Original Article
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Medical Journal of the Islamic Republic of Iran (MJIRI)

Med J Islam Repub Iran. 2024 (17 Jun);38.68. https://doi.org/10.47176/mjiri.38.68

Refining Risk Factors for Developmental Dysplasia of the Hip in Neonates: A Cross-Sectional Study in a Tertiary Referral Center

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Received: 27 Dec 2023 Published: 17 Jun 2024

Abstract

Background: Developmental dysplasia of the hip (DDH) is used to describe a spectrum of structural abnormalities that involve the growing hip. Early diagnosis and treatment are critical to providing the best possible functional outcome. This study aimed to evaluate the prevalence of DDH in neonates with and without risk factors and determine the role of ultrasound screening on the initial diagnosis.

Methods: This prospective cross-sectional study was conducted on 399 infants at the Pediatric Treatment Center, Tehran University of Medical Sciences, between December 2015 and June 2016. Infants with suspected DDH who underwent hip ultrasonography were included, and the presence or absence of each risk factor was documented according to the checklist. The ultrasound findings were also registered in the checklists. The odds ratio (OR) of each risk factor for DDH was calculated. The collected data were analyzed by SPSS software version 18 at a 0.05 significance level.

Results: In 16 months of study, 174 (43.6%) male and 225 (56.4%) female infants under the age of 18 months were studied. Risk factors were detected in the medical history of 329 infants. Out of them, 230(57.6%) were firstborn children, 7 (1.75%) had a positive family history of DDH, and 26 (6.5%) had limb anomalies. There was also a history of breech presentation in 16 (4.01%) and a history of oligohydramnios in 21 (5.1%) of infants. The prevalence of DDH was 25.8% in infants with risk factors and 2.8% in those without risk factors. (OR = 11.84, $P < 0.05$).

Conclusion: In this study, the frequency of DDH was significantly higher in infants with risk factors. The female gender and limb anomalies were stronger risk factors for DDH. Overall, ultrasound showed great potential for DDH screening.

Keywords: Developmental dysplasia of the hip, Ultrasound, Screening, Risk factor

Conflicts of Interest: *None declared*
Funding: *None*

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Cite this article as: Kamali Hakim P, Mehdizadeh M, Zeinalkhani F, Karimi Rouzbahani A, Zeinalkhani H, Rajabi H, Ghorani H, Delazar S. Refining Risk Factors for Developmental Dysplasia of the Hip in Neonates: A Cross-Sectional Study in a Tertiary Referral Center. *Med J Islam Repub Iran.* 2024 (17 Jun);38:68. https://doi.org/10.47176/mjiri.38.68

Introduction

Developmental Dysplasia of the Hip (DDH) represents the most common developmental disorder of the musculoskeletal system in infants, encompassing a wide array of hip abnormalities such as acetabular instability, acetabular dysplasia, hip subluxation, and true hip dislocation (1). Additionally, the incidence of DDH varies significantly, ranging from 0.06 per 1000 live births among Africans to 76.1 per

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↑What is "already known" in this topic:
Developmental Dysplasia of the Hip (DDH) is a significant musculoskeletal disorder in infants, recognized for its spectrum ranging from acetabular dysplasia to dislocation. Early detection through screening, particularly using ultrasound, is crucial for effective management, with various risk factors, including gender and familial history impacting prevalence.

→What this article adds:
This study refines the understanding of DDH screening's efficiency, emphasizing the enhanced detection in female infants and those with specific limb anomalies. It challenges the utility of broad-risk-factor screening, advocating for a targeted approach that optimizes resource allocation and potentially improves early diagnostic outcomes.

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[DOI: 10.47176/mjiri.38.68]

1000 in Native Americans. However, the incidence of DDH diagnosed late stands at 1.28 per 1000 newborns, with the majority of these cases being identified between the ages of 1 and 2 years (2, 3). A multitude of risk factors, including fetal breech presentation, female gender, being a firstborn child, swaddling, oligohydramnios, and positive family history, contribute to the incidence of DDH (4, 5). Additionally, congenital anomalies such as metatarsus adductus, clubfoot, calcaneovalgus, and congenital muscular torticollis may be associated with DDH (6).

