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ORIGINAL RESEARCH

Incidence and Associated Risk Factors of Neonatal Developmental Dysplasia of the Hip in Saudi Arabia: A Retrospective Cohort Study

Jamal Sayed[1], Ihdaa Jamal Abdulwahab[2], Banan Bakheet Aldaadi[1], Ayman Eltahan[1], Noha Ahmed Alzahrani[2], Abdullah Jameel Aburiziza[3], Ghaida Ali Mubarak Alzahrani[4]

[1]Security Forces Hospital, Makkah, Saudi Arabia; [2]Ministry of National Guard Health Affairs, Jeddah, Saudi Arabia; [3]Faculty of Medicine, Umm Al Qura University, Makkah, Saudi Arabia; [4]Ibn Sina National College for Medical Studies, Jeddah, Saudi Arabia

Correspondence: Jamal Sayed, Security Forces Hospital, Mohammed Salih Jamal Street (PO-Box 16415), Makkah, 24342, Saudi Arabia, Tel +966555265633, Email drjamal@hotmail.com

Purpose: Developmental dysplasia of the hip (DDH) is a malformation of the hip joint that can lead to subluxation or dislocation. Early diagnosis is crucial for effective non-surgical management. The reported prevalence of DDH varies across studies.

Objective: To determine the cumulative incidence of DDH based on clinical examination and diagnostic ultrasonography and to identify associated risk factors.

Patients and Methods: Between January 2020 and June 2023, 279 ultrasound studies were retrieved from the Security Forces Hospital in Makkah, Saudi Arabia. From the patients' files, we identified risk factors for DDH, including prematurity, gender, breech presentation, mode of delivery, and family history using the Chi-square test and odds ratios (OR).

Results: After excluding two cases with chromosomal abnormalities, the final cohort included 277 neonates (60.6% female) and 39.4% males. A positive family history was present in 5%, and 31.5% had a breech presentation. The Ortolani and Barlow tests indicated a DDH incidence of 8.05 per 1000 live births, while selective ultrasound confirmed an incidence of 2.13 per 1000 live births. Prematurity was significantly associated with DDH (P = 0.046), and breech presentation increased the risk approximately fourfold, OR = 3.95, P = 0.016.

Conclusion: DDH incidence in Makkah aligns with global averages. Prematurity significantly increases DDH risk, and breech presentation increases the risk by approximately four times.

Keywords: Saudi Arabia, developmental hip dysplasia, prevalence, family history, prematurity, Breech, cesarean section

Introduction

Developmental hip dysplasia (DDH) is an abnormal hip joint development that results in an abnormal relationship between the femoral head and acetabulum, including dysplasia, subluxation, or dislocation.[1] A diagnosis is usually made after birth, and a newborn onset of manifestations is common. The clinical presentation of DDH is variable and affected by several factors including infant age, severity, location, and duration of the condition.[2] The continuation of DDH into adulthood can cause abnormal walking gait patterns and a higher risk for osteoarthritis in the hip and knee joint.[3] Early diagnosis allows for improvement in DDH without surgical interventions. One of the common conservative management options is the Pavlik harness, which has a 97% success rate in early cases.[4] Late-diagnosed cases may necessitate invasive surgical treatments, with an increasing risk of complications such as avascular necrosis.[4,5]

The exact prevalence of DDH is still unclear, with different estimates in the literature. A previous meta-analysis in 2022 reported that the incidence rate of newborn infants with DDH was 8.4 per 1000 live births based on clinical screening, and 4.4 per 1000 newborns for whom ultrasonographic screening was done.[6] In Saudi Arabia, a recently published retrospective analysis reported that the incidence of DDH was 11.58 per 1000 live births.[7] The prevalence of DDH is attributed to many risk factors such as positive family history, breech presentation, female gender, firstborn status, the left side of the hip, mode of delivery, and oligohydramnios.[8,9]

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There is conflict regarding whether all newborns should undergo universal or selective ultrasound screening for infants with clinical hip instability or established DDH risk factors.[10] The recommended newborn screening method for DDH in the United States is selective ultrasound instead of universal screening due to a lack of evidence to reduce late diagnoses.[11] Besides, cost-effectiveness analyses do not support universal screening. Recent evidence revealed that universal ultrasonographic screening leads to higher initial detection rates but does not reduce late detection or operative treatment rates compared to selective or clinical screening.[6] In line with the American Academy of Pediatrics (AAP) guidelines, the Saudi Clinical Preventive Guidelines suggest the application of Barlow and Ortolani maneuvers to all newborns to detect DDH.[12] As a result, this study is designed to investigate DDH incidence using both clinical exams and diagnostic ultrasonography. The objective is to identify the common risk factors associated with the disease.

