrasonography are the two most frequently used methods. Because clinical evaluations can differ between examiners and because plain radiographs can give inaccurate measurements of the hip joint in the first three months, the use of hip ultrasonography has become widespread in the early diagnosis and treatment of DDH. Advantages of ultrasonography are that it is noninvasive, does not involve radiation and it is easy to use [6].

One of the previous studies shows that the sonographic signs of developmental dysplasia of the hip were found in 0.24 % of the newborns. A significant negative influence of the risk factors birth weight, family history of DDH, and female gender on the α-angle was found. Early or preterm delivery showed a protective potential for DDH [3].

In our study, we tried to provide evidence that DDH can be screened using sonarograph at the age of 2 months to decrease the risk of misdiagnosed DDH; and count the number of at risk infants who are undergoing ultrasound of the hip to determine the most frequent method of radiological screening that the infants underwent.

Materials and Methods

Subjects:
This is a retrospective observational study that targeted all infants at risk of DDH who were born between January 1, 2019 to December 31, 2020 at Abha Maternity and Children Hospital (AMCH), Abha, Saudi Arabia. During this period, a total of 7,573 babies were born in 2019 and 6,931 newborns in 2020. The inclusion criteria applied to 201(1.38%) of total newborns in the study period.

Inclusion and exclusion criteria:
Included in the study were newborns who underwent radiological screening for hip with known risk factors for DDH, i.e., breech presentation, first degree relative with DDH, metatarsus adductus, congenital torticollis, talipes, high birth weight, and oligohydramnios. Newborns who did not meet one or more of these criteria were excluded from the study.

Data collection and management:
Demographic and clinical data were collected from the hospital electronic system. These data included subjects' age and sex, documented ultrasonography screening, documented X-ray diagnosis of DDH, and type of treatment. Graf method ultrasound examination was conducted and reported for all subjects. It is the standard screening technique in the study age group (below 6 months). The radiologists' conclusion of whether a case is positive or negative for DDH was obtained. According to the radiology department protocol in the hospital, ultrasound positivity was noted if α angle was < 55°. X-ray positivity was defined as an acetabular index of >25 associated with Hilgenreiner line, large distance between the neck of the femur and acetabulum, and Perkin line. Positive cases on ultrasound were referred for confirmation by X-rays and fixed abduction brace for confirmed cases. Follow-up every 1.5 months was offered to all confirmed cases. In case of irreducible high dislocation of hip, closed reduction with arthrogram was done according to the hospital protocol. Data were entered using an Excel sheet and then analyzed using the Statistical Package for the Social Sciences (SPSS version 25).

Statistical analysis:
Analyzed data included descriptive (frequency, percentage, mean, and standard deviation) and comparative statistics ($\chi 2$ test). The number of test-positive and test-negative newborns were calculated and used to calculate the accuracy, sensitivity, specificity, positive predictive value, and negative predictive value. P-value <0.01 was set to indicate statistical significance.