Given that DDH is asymptomatic in infants and young children, screening plays a critical role in early detection (7). Clinical examination and/or sonography are commonly used for screening DDH. Clinical hip screening consists of Ortolani and Barlow maneuvers (8). Ultrasonography provides both static and dynamic imaging of the hip. Static ultrasonography demonstrates the coverage of the femoral head by the cartilaginous acetabulum, known as α angle, while the dynamic type provides a real-time image of the Ortolani and Barlow maneuvers (7). Graf introduced a method for evaluating hip maturation disorders. In this classification, the α and β angles are measured to determine the type of disorders, which ranges from type I (mature hip) to type IV (dislocated hip) (9). In infants younger than 6 months, conservative management with a Pavlik harness is preferred. Surgical intervention followed by application of a hip spica cast is considered in cases where reduction is not achieved or in late presentations (10)

The current screening program for DDH, adopted by our center and others globally, is recognized as a selective strategy, targeting infants at high risk. However, this approach has drawbacks, as some infants still present with late-diagnosed forms of DDH, often in the absence of known risk factors (11). Recognizing the critical importance of early DDH diagnosis, which may be elusive in infants without risk factors, our study aims to evaluate the prevalence of DDH in neonates, both with and without known risk factors, and to determine the impact of ultrasound screening in the initial diagnosis across different risk groups.

Methods

Study design and participants

This prospective cross-sectional study was conducted at the Pediatric Treatment Center, Tehran University of Medical Sciences, between December 2015 and June 2016. The inclusion criteria were infants younger than 18 months with suspected DDH who were referred for ultrasonography. The patients were excluded if their parents did not consent to participate in the study.

Data Collection and Ultrasonography Examination

After securing written informed consent, we meticulously collected data encompassing birth order, gender, delivery method, family history, and the presence of associated conditions such as clubfoot and torticollis, along with other pertinent physical findings. This collection was facilitated through a comprehensive questionnaire. For the ultrasonography examinations, we employed a 6-8 MHz multi-frequency linear-array probe alongside the Medical C260 (Pie) device, enabling both static and dynamic assessments of hip anatomy. For static evaluation, while the infants were in a supine position with legs being parallel, the probe was placed at the lateral margin of hip joints in the coronal plane, α, and β angles, and the type of DDH was determined. For dynamic evaluation, while knee joints were flexed, posterolateral pressure was exerted on hip joints and the dislocation size of the femoral head was calculated. Dislocation of less than 6 mm was classified as the hypermobile femur (non-pathological) and dislocation of more than 6 mm was classified as complete dislocation if the femoral head was completely out of the acetabular cavity or partial dislocation in case of mild displacement. An α angle less than 60 was considered abnormal.

Data analysis

The collected data were analyzed by SPSS software version 18. Qualitative indexes, including frequency, percentage, mean, and OR, were used to describe the data. The OR for DDH risk factors was calculated. The significance level was set at 0.05 for all statistical tests.

Ethical Considerations

This study was conducted with the permission of the Tehran University of Medical Sciences Ethical Committee by the code of IR.TUMS.CHMC.REC.1397.4972. Written, informed, and voluntary consent was obtained from all parents of participants in the study. The checklists were designed anonymously, and the patients' personal information remained confidential.

Results

Three hundred ninety-nine patients were enrolled in this study. 174 of them (43.6%) were male and 225 (56.4%) were female. The female-to-male ratio was 1.29. The type of birth was normal vaginal delivery in 151 (37.8%) and cesarean section in 248 (62.2%). In terms of fetal history, amniotic fluid levels were normal in 378 infants (94.7%) and oligohydramnios was reported in 21 (5.3%). 230 infants (57.6%) were firstborn child, 131 (32.8%) were second-born, and 38 (9.5%) were third-born or higher. The family history of DDH was positive in 7% of the infants and negative in 371 (93%). The recordings of neonatal examination revealed that 26 (6.5%) had organ abnormalities, 11 had renal abnormalities (2.8%) and 17 (4.3%) had abnormalities in other organs. In total, in 47 of 329 patients (11.8%), a single risk factor. In 121 (30.3%) 2 risk factors, in 136 cases (34.1%) 3 risk factors, and in 25 infants (6.3 %), 4 or more risk factors were observed. Out of 399 infants examined, DDH was confirmed by ultrasound examination in 87 (21.8%) and in the other 312 cases, the ultrasound findings were normal. Out of 87 cases diagnosed with DDH, 52 had bilateral involvement, 23 (5.8%) on the left side, and 12 (3%) on the right side. Overall, the prevalence of DDH was 2.8% in infants without any risk factors (2 out of a total of 70 cases) and 25.8% in those with at least one risk factor (85 out of a total of 329 cases). The likelihood of DDH among infants with risk factors was 11.84 times that of those with no risk factors. (95% CI: 2.8-49.3).

