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CLINICO-RADIOLOGICAL PROFILE OF DEVELOPMENTAL DYSPLASIA OF HIP (DDH) IN INFANTS ATTENDING A TERTIARY CARE CENTER.

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Abstract

BackgroundDevelopmental Dysplasia of the Hip (DDH) is a widely occurring paediatric musculoskeletal disease whose aetiology is multi-factorial, with a diverse presentation. In developing countries such as India, late diagnosis is still widespread because of the limited screening facilities. This paper set out to characterize the clinico-radiological picture of DDH among the infants who present to a tertiary care unit in central India.

Methods A cross-sectional observational study at the hospital was carried out in 12 months (October 2021-September 2022) involving 50 infants with suspected DDH on the basis of clinical symptoms or risk factors. Clinical examination (Ortolani, Barlow, hip abduction, Galeazzi sign) and imaging (ultrasonography with Graf classification less than 6 months; pelvic radiographs with acetabular index more than 6 months) was done. The analysis of data was performed with the help of descriptive statistics and sensitivity calculations.

ResultsOf the 50 babies, 82% were female, 64% were first-born and 24% were presented with the breech. The most common clinical signs were limited hip abduction (76%), and asymmetric thigh folds (66%). In 60% (unilateral 84, bilateral 16), the left hip was affected. In 68 ultrasonography demonstrated Graf Type III/IV (severe), and radiographs demonstrated acetabular index 30 or more degrees and >40 or more degrees, respectively 88 and 32, respectively. Sensitivity of Barlow manoeuvre 72/2, and that of Ortolani manoeuvre 44/2, was associated with late presentation with irreducible dislocations.

ConclusionIn this context the frequency of late presenting severe DDH is the most common, and clinical manoeuvres (particularly the Ortolani) and complex radiological dysplasia is not well sensitive to diagnosis. To enhance early diagnosis and resulting provision in resource limited areas, targeted ultrasound screening of the infants of the high risk population, compulsory clinical examination and community education are necessary.

Keywords: Developmental Dysplasia of the Hip, DDH, Ortolani manoeuvre, Barlow manoeuvre, Graf classification, acetabular index, late presentation

Introduction

Developmental Dysplasia of the Hip (DDH) is a continuum of morphological defects of hip joint, which may include mild acetabular dysplasia or total dislocation of the head of the femur out of the acetabulum [1]. The term Developmental Dysplasia of the Hip is the current term, having replaced the previous term, Congenital Dislocation of the Hip (CDH), as the pathology may not be present at birth, but may develop or become apparent in infancy and early childhood.[2] DDH is a prevalent musculoskeletal disorder that is experienced by the paediatric population with about 3- 4 cases per 1000 live births worldwide. In India, the reported incidence figures range between 1.0 and 9.2 per 1000 live births in different regions with a higher incidence rate reported in the north of India.[3] DDH aetiology is a multifactorial process, which engages a complicated network of genetic predisposition, hormonal impact, and mechanical factors. Risk factors which are established are female sex, breech presentation, positive family history of DDH, and oligohydramnios, the firstborn, multiple gestation, and improper swaddling practices[2]. Of these, the risk of breech presentation is the highest because about 25-50 percent of patients diagnosed with DDH history of breechdelivery[4]. The disease is unilateral, with the left hip being affected most (64%), whilst the right is affected in about 37%. In girls, the rate of occurrence is 4-6 times more prevalent than in boys and is attributed to the augmented ligamentous slackness caused by maternal relaxin hormone in the female newborns[5].The clinical diagnosis of DDH among the neonates is based in physical examination processes, which are mostly the Ortolani and Barlow manoeuvres. The Ortolani manoeuvre tries to dislocate a dislocated hip with the abduction, whereas the Barlow manoeuvre tries to induce dislocation with the adduction with the posterior force [6].