Materials and Methods

Study Design and Setting

A single-centre retrospective cohort study was conducted at the Security Forces Hospital in Makkah, Saudi Arabia, between January 2020 and June 2023.

Case Definition and Procedure

In our hospital, we follow the American Academy of Pediatrics (AAP) guidelines for DDH screening.[12] Based on these guidelines, the clinical examination of the hips involves several key points: A) The child should be evaluated in a spontaneous posture to detect any observable abnormalities. B) The paediatrician focuses on any notable leg length discrepancies, especially in thigh length (Galeazzi sign). C) Then the pelvic range of motion is evaluated for any limitation, especially in thigh abduction. D) After that, they perform the Ortolani maneuver, followed by the Barlow maneuver.

Clinically positive cases or cases with a history of any associated risk factors as defined in published literature were eligible for ultrasound confirmation by board-certified radiologists. Risk factors that were taken into consideration included pre-maturity (gestational age less than 37 weeks), gender, breech presentation, mode of delivery, and family history.[13,14] The ultrasound examination was performed within the age range of six weeks to six months. Early detected cases were defined as newborns who had a positive ultrasound before the age of three months, while late detected cases were newborns with a positive ultrasound after the age of three months. After the clinical examination and ultrasound confirmation, positive cases were referred to orthopedic surgeons for reassessment and to choose the most appropriate treatment options.

Pavlik harnesses are recommended for infants aged six weeks to six months. Moreover, treatment options are at the discretion of a pediatric orthopedic surgeon.

The Procedure of Clinical Examination and Ultrasound Screening

All newborns underwent a clinical hip examination to assess for developmental dysplasia of the hip (DDH). The examination was performed by pediatricians using the Barlow and Ortolani maneuvers.

- **If Barlow/Ortolani negative**: Newborns were discharged without further examination.
- **If Barlow/Ortolani positive**: Newborns were referred to a "One-stop" orthopedic clinic for further clinical examination and an ultrasound hip scan. The ultrasound was performed by four senior registrar radiologists.
  - **If normal**: Newborns were discharged.
  - **If abnormal**: Newborns received treatment if pathological DDH was diagnosed.

Screening for At-Risk Hips

For infants with identified risk factors (eg, breech presentation, family history of DDH), hip ultrasound was performed by 6 weeks of age.

- **If normal**: Newborns were discharged.
- **If abnormal**: Newborns received treatment if pathological DDH was diagnosed.

General Practitioner (GP) Clinical Examination

A second clinical hip assessment was performed by a GP at 6–8 weeks of age.

- **If normal**: Newborns were discharged.
- **If abnormal**: Newborns were referred to Pediatric Orthopaedics.

Ultrasound Confirmation Criteria for DDH

Ultrasound confirmation of DDH was based on the following criteria:

1. **Graf Alpha Angle (α-angle):**

   - **Normal**: ≥60°
   - **Borderline/Dysplastic**: 50–59°
   - **Severely Dysplastic**: <50°

2. **Femoral Head Coverage (FHC):**

   - **Normal**: ≥50%
   - **Borderline**: 40–49%
   - **Abnormal**: <40%

Graf Classification:

Based on the alpha angle and hip morphology:

Timing of Ultrasound Examination

Ultrasound examination was performed between 6 weeks and 3 months of age. Of the 68 newborns identified with suspected DDH through clinical examination, only 18 cases were confirmed by ultrasound to have DDH. Of these, 17 were diagnosed before 3 months of age, and one case was diagnosed after 3 months.

Screening Based on Risk Factors vs Clinical Examination Findings

Ultrasound screening was performed based on either risk factors or clinical examination findings:

- **Risk factors (eg, breech presentation, family history**): 211 cases (75.6% of the total cohort) underwent ultrasound.
- **Clinical examination findings (positive Barlow/Ortolani tests**): 68 cases (24.4% of the total cohort) underwent ultrasound.

Graf Type	Alpha Angle (α)	Description
Type I	≥60°	Normal hip
Type IIa	50–59°	Physiological immaturity (<3 months)
Type IIb	50–59°	Persistent dysplasia (>3 months)
Type III	<50°	Subluxated hip (poor femoral head coverage)
Type IV	<43°	Dislocated hip (no femoral head coverage)

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Eligibility Criteria and Data Collection

In our retrospective analysis, we included the ultrasound studies and clinical records for children who have the following criteria: A) Saudi. B) Born in our hospital between January 2020 and June 2023. C) Clinical suspension of DDH.