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[DOI: 10.47176/mjiri.38.68]

Assessment of Risk Factors

Table 1 presents the distribution and prevalence of Developmental Dysplasia of the Hip (DDH) across various risk factors, evaluating the association of DDH with the presence or absence of these factors and delineating the significance attributed to each. According to the outcomes derived from the Pearson regression analysis, a pronounced correlation was identified linking DDH incidence with factors such as gender, type of delivery, and the presence of organ anomalies. Conversely, no statistically significant relationship was discerned between DDH occurrence and aspects like firstborn status, amniotic fluid volume, familial predisposition, gestational age at birth, and initial presentation.

Ultrasound Findings

Among the 87 infants identified with Developmental Dysplasia of the Hip (DDH), the left hip was implicated in 72 instances, whereas the right hip was involved in 64 cases. Notably, bilateral hip dysplasia was observed in 52 of these infants. The classification of femoral ultrasound findings, spanning Types I to IV, along with their respective subcategories, is detailed in Table 2. A significant proportion of cases, 93.2%, exhibited positive static ultrasound features (Types II, III, IV) in the right hip, a figure that escalated to 96.8% for the left hip. Notably, Type IIa represented the most prevalent category of ultrasound-determined hip involvement.

Table 2. Frequency of ultrasound finding types in the bilateral hips

Type	Frequency (percentage)	
	Left hip	Right hip
I	5 (6.8%)	2 (3.2%)
IIa	40 (54.1%)	35 (55.6%)
IIb	7 (9.5%)	4 (6.3%)
IIc	6 (8.1%)	4 (6.3%)
IId	4 (5.4%)	6 (9.5%)
III	7 (9.5%)	7 (11.1%)
IV	5 (6.8%)	5 (7.9%)
Total	74 (100.0%)	63 (100%)

Discussion

Developmental Dysplasia of the Hip (DDH) represents a dynamic and progressive disorder, necessitating a multidisciplinary management approach (12). The pivotal role of early diagnosis cannot be overstated, as it paves the way for more conservative and effective treatment modalities. Consequently, various screening strategies have been proposed to facilitate early detection. Notably, ultrasound screening has demonstrated high diagnostic accuracy, boasting a sensitivity of 88.5% and a specificity of 96.7% for DDH in newborns (13). This study sought to explore the prevalence of DDH among neonates, examining both those with and without established risk factors and to assess the impact of ultrasound screening in initial diagnosis. Our findings reveal a nuanced understanding of DDH risk associated with each factor, informing the refinement of screening protocols for high-risk infants and potentially streamlining future screening efforts.

A noteworthy aspect of our findings pertains to the relationship between DDH and familial history. With a positive family history present in 7% of all infants and 10.3% of those with DDH, the anticipated correlation with DDH risk (OR: 1.77) fell short of statistical significance. This contrasts with previous studies, which have attributed a higher risk associated with family history (14, 15). Such variance points towards the complex etiology of DDH, suggesting that genetic predisposition, while relevant, may not be the sole factor in DDH development. The genetic intricacies are further illustrated by the differential concordance rates in identical versus dizygous twins, hinting at a polygenic inheritance pattern that contributes to the disorder (16, 17).

Gender disparity in DDH prevalence was evident in our

Table 1. Prevalence, risk estimation and significance of each risk factor in the diagnosis of DDH

Risk factors	Number (percentage)	Prevalence of DDH	DDH risk Estimation (OR)	*P* value
Birth order			0.991	
Firstborn	230 (57.6%)	50 (21.7%)	0.995	0.823
Not firstborn	169 (42.4%)	37 (21.8%)	1.004	
Gender			3.024	
Female	225 (56.4%)	66 (29.3%)	2.032	<0.001
Male	174 (43.6%)	21 (28.3%)	0.672	
Type of delivery			2.083	
Cesarean	248 (62.2%)	65 (35.5%)	1.635	0.006
Vaginal	151 (37.8%)	22 (14.5%)	0.785	
Amniotic fluid			0.836	
Oligohydramnios	21 (5.3%)	4 (21.9%)	0.991	0.751
Normal	378 (94.7%)	83 (19.04%)	1.185	
Family history			1.779	0.162
Positive	28 (7%)	9 (32.14%)	1.047	
Negative	371 (93%)	78 (21.02%)	0.589	
Organ abnormality			2.866	
Presence	26 (6.5%)	11 (42.3%)	1.090	0.009
Absent	373 (93.5%)	76 (20.3%)	0.380	
Birth age			0.739	0.414
Preterm	58 (14.5%)	12 (20.6%)	0.943	
Term	341 (85.5%)	75 (23.8%)	1.276	
Presentation			1.722	0.321
Breech	16 (4%)	5 (31.25%)	1.151	
Cephalic	383 (96%)	82 (21.4%)	0.668	

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[DOI: 10.47176/mjiri.38.68]

cohort, with females showing a marginally higher prevalence than males. This aligns with the broader consensus in the literature, which posits the female gender as a significant risk factor for DDH, presumably due to the influence of female hormones on ligamentous laxity (18-20). Such hormonal effects underscore the biological underpinnings of DDH and highlight the need for gender-specific considerations in screening and management strategies.