Results

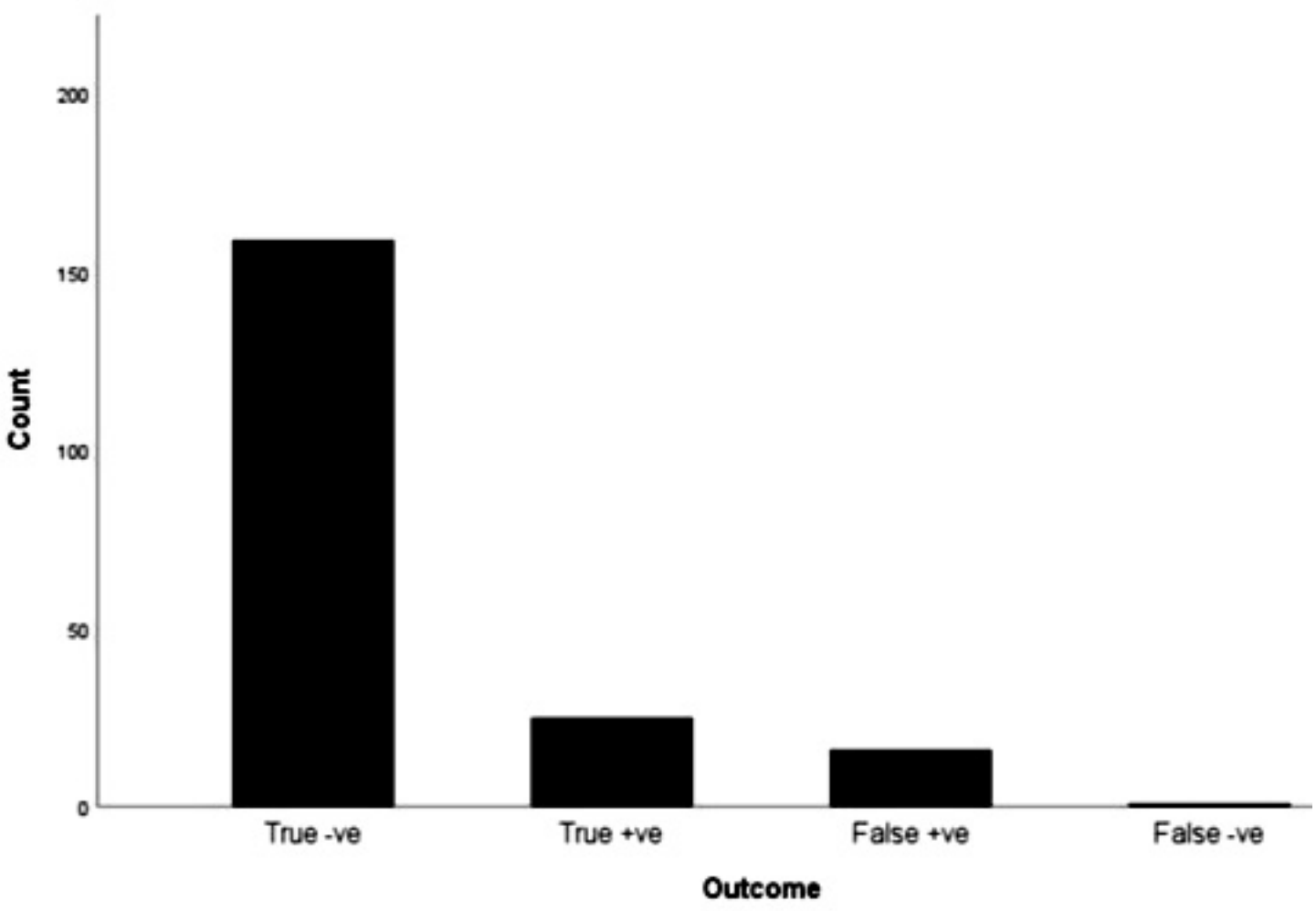
A total of 201 infants (101 female, 100 male) aged from one day to six months (mean age 51.46 days, standard deviation 19.21 days) were included in the study. Ultrasonography screening revealed 40 subjects (19.9%) with positive DDH findings. X-ray done at age 4 to 6 months confirmed 26 (12.9%) DDH cases. Descriptive statistics of the study variables are shown in Table 1.

Table 1. Descriptive statistics of the study variables (n = 201)

Characteristics	Frequency	Percent
Mean age in days, Mean (SD)	51.46 (19.21)	
Sex		
Female	101	50.2
Male	100	49.8
Ultrasonography		
Positive	40	19.9
Negative	161	80.1
X-ray at age 4-6 months		
Positive	26	12.9
Negative	175	87.1
Method of treatment		
None	175	87.1
Brace	25	12.4
Open reduction + pelvic osteotomy + shortening of femur	1	.5
DDH diagnosis		
True negative	159	79.1
False negative	2	1.0
True positive	24	11.9
False positive	16	8.0
SD: Standard deviation; DDH: developmental dysplasia of the hip.		