We excluded any cases with chromosomal abnormalities.

During the study period, 279 ultrasound studies were retrieved from the hospital's Picture Archiving and Communication System (PACS). Patient files were reviewed to retrieve the clinical assessments and identify risk factors for DDH, including gestational age (less than 37 weeks), gender, breech presentation, mode of delivery, and family history. Two patients were excluded from the study due to chromosomal abnormalities (Chondroplasia punctata and Noonan syndrome). The researcher conducted a follow-up of the cases with four infants referred to another hospital; three showed improvement while one infant did not respond to treatment.

Ethical Consideration

Ethical clearance for this research was obtained from the Ethical Review Committee of the Security Forces Hospital Program in the Holy Capital. The Ethical Review Board number is [IRB: 0620-240823], and approval was granted on December 10, 2024. As this was a retrospective study, informed consent from parents or legal guardians was not required, as the data were collected from their medical charts after discharge from the healthcare institutions. The study adhered to the principles outlined in the Declaration of Helsinki.

Statistical Analysis

IBM SPSS for Windows, version 29, was used for the analysis. Categorical variables are presented as frequencies and percentages. The chi-square test and Fisher's exact test were used to study the association between having DDH and other variables. Multiple logistic regression was used to study possible risk factors affecting the occurrence of DDH. Statistical significance was defined as a P-value of 0.05 or less.

Results

A total of 279 hip ultrasound studies were collected from our institute in Makkah, Saudi Arabia, during the study period. The majority of our included cases were female 169 (60.6%). Nearly 5% of the cases have a positive family history of DDH. Breech presentation was observed in 88 (31.5%) cases. Ultrasound confirmed the presence of DDH in 18 cases; 17 were diagnosed early before three months of age, and one was diagnosed late after three months of age. Joint affection was bilateral in 11 cases, left-sided in 6 cases, and right-sided in one case. Based on clinical examination a total of 68 (24.4%) were found to have positive Barlow and Ortolani Maneuvers. Twelve cases improved with the Pavlik harness, one failed with the Pavlik harness, one improved with surgical treatment, while two cases were referred to another hospital and two cases were lost to follow-up Table 1.

Table 1 Characteristics of the Study Sample (N=279)

Variables	N	%
DDH Present		
No	261	93.5%
Yes	18	6.5%
Gender		
Male	110	39.4%
Female	169	60.6%

(*Continued*)

Table 1 (Continued).

Variables	N	%
Side (N=18)		
Left	6	33.3%
Right	1	5.6%
Bilateral	11	61.1%
Barlow and Ortolani Maneuvers		
Negative	211	75.6%
Positive	68	24.4%
Gestational age		
Full term	275	98.6%
Preterm	4	1.4%
Mode of delivery		
Spontaneous vaginal delivery	184	65.9%
Cesarean section	95	34.1%
Breech presentation		
No	191	68.5%
Yes	88	31.5%
Family history		
Negative	265	95.0%
Positive	14	5.0%
Treatment (N=18)		
Pelvic harness (Improved)	12	66.7%
Pelvic harness (failed)	1	5.6%
Surgical treatment (improved)	1	5.6%
Referred to other hospital	2	11.1%
No follow up	2	11.1%

Note: Data are represented as frequency and percentage (%).

Associated Risk Factors

We studied the associated risk factors for all cases with clinical suspension of DDH and cases who were confirmed to have DDH by ultrasound (US).

Concerning the US-confirmed cases, there were slightly more females diagnosed with DDH. However, the difference between the DDH group and the normal newborns in gender was not statistically significant to evidence that the female gender is a definite risk factor (p-value = 0.652). The majority of our included cases were born full-term (98.5%) and only four cases were preterm, with none of them having DDH. The breech presentation was much higher in the DDH group, with 50% having breech presentation, while in the normal newborns, only 30% had breech presentation, but this difference did not reach the statically significant limit (p-value = 0.081). Furthermore, the positive family history showed

a trend of being more likely to have DDH, with 11.2% of cases in the DDH group having a positive history, compared to only 4.6% of normal newborns having a positive history (p-value = 0.22). In addition, according to our data, there was no difference in DDH rates between vaginal and cesarean section births Table 2.