Other clinical manifestations are asymmetric folds of skin on the thigh, shortening of the limbs and limitation of hip abductor. In spite ofthis however, clinical examination has been identified as having limitations in the sensitivity, especially in milder or subclinical forms of the condition[7]. The screening DDH imaging technique has taken the form of ultrasonography (USG) that can provide direct visualisation of the non-ossified cartilaginous femoral head and acetabulum, and as such is considered the imaging technique of preference in infants under 6 months of age (Smith et al., 2017). The most popular sonographic classification system is the static technique of Graf (measuring alpha (0) and beta (0) angles based on a standard coronal image of the hip and classifying hips between Type I (normal, 0 > 60) and Type IV (complete dislocation, 0 < 43). Femoral head epiphysis ossification after 6 months of age makes ultrasound less accurate, and plain radiographs of the pelvis (AP view) are now the investigative procedure of choice. Radiological evaluation is based on the known reference lines and index such as the Hilgenreiner line, Perkins line, Shenton line, acetabular index, and the Tönnis and International Hip Dysplasia Institute (IHDI) grading scale[7]. The diagnosis and timely intervention are significant factors in outcome determination in DDH. The Pavlik harness is the first-line non-operative management of infants up to 6 months old that has a rated success rate of 7393 per cent when used at the earliest age. Undiagnosed or diagnosed late, DDH causes progressive acetabular insufficiency, abnormal gait, leg-length discrepancy, and the development of osteoarthritis at an early age in adulthood. The residual hip dysplasia is linked with great risk of hip osteoarthritis and could likely require total hip replacement as early as the fourth decade of life[9]. The most feared complication is the avascular necrosis (AVN) of the femoral head, which may occur in untreated individuals, as well as be part of treatment, with incidence being reported over an 6-48 per cent following surgery management of the condition [10]. Although there is improvement in awareness and imaging techniques, late presentation still remains a problem in the developing nations such as India where poor screening facilities, lack of awareness among parents, and socioeconomic factors are some of the reasons that lead to late diagnosis and preventable morbidity. A tertiary care home clinico-radiological study thus presumes significance in the character of local epidemiological and diagnostic character of DDH, to guide screening interventions and patient improve patient outcomes.

Materials &Methods

Study Design and Setting

This was a hospital-based, cross-sectional observational study conducted in the Department of a tertiary care centre in central India, over a period of 12 months from October 2021 to September 2022. written informed consent was taken from the parents or guardians of all enrolled infants prior to inclusion in the study.

Study Population

Inclusion Criteria:

- Infants aged 0 to 12 months presenting to the orthopaedic outpatient department or referred from the paediatrics/neonatology department with suspected DDH
- Infants with clinical signs suggestive of DDH (restricted hip abduction, asymmetric thigh folds, positive Ortolani/Barlow manoeuvre, limb length discrepancy, or Galeazzi sign)
- Infants with one or more established risk factors for DDH (female sex, breech presentation, first-born status, family history of DDH, oligohydramnios, or multiple gestation)
- Infants whose parents/guardians provided written informed consent

Exclusion Criteria:

- Infants with congenital neuromuscular disorders (e.g., arthrogryposis, spina bifida, cerebral palsy) causing secondary hip pathology
- Infants with known skeletal dysplasias or chromosomal anomalies
- Infants who had previously received treatment for DDH (Pavlik harness or surgical intervention)
- Infants whose parents/guardians declined consent
- Incomplete clinical or radiological records

Sample Size

A total of 50 infants fulfilling the inclusion criteria were enrolled using consecutive purposive sampling during the study period of October 2021 to September 2022.

Data Collection

A detailed structured proforma was used to record the following information for each enrolled infant:

- **Demographic data:** Age at presentation, sex, birth order, and mode of delivery (vaginal/Caesarean section)
- **Antenatal and perinatal history:** Breech presentation, oligohydramnios, multiple gestation, and birth weight
- **Family history:** First- or second-degree relative with confirmed DDH
- **Clinical examination findings:** Range of hip abduction measured with a goniometer in the supine position with hips and knees flexed to 90°, presence of Galeazzi sign, asymmetric thigh skin folds, and limb length discrepancy

Clinical Examination Protocol

All infants underwent a standardised hip examination performed by a single experienced orthopaedic surgeon to minimise inter-observer variability.

- **Ortolani Manoeuvre:** With the infant supine and hips flexed to 90°, the examiner gently abducted the hip while applying upward pressure over the greater trochanter. A palpable or audible "clunk" indicating reduction of a dislocated femoral head into the acetabulum was recorded as a positive result.
- **Barlow Manoeuvre:** With the infant supine and hips and knees flexed to 90°, the examiner adducted the hip while applying gentle posterior pressure. Perceived instability or posterior displacement of the femoral head was recorded as a positive result.

- **Galeazzi Sign:** Asymmetry in knee height with the infant supine, hips flexed to 90°, and feet flat on the examination table, was recorded as positive for femoral shortening.
- **Hip Abduction Assessment:** Limitation of passive hip abduction to less than 60° in flexion was considered clinically significant and recorded as a positive finding.