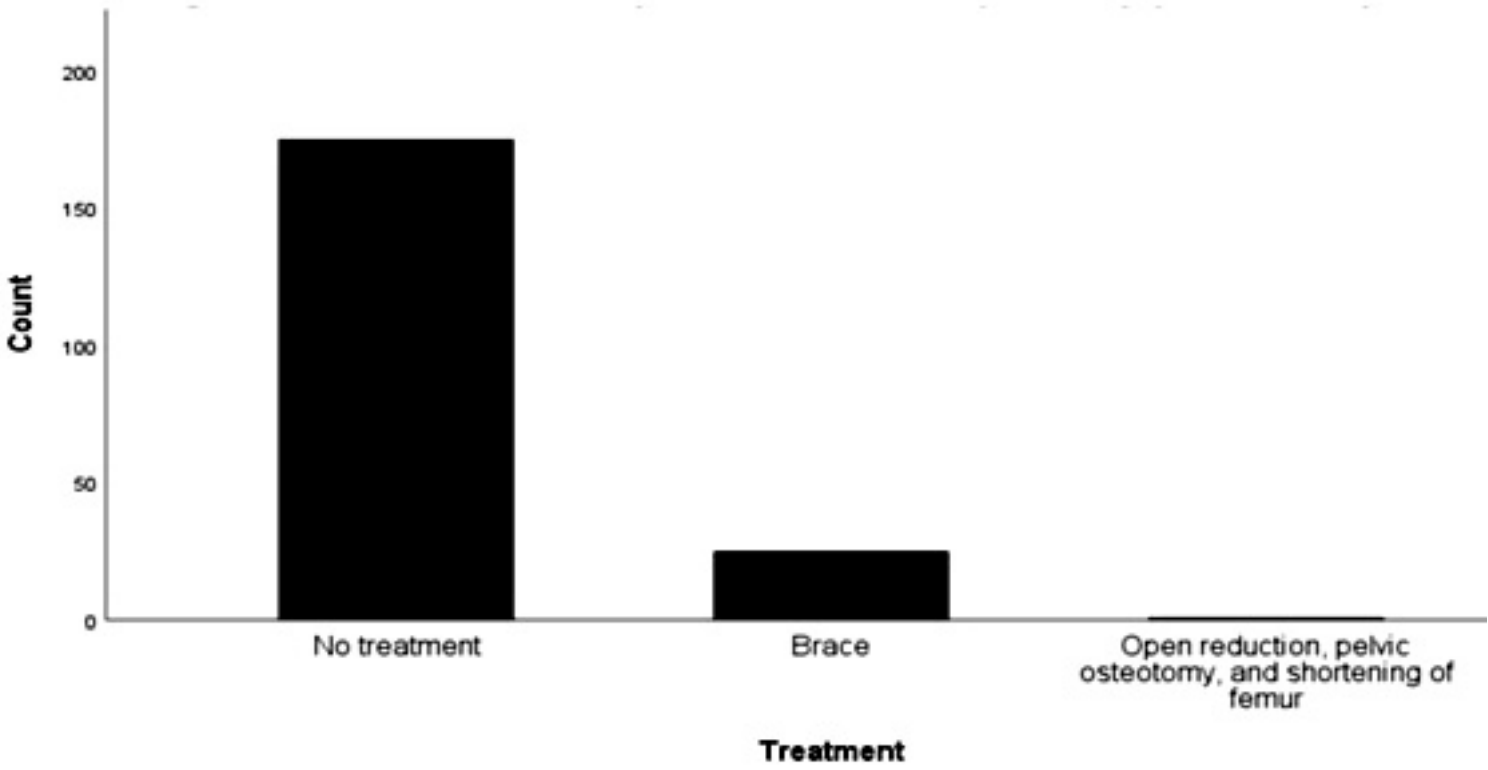
Ultrasonography correctly detected 24 (11.9%) and excluded 159 (79.1) patients with DDH. However, two cases (1.0%) were not detected by ultrasonography and later detected by X-ray, and 16 cases (8.0%) were falsely detected as positive DDH (Figure 1).

Figure 1: Outcome of screening for developmental dysplasia of the hip using ultrasonography and X-ray at age 4 to 6 months



Twenty-five subjects (12.4%) were treated conservatively, and one subject (0.5%) was treated surgically (Figure 2).

Figure 2: Method of treatment of true positive cases of developmental dysplasia of the hip.



Twenty-four cases of DDH showed hip abnormalities with ultrasound, giving a sensitivity rate of 92%. On the other side, 159 subjects who did not have DDH were screened negative on ultrasound (specificity rate 91%). The positive predictive value for hip ultrasonography was 60%, meaning that out of the 100 subjects who were screened positive on ultrasound, 60 of them would eventually receive a diagnosis of DDH. Furthermore, out of 100 subjects who were screened negative on ultrasound, 99 of them did not receive DDH diagnosis. The accuracy of ultrasonography to differentiate the patient and healthy cases correctly was 91% (Table 2).

Table 2. Test characteristics for clinical and ultrasound DDH screening

Characteristics	Ultrasonography		
	Positive	Negative	Total
DDH positive	24 (11.9)	2 (1.2)	26 (12.9)
DDH negative	16 (8.0)	159 (79.1)	175 (87.1)
Total	41 (20.4)	160 (79.6)	201 (100.0)
Sensitivity (TP/TP+FN)	24/26 (.92)		
Specificity (TN/TN+FP)	159/175 (.91)		
Positive predictive value (TP/TP+FP)	24/40 (.60)		
Negative predictive value (TN/TN+FN)	159/161 (.99)		
Accuracy (TP+TN/TP+TN+FP+FN)	183/201 (.91)		
DDH: Developmental dysplasia of the hip; TP: true positive; TN: true negative; FP: false positive; FN: false negative.			

The analysis showed a statistical difference in case treatment according to ultrasonography results ($\chi 2=103.779$, $P<.001$). Among subjects who tested positive for DDH on ultrasound, 60.0% were treated non-invasively, meaning that ultrasonography screening was more likely to detect DDH early and lead to earlier management (Table 3).

Table 3. Sonographic results according to treatment type and rate

Ultrasonography results N (%)	Treatment, N (%)			χ2	P
	None	Non-invasive method	Invasive method		
Positive	16 (40.0)	24 (60.0)	0 (0.0)	103.779	.000
Negative	159 (98.8)	1 (0.6)	1 (0.6)		
Non-invasive: brace; invasive: open reduction + pelvic osteotomy + shortening of femur.					