Focusing on the clinically positive cases we found similar results. The gender did not differ significantly between both groups, with higher rates of DDH among the females (p-value= 0.60). Interestingly, the rates of CS delivery were higher in the normal group (37%) compared with the DDH group (25%) with a p-value of 0.07. Besides, breech presentation does not appear to be a major risk factor (p-value= 0.61). We found a statistically significant association between gestational age and positive maneuver results; of four preterm cases, three had a positive clinical examination for DDH (p-value = 0.046) Table 3.

Predictive Analysis Model

We performed a univariate and multivariate regression model to study the factors affecting the occurrence of DDH. For the univariate analysis, none of the variables showed a statistically significant association. In the multiple logistic regression model, having breech presentation was associated with higher odds of having DDH (OR=3.95, 95% CI: 1.29–12.07, p-value=0.016) Table 4.

Discussion

During the study period from 2020 to 2023, 8441 live births were recorded. In this regard, 279 infants underwent clinical examination for DDH, of which 68 were clinically positive by Ortolani and Barlow tests, resulting in an incidence rate of 8.05 per 1000 live births. Additionally, the selective US for clinically positive cases confirmed 18 cases of DDH, giving an incidence rate of 2.13 per 1000 live births. The current study findings are consistent with a previous systematic review and meta-analysis on 16,901,079 patients. The meta-analysis reported that the DDH rate was 8.4 per 1000 newborns with clinical screening.[6] Concerning the DDH diagnosed with selective ultrasonographic screening the meta-analysis reported a higher incidence compared with our findings, with an incidence of 4.4 per 1000 newborns. Previous studies reported a similar prevalence of DDH in Saudi. A systematic review from the period 1980–2018 showed that the incidence of DDH was nearly 10.46 per 1000 live births in Saudi Arabia.[8] A more recent study by Almutairi et al[7] reported that the incidence of DDH was 11.58 per 1000 live births. In 2024, another review by Alrashdi et al[15] reported that the prevalence rates of DDH in Saudi were between 3.1 and 4.9 per 1000 births. However, this review is limited by the heterogeneous findings across the published reports in the included studies, as well as discrepancies in the study designs concerning the

Table 2 Association of Different Risk Factors with DDH Presentation

Variables		DDH Present		P-value
		No	Yes	
		N (%)	N (%)	
Gender	Male	102 (39.1%)	8 (44.4%)	0.652
	Female	159 (60.9%)	10 (55.6%)	
Gestational age	Full term	257 (98.5%)	18 (100.0%)	>0.999
	Preterm	4 (1.5%)	0 (0.0%)	
Mode of Delivery	Spontaneous vaginal delivery	171 (65.5%)	13 (72.2%)	0.562
	Cesarean section	90 (34.5%)	5 (27.8%)	
Breech presentation	No	182 (69.7%)	9 (50.0%)	0.081
	Yes	79 (30.3%)	9 (50.0%)	
Family history	Negative	249 (95.4%)	16 (88.9%)	0.226
	Positive	12 (4.6%)	2 (11.1%)	

Table 3 Association of Different Risk Factors with the Result of Barlow and Ortolani Maneuvers

		Barlow and Ortolani Maneuvers				P-value
		Negative		Positive		
		N	%	N	%	
Gender	**Male**	85	40.3%	25	36.8%	0.606
	Female	126	59.7%	43	63.2%	
Gestational age	**Full term**	210	99.5%	65	95.6%	0.046*
	Preterm	1	0.5%	3	4.4%	
Mode of Delivery	**SVD**	133	63.0%	51	75.0%	0.070
	CS	78	37.0%	17	25.0%	
Breech presentation	**No**	146	69.2%	45	66.2%	0.641
	Yes	65	30.8%	23	33.8%	
Family history	**Negative**	199	94.3%	66	97.1%	0.529
	Positive	12	5.7%	2	2.9%	

Note: *Statistically significant at p<0.05.

Table 4 Logistic Regression for the Factors Associated with DDH Presentation

	Univariate Analysis			Multivariable Analysis		
	uOR	P-value	95% CI for OR	aOR	P-value	95% CI for OR
Gender (Female)	0.80	0.653	0.31–2.10	0.78	0.621	0.29–2.08
Mode of Delivery (CS)	0.73	0.563	0.25–2.12	0.41	0.148	0.12–1.38
Breech presentation (Yes)	2.30	0.089	0.88–6.02	3.95	0.016*	1.29–12.07
Family history (Positive)	2.59	0.237	0.53–12.59	3.14	0.176	0.60–16.55

Note: *Statistically significant at p<0.05.
Abbreviations: uOR, Unadjusted odds ratio; aOR, adjusted OR.

diagnosis and management of DDH. We also reported that bilateral affection of the hip joint was commonly observed. Similarly, Ibrahim et al[16] and Alhunaishel et al[2] found that bilateral hip involvement is prevalent in 56.5%.