Radiological Assessment

Ultrasonography (USG): All infants aged less than 6 months underwent standardised hip ultrasonography in the lateral decubitus position using a 7.5 MHz linear array transducer, performed by a single trained musculoskeletal radiologist at the tertiary care centre. The Graf static method was employed, wherein the coronal plane image of the hip was obtained and the alpha (α) angle (reflecting bony acetabular coverage) and beta (β) angle (reflecting the cartilaginous roof orientation) were measured. Hips were classified according to the Graf grading system as follows:

Graf Type	Alpha Angle	Interpretation
Type I	> 60°	Normal, mature hip
Type IIa/b	50–59°	Physiological immaturity / mild dysplasia
Type IIc/D	43–49°	Critical dysplasia / decentralising
Type III	< 43°, bony roof displaced superiorly	Eccentric / subluxed
Type IV	< 43°, labrum inverted inferiorly	Frankly dislocated

Plain Radiography (X-ray Pelvis AP View): Infants aged 6 months or older, and those under 6 months in whom radiography was additionally indicated for clinical decision-making, underwent a standardised antero-posterior (AP) radiograph of the pelvis in the supine position with hips in neutral extension and slight internal rotation. The following radiological parameters were measured and recorded:

- **Acetabular Index (AI):** The angle between the Hilgenreiner line and the oblique line drawn from the triradiate cartilage to the superolateral acetabular margin; values > 30° were considered dysplastic
- **Hilgenreiner line, Perkin's line, and Shenton's line** for assessment of femoral head position and continuity
- **Tönnis grading** for degree of proximal femoral displacement where applicable

Outcome Variables

The primary outcome variables were:

1. Frequency and distribution of demographic features, clinical signs, and risk factors
2. Laterality and pattern of hip involvement
3. Radiological severity of DDH by Graf classification (USG) and Acetabular Index (X-ray)
4. Sensitivity of the Barlow and Ortolani manoeuvres against radiological diagnosis as the reference standard

Statistical Analysis

The data were inputted and analysed with the help of IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA). Frequencies and percentages were used to describe categorical variables. Continuous variables were described as the mean SD. Radiological data was used as the reference standard to calculate sensitivity of the Ortolani and Barlow manoeuvres, with the use of radiological findings (Graf Type II34 on USG and/or Acetabular Index 30 or above on X-ray). The p-value of less than 0.05 was assumed to be significant.

Results- The study reveals a distinct clinico-radiological profile characterized by a strong female preponderance (82%) and a high incidence of first-born involvement (64%), as detailed in the Demographic Profile (Table 1). Clinical evaluation remains the primary screening tool, with limited hip abduction and asymmetric thigh folds being the most consistent findings, appearing in 76% and 66% of cases respectively (Table 2). Geographically, the left hip was the most frequently affected site (60%), following the standard literature trend of intrauterine positioning (Table 3).Radiological correlation proved essential for confirming the severity of the condition; while the Graf Classification identified 68% of infants with significant dislocation (Type III/IV), X-ray measurements showed that 32% of the cohort presented with a severe Acetabular Index exceeding >40º (Table 4). Interestingly, while the Barlow maneuver showed a 72% sensitivity for detecting instability, the Ortolani maneuver was positive in only 44% of cases (Table 5), likely due to the late presentation of infants at a tertiary center where many hips had already become fixed and irreducible.

Table 1: Demographic Profile of Infants

Variable	Category	Frequency (n=50)	Percentage (%)
Gender	Female	41	82%
	Male	9	18%
Birth Order	First-born	32	64%
	Subsequent	18	36%
Mode of Delivery	Vaginal	35	70%
	Cesarean Section	15	30%

Table 2: Clinical Presentation and Risk Factors

Clinical Feature / Risk Factor	Present (n)	Percentage (%)
Breech Presentation	12	24%
Family History of DDH	5	10%
Oligohydramnios	8	16%
Limited Hip Abduction	38	76%
Galeazzi Sign (Shortened femur)	14	28%
Asymmetric Thigh Folds	33	66%

Table 3: Laterality and Distribution of Dysplasia

Laterality	Frequency (n=50)	Percentage (%)
Left Hip Only	30	60%
Right Hip Only	12	24%
Bilateral	8	16%