In an intriguing departure from prevailing assumptions, our analysis revealed that being the firstborn child serves as a protective factor against DDH. This finding challenges the established notion that DDH risk diminishes with increasing parity (15). We hypothesize that the restricted intrauterine mobility experienced by firstborns due to the yet-to-be-stretched maternal organs may inadvertently reduce the risk of developing DDH (21). This observation invites a reevaluation of the factors contributing to DDH risk and emphasizes the multifaceted nature of its etiology.

The role of breech presentation and the mode of delivery in DDH risk was also scrutinized. Our findings, indicating a lower-than-expected correlation between breech presentation and DDH (OR: 1.72), diverge from previous reports (22-24). This discrepancy may reflect the complex dynamics of fetal positioning and its impact on hip development. Similarly, the debate around the mode of delivery and DDH risk was reignited by our study, which found cesarean delivery to have a minimal impact on DDH risk, challenging both previous research and meta-analyses (25, 26). Likewise, the relationship between preterm birth and DDH remains ambiguous, with our findings indicating no significant association, thus contributing to the ongoing discourse on prematurity and DDH risk (27-29). Such findings underscore the necessity for a nuanced understanding of the interplay between birth practices and DDH risk.

Furthermore, our study did not find a significant correlation between oligohydramnios and DDH, diverging from previous suggestions of its role as a risk factor (30). However, the association between DDH and other limb abnormalities, such as congenital muscular torticollis, was corroborated, aligning with existing literature and underscoring the interconnected nature of musculoskeletal anomalies (20).

The laterality of DDH, with a predominance of left hip involvement observed in our cohort, echoes the findings of previous studies and suggests a potential link to common intrauterine positions. This observation offers valuable insights into the pathophysiological mechanisms underlying DDH and highlights the importance of considering fetal positioning in screening and early intervention strategies (31, 32).

Despite the extensive body of research on DDH, the debate over the optimal approach to screening persists. The divergence between universal screening protocols in Europe and selective screening in North America reflects broader disparities in healthcare policy and resource allocation.(33, 34) Our study lends support to the targeted use of ultrasound screening in infants at high risk, suggesting a more efficient allocation of resources and potentially improved outcomes for those most at risk.

In acknowledging the limitations of our study, including the modest size of our cohort and the absence of long-term follow-up data, we advocate for further research. Larger-scale studies with longitudinal tracking are crucial for refining screening guidelines, enhancing our understanding of DDH, and ultimately improving patient care.

Conclusion

In light of our findings, we strongly advocate for the implementation of targeted hip ultrasound screening protocols for the early detection of developmental dysplasia of the hip (DDH), with a particular emphasis on female infants and those presenting with limb anomalies such as torticollis and clubfoot. This recommendation stems from the discernible impact of these specific risk factors on the prevalence of DDH, underscoring the potential for more efficient and effective screening strategies. However, it is crucial to acknowledge that the inclusion of infants with a broader spectrum of established risk factors did not correspondingly increase the detection rate of DDH in our study. This observation suggests the need for a refined approach to DDH screening, one that balances the benefits of early detection with the practicalities of healthcare resource allocation. Future research should aim to further elucidate the optimal screening criteria, potentially incorporating advanced imaging techniques and genetic markers to enhance the early identification and management of DDH. Through such efforts, we can hope to improve outcomes for affected infants, optimizing both the efficiency of screening programs and the efficacy of subsequent interventions.

Authors' Contributions

P.K.H. and M.M. contributed to the study design. F.Z., H.Z., H.R., and H.G. contributed to the data acquisition and analysis. F.Z., A.K.R., and S.D. contributed to the data interpretation. F.Z. and S.D. drafted or substantially contributed to revising the work. All authors read and approved the manuscript.

Ethical Considerations

This study was conducted with the permission of the Tehran University of Medical Sciences Ethical Committee by the code of IR.TUMS.CHMC.REC.1397.4972.

Acknowledgment

The authors thank all those who contributed to this study.

Conflict of Interests

The authors declare that they have no competing interests.

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[DOI: 10.47176/mjiri.38.68]