The disparity in the DDH rates between the clinical examination and the US makes it important to have a precise diagnosis. Clinical examination alone may not be enough to diagnose DDH accurately as it can be missed in asymptomatic infants. Contrarily, ultrasound can give a more detailed image of the joint and assist in early detection and intervention. The disparity in the incidence rate of physical and US examinations may be explained by the fact that neonatal hip instability often resolves itself. It has been well documented in the literature that about 60% of infants who are born with hip instability recover within the first week. Furthermore, 88% of them recover within the first two months.[17] Moreover, some consider mild hip instability and morphologic differences normal developmental variations, while others consider them pathologic.[18] Furthermore, following AAP clinical guidelines, the Ortolani and Barlow tests are recommended for screening DDH, despite their demonstrated low sensitivity (26%) and high specificity (84%).[19] These tests require a well-trained specialist. Specifically, a new type of application integrated with the clinical screening test, the Saccomanni test 3, has been used recently and has recorded a sensitivity of 76% and a specificity of 94% in addition to DDH detection. Moreover, it is worth highlighting that the Saccomanni test exhibits comparable sensitivity (88.8%) and specificity (98.7%) to hip ultrasound, which serves as the gold standard for diagnosis.[20]

In addition to the prevalence of DDH, we studied the associated risk factors related to DDH in Saudi Arabia. We did not observe any significant association between gender, family history, mood of delivery, and breech presentation. The only significant association was observed between gestational age and clinically diagnosed DDH cases. Our predictive model revealed that breech presentation was associated with higher odds of having DDH. Conversely, local studies have highlighted

significant associations between DDH and female gender, delivery mode, and positive family history.[16,21,22] Specifically, one study revealed that first-degree relatives face a 12-fold higher risk of DDH compared to controls.[23] Cultural practices, such as swaddling techniques in Arabic culture, have also been implicated as potential risk factors for DDH.[18] The only significant risk factor for DDH in our study was prematurity (P = 0.046). This is likely because preterm infants have less time to develop in the womb, and their muscles and ligaments are not as strong. Nevertheless, it is evident that the systematic review and meta-analysis published in 2023 came to the conclusion that premature birth does not lead to an increase in the DDH risk, leading to unclear evidence in the literature.[24] Conversely, recent retrospective research also tends to favor the idea that premature delivery may internally strengthen the development of the hips, referring to the complexity of this relationship.[25] Nevertheless, caution must be applied, as our findings might not apply to clinical situations due to the small sample size. However, for cases screened by selective US screening, no statistically significant differences were observed among all risk factors. These results may be explained by the lack of an adequate sample, as ultrasound was performed on only 18 infants.

Limitation

This study had some limitations. First, our data was retrieved from a single institution that does not specialize in pediatric care. Second, we were limited to variables and risk factors available in records, which could be a source of information bias. Third, A long follow-up period is necessary to detect complications that arise late in the treatment process.

Recommendation

Based on the findings of this study, we can suggest and recommend: (1) Promote education and awareness among parents about DDH, especially for preventable risk factors such as swaddling. 2) Developing a workforce with sufficient knowledge and practice of screening and referral is a critical step to preventing long-term health outcomes. Longstanding dysplasia impacts an individual's physical, psychological, occupational, and quality of life, highlighting the importance of prevention. Effective secondary screening by ensuring the screening is done as soon as possible by the primary care physician during scheduled well-child care visits to detect DDH earlier, to refer the child in a timely manner so that DDH can be handled by a multidisciplinary team.

Conclusion

This study found the incidence rate of DDH in Makkah city to be consistent with the global average. Moreover, further studies are needed with a larger sample size, at the national level, to detect true incidence and examine more risk factors. Several questions remain unanswered, such as the impact of swaddling technique and carrying habits as risk factors, and the efficacy of the Saccomanni Test 3 as an innovative screening tool for DDH. In addition, complications can result from late treatment. Therefore, prospective, multicenter studies incorporating these questions are necessary.

Data Sharing Statement

Data available on request.

Ethical Considerations

The study protocol for health records review and data collection was approved by the hospital's Clinical Research Ethics Committee.

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