Table 4: Radiological Assessment

Parameter	Finding	Frequency (n=50)	Percentage (%)
Graf Type (USG)	Type I (Normal)	4	8%
	Type II (Physiological/Dysplastic)	12	24%
	Type III/IV (Dislocated)	34	68%
Acetabular Index	<30º (Normal range)	6	12%
(on X-ray)	30º - 40º	28	56%
	>40º	16	32%

Table 5: Correlation of Clinical Tests (Barlow & Ortolani)

Test Performed	Positive Result (n)	Negative Result (n)	Sensitivity in Study
Barlow Maneuver	36	14	72%
Ortolani Maneuver	22	28	44%

Discussion

The current paper includes an elaborate clinico-radiological description of Developmental Dysplasia of the Hip (DDH) among 50 newborns visiting a tertiary care centre. The results are consistent with the literature on the topic in the world and in India, as well as with the peculiarities of late presentation and low rates of structured screening in the Indian setting. It will be discussing the effectiveness of clinical and radiological screening strategies as per the findings of the study.In the current study, 82 percent of the affected infants were females, as is commonly known about DDH; it predominates in females owing to the high levels of ligamentous laxity brought about by the relaxin hormone in female babies. This sex ratio of near 4.5:1 is almost similar to those found in the published literature of 4- 6:1 female-to-male ratios. The first born was found in 64 percent of the cases, which is itself a known risk factor because the uterine musculature of primiparous mothers is relatively tight and has less space to allow the fetus to move around. The proportion of vaginal delivery in the cohort is 70 percent of the births as does breech vaginal delivery, which was found to have a very high risk of DDH with estimates published of DDH in 2-27 percent of all breeches[2,4].Some of the clinical risk factors recorded included limited hip abduction, which was reported to be the most common demarcation in 76% of infants. It is one of the clinical signs of DDH, and it is always noted as one of the most stable physical appearances in the post neonatal period, especially when instability of the hips by ortholani/barlowmanoeuvres is no longer elicitability. Those infants had asymmetric thigh folds in 66% of the cases, which, as frequently, have the limited positive predictive value as an independent screening criterion. The incidence of oligohydramnios (16 per cent) was also observed, which is a known intrauterine mechanical risk factor, which hampers the mobility of the fetus and encourages abnormal hip positioning. There was a positive family history in relation to DDH with only 10% but inheritance part might be underestimated because of lack of parental awareness among the study population population[4,6]. The left hip prevalence (60) in the current cohort supports the well-known literature that left hip is more commonly affected, i.e. 60-64% of unilateral cases because the left hip is adducted on the maternal spine, and is prone to dysplasia. It was reported that bilateral involvement occurred in 16% cases which is in line with bilateral rates of 1520 which has been reported to be bilateral. The Barlow and Ortolani manoeuvres are still the pillars of the clinical DDH screening, but their efficaciousness has become a controversial issue. The Barlow manoeuvre of the current study showed a sensitivity of 72 and the Ortolani manoeuvre showed much lower sensitivity of 44. These findings are indicative of what has been well-documented in the literature -that the sensitivity of clinical examination is very variable, ranging between 30 and 74% of the Ortolani test and 45 to 81% of the Barlow test based on examiner training and the age of the infant when the examinations are done[6.11]. It is not surprising that the Ortolani test was shown to have a lower sensitivity than the Barlow test in the given study due to pathophysiological reasons. In the Ortolani manoeuvre, an unstable (reducible) dislocation of the hip is detected, whereas in the Barlow manoeuvre, an unstable (reducible) but already present dislocation of the hip is detected. In older infants with fixed or irreducible dislocations - these formed 68% of this group by the Graf classification (Type III/IV, Table 4) - the Ortolani manoeuvre gives a negative result not due to the hip being normal but because the dislocation is no longer reducible at the age of examination. This is why the percentage of false negatives in the current series of Ortolani is so high and emphasizes the risk of using this manoeuvre alone to screen populations with a high rate of late presentations[3,11]. An important weakness of clinical screening is alone is that it will miss a considerable fraction of cases, especially those with milder or sub-clinical dysplasia. A pioneering prospective study by Rosendahl et al.,[12] showed that the late presentation rate using clinical screening alone is 1.3 per 1000 births as compared to 0.3 per 1000 using universal ultrasound screening. Clarke et al.[13] showed that the rates of late presentation decreased by 42% in 20 years when clinical screening was combined with selective ultrasound. Moreover, late-presenting DDH has been identified to have up to 72 percent no reported risk factors at the time of the neonatal examination, so risk-factor-based selective screening cannot be applied as an independent intervention. In the current paper, 92% of the infants were either abnormally classified in terms of their Graf on ultrasonography with 68% of them