Discussion

This study evaluated the sonographic characteristics and the role of early ultrasound screening for DDH in a cohort of newborns from one maternity hospital in Saudi Arabia. DDH is a relatively common condition affecting 10/1000 newborns and several screening methods exist to facilitate early detection of abnormal hips and timely clinical management. Although US is the most frequently used screening tool for neonates at risk of DDH, there is controversy regarding the optimal method for DDH screening. As discussed by other authors, the timing of screening programs is strikingly variable with some countries screening as early as the first week (e.g., Austria and Switzerland), two to three weeks (e.g., Netherlands), and other countries screening later at four to five weeks (e.g., Germany) [7]. The current study found that 60.0% of newborns who tested positive on US for DDH were referred early and treated noninvasively. Furthermore, 98.8% of newborns with negative US for DDH received no treatment within a 2-year period. These findings are in line with previous research that confirmed the role of US screening in maximizing clinical outcomes of early nonoperative interventions, as early as the first days of life, and reducing the incidence of operative procedures [8–12].

The analysis showed that US screening for DDH had a perfect sensitivity of 92% and all 25 positive cases were confirmed upon subsequent imaging and treated conservatively. These findings agree with what has been shown in previous studies. For example, Lussier et al. examined a large sample of 1,683 newborns in 2016 and found that US had a sensitivity of 100% in newborns screened before the age of 28 days [13]. Similarly, in our study screening before 28 days of age yielded a sensitivity of 100% (1/1), however, this finding was limited by the small sample size.

A total of 16 (8.0%) who screened positive on US failed to be screened positive by X-ray radiography at age 4 to 6 months (specificity 91%). This figure falls in the range of US specificity across different screening ages as shown by a 15-year prospective longitudinal observational study, where the specificity of US screening for DDH was 99.8%, 90.0%, 97.3% at 28 days, less than 28 days, and 28 days, respectively [14]. Despite early screening for DDH being a prerequisite for preventing invasive surgical correction of dislocated hips discovered at late stages, studies have shown that US screening in the first 6 weeks tends to be highly sensitive and may lead to overdiagnosis [15]. The number of misdiagnosed cases of DDH doubled in cases screened within 4 weeks of life [16]. Hip immaturity is thought to affect the sensitivity and specificity of US screening before 4 weeks owing to interrater variability [16,17].

Clinicians are yet to reach a consensus on the timing of screening for DDH. Early screening has an excellent sensitivity but may increase the cost of frequent follow-up visits, while late diagnosis risks rapid progression of the disease and is considered cost-effective. However, a good body of evidence suggests that early screening is preferable. After 8 to 12 weeks of age, dislocation of the femoral head results in anatomical changes that are likely to consolidate, making it difficult to reduce the femoral head within the acetabular cavity by non-surgical treatment [12]. Furthermore, late treatment is associated with a high risk of adult osteoarthritis due to residual anatomical changes in the acetabulum [18].

In this study, surgery (open reduction, pelvic osteotomy, and shortening of the femur) was done in one case which was screened negative by US at age 2 months and treated late after 6 months. Despite the limitation of the small sample size, these data further support the current practice of early screening of newborns at high risk for DDH (breech, twins, family history). Moreover, even with programs that aim at early screening of at-risk newborns, recent research over the past 10 years shows that selective screening has not significantly reduced late diagnosis and subsequent surgical correction of complicated DDH [12]. Studies conducted in countries that have pioneered "universal" US screening programs, such as Austria, reported a significant reduction in late diagnosis of DDH and a 46% [19] to 52% [20] reduction in surgical correction. Parent adherence to a universal screening program after one month is expected [13].

Strengths and Limitations:

The current study has several strengths as it is among the few studies in Saudi Arabia examining the role of US screening for DDH in infants at risk. The study included all newborns from 2019 to 2020. However, several limitations exist and may reduce the generalizability of our findings.

First, the relatively small sample size should be taken into consideration and conclusions should be made cautiously. Second, the statistical analysis consisted mainly of descriptive tests. Therefore, no inferences could be made from the current data. Third, the retrospective nature of the study, along with relying on electronic files for data collection, hampered the collection of demographic and clinical risk factors for DDH in this sample. Therefore, we could not model the statistical analysis into a regression analysis controlling for confounding factors. The study still has the potential to inspire local future research and a randomized controlled design is necessary to confirm our findings.

Conclusion

The present study reveals that early US screening for DDH has high sensitivity and specificity and was associated with a lower rate of invasive intervention. We believe that DDH screening program should be mandatory, either with ultrasound at the age of 2 months or with X-ray at the age of 4 months, which is the most accurate method, and will diagnose DDH patients early with less cost. Further research is needed to confirm these findings and examine potential factors influencing the accuracy of Early Radiological-based screening programs in Saudi Arabia.

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