having Grade III/IV (frank dislocation). This high percentage of severe disease manifestation is an indicator of late or un-detected disease early stage - a trend that is parallel in the Indian situation, where the average age of DDH presentation has been reported to be 1-2 years of age and is usually when the child starts walking. The gold-standard imaging modality in the infant less than 6 months of age DDH is ultrasound with the Graf method which provides direct visualisation of the cartilaginous femoral head and measures the acetabular morphology in terms of alpha (0) and beta (0) angles. A dysplastic α-angle is defined as less than 60, Type II hips (4359) are immature or slightly dysplastic hips and Type III/IV hips (43) are dislocated or severely dysplastic hips.[3]. Programmes of universal ultrasound screening (since 1992 in Austria and since 1996 in Germany) have shown almost zero late-presenting incidence of DDH, with under universal screening at 0.13/1000 live births compared to 0.65/1000 under selective screening.[14]. Evidence of decreasing first operative procedures in DDH was observed in Germany by von Kries et al. [15], as a result of universal ultrasound screening of patients. There are however opponents to universal screening who cite the issue of overtreatment and possible risk of avascular necrosis (AVN) due to unnecessary bracing. Modern flexible orthoses like Tubing abduction brace have been used in modern studies that have reported zero rate of AVN, and thus partially, these fears are dismissed. In India, the training of sonographers and financial resources are limiting the logistics of universal ultrasound screening especially in tier-2 and tier-3 cities. As pointed out by Karnik et al.,[3] radiographs are the leading first line test conducted in most of India because the X-ray facilities are as common as ultrasound. The American Academy of Pediatrics (AAP) and PaediatricOrthopaedic Society of North America (POSNA) do not support the routine use of ultrasound but support the use of selective ultrasound in high-risk infants using 6 weeks to 6 months of age with a normal clinical examination.Radiographic evaluation was done on the acetabular index (AI) which showed a 88 percent of the infants in this study had an acetabular index of 30 or above, and 32 percent had an acetabular index of more than 40 or above which showed there was acetabular dysplasia in the entire cohort of infants. Normal AI is less than 30 in neonates which gradually reduces to less than 22 in age of one year. The risk of hip replacement in early adulthood has been linked to an AI post-reduction of greater than 35. The fact that the proportion of significantly high AI in the current study is high supports the idea that the majority of infants were presenting with a stage of established structural dysplasia and not early instability a result that is in line with a late-presenting predominant cohort. The findings of the current research restate the previous findings by confirming that clinical screening, even in a tertiary care unit, is not enough to diagnose DDH at an early stage, which can be treated. Graf Type III/IV hips and high acetabular indices at presentation suggest that most of the infants are only being presented when further structural damage has already taken place. Indian studies have continuously claimed that late diagnosis and delay in referral to specialist centres have been the key determinants of poor outcome, which requires more serious and complex interventions such as open reduction and osteotomy.

To enhance the screening performance in the Indian situation, the following will be necessary (i) a system of mandatory Ortolani and Barlow test on trained personnel during all newborn checkups and well-baby visits, (ii) a system of selective ultrasound screening of high-risk (breech presentation, positive family history, first infant, oligohydramnios) infants at 6 weeks of age, (iii) a system of referral channels between primary health centres and tertiary care centres between clinical and ultrasound anomalies, and (iv) community-level awareness programs to educate parents and primary care physicians about early warning signs of DDH, including restricted hip abduction and asymmetric thigh folds.[3,6,16]

Conclusion - This paper identifies a high incidence of late-presenting Developmental Dysplasia of the Hip (DDH) in infants at a tertiary care centre in central India, with a high amount of female preponderance, left hip involvement, and severe radiological dysplasia (Graf Type III/IV in 68% and Acetabular Index >40 in 32). There was a poor sensitivity of clinical manoeuvre of this cohort, especially the Ortolani test, because of fixed dislocations caused by late diagnoses. These results highlight the insufficiency of clinical screening in resource-limited environments and the urgent

necessity to empower newborn screening guidelines, selective ultrasonography of high-risk newborns, better referral patterns, and parental education to promote early diagnosis and treatment and, therefore, minimize morbidity in the long term and the need to resort to more complicated surgical treatments.

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