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Research Article

The Validity of Certain Clinical Sign and Risk Factors in Relation to the Results of Ultrasound Examination of the Hip in Static and Dynamic Modalities

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ABSTRACT

During the period from January 2001 to March 2002, one hundred infants below 6 months of age (62 females and 38 males) attending orthopedic outpatient unit in Saddam General Hospital in Mosul with inconclusive clinical diagnosis of developmental dysplasia of the hip (DDH) were included in this study. The study aimed at evaluating the validity of certain clinical signs (including unequal thigh and inguinal skin folds, hip click and limited abduction) and risk factors (including sex, cesarean section, breech presentation, family history, birth order or parity of the mother and associated foot deformities) by relating them to the results of ultrasound examination of the hip in the static and dynamic modalities. The clinical signs and risk factors were appraised using within-group comparison statistical analysis and considering ultrasound as the reference standard for diagnosis of DDH in this age group.

Abnormal hips were more frequently detected in females (female to male ratio 1.5-1) but males tended to have more severe pathology (38% of male had dislocatable hips compared to 19 % of females) especially when associated with foot deformities. Breech presentation was more frequently associated with subnormal hips (type IIa/b in 47% of breech presenting versus 29.5% of head presenting infants) but did not significantly affect the severity of DDH. Cesarean section had no significant effect on frequency and severity of DDH when considered in isolation. The first born child was clearly more at risk of having DDH and their hips represented 42% of the total abnormal hips. Foot anomalies increased the possibility of DDH both quantitatively and qualitatively (P value 0.001 and OR 3.24). Positive family history of DDH was the most significant risk factor encountered in the study population (P value 0.01 and 3.5).

Unequal skin folds represented a sensitive indicator of hip abnormality (sensitivity 82%) but had low specificity (15.8%). Yet, this sign should be regarded as an indispensable adjunct to other criteria for the diagnosis of DDH. Hip click had moderate sensitivity and specificity but a high positive predictive value (71) denoting its value in detecting true positive cases of DDH. Limited abduction was the most specific sign in DDH (71.2) and hence, the most valuable clinical sign. Depending on the foregoing clinical criteria, the diagnostic accuracy in this age group in the absence of frank sings of DDH (positive Barlow and Ortolani tests and severe limitation of abduction) was 63%.

Key words: Congenital dislocation; Developmental dysplasia; Ligamentous laxity

INTRODUCTION

Congenital dislocation of the hip consists of partial or complete displacement of the femoral head from the acetabulum. Because of the inadequacy of the definition of congenital dislocation of the hip, introduced the term “developmental dysplasia” (DDH) which covers more accurately the various abnormalities around the hip joint before, during and after birth. He subgrouped DDH into:

1. DDH “at risk”, the “at risk” factors, e.g. family history, breech presentation, female child, oligohydramnios, associated deformities of torticollis, talipes and genu recurvatum.
2. DDH- hypoplastic with limited abduction.
3. DDH- reducible displacement with a jerk/click on entry.
4. DDH- reducible displacement with a jerk/click on exit.

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5. DDH- subluxation and limited abduction.
6. DDH- dislocation with limited abduction, femoral shortening and telescoping. It should be remembered that this is unusual in newborns and usually associated with arthrogryplasia or myelodysplasia (about 2%) [1] .

Instability: Instability is the inability of the hip to resist an externally applied force without developing a subluxation or dislocation.

Malformation: Any abnormality in the development of the femur and/or acetabulum.

Subluxation: Incomplete dislocation with some residual contact between the femoral head and acetabulum.

Dislocation: Complete displacement of the femoral head from the acetabulum.

Teratologic dislocation: Occurs early in utero and is associated with other malformations such as chromosomal abnormalities and neuromuscular disorders.

Typical dislocation: Occurs in an otherwise healthy infant and may occur in utero, at birth or after birth [2].

Factors associated with DDH

Ligamentous laxity: The maternal hormone relaxin, which contributes to ligamentous laxity in the mother's pelvis during childbirth, passes freely through the placenta to the newborn. Relaxin and other maternal hormones contribute to neonatal ligamentous laxity (especially in the female fetus) and may increase the risk of DDH. Joint laxity and femoral neck anteversion have long been thought to be two of the main causes of DDH [2].

Genetic factors: There is evidence that genetic factors play a role in the etiology of DDH.

A. Healthy parents with one child affected, risk to subsequnt children is 6%,
B. One affected parent, risk is 12%,
C. One affected parent and one affected child, risk is 36%.

Other investigators postulated that there is a 7-fold increase in the incidence of DDH in siblings and a 10-fold involvement of index patients compared to general population.

Imaging of the hip in DDH

Radiographic evaluation: The anteroposterior radiograph is difficult to interpret in the neonatal period [3]. A normal newborn radiograph may be misleading and deceptive because much of the femoral head and pelvis are cartilagenous so the relationship between the femoral head and the acetabulum is difficult to determine. Neonatal hip instability by radiography is false negative in about half of the cases. In positioning the newborn for the radiograph, the technician may spontaneously reduce a dislocated hip producing a normal radiograph. In addition, if the newborn is not positioned properly, asymmetry is introduced that makes interpretation difficult [3].

Andren-von rosen view: Patient's femora are held at 45° abduction from midline and the hip is internally rotated for about 25° or until some resistance is met. If the line drown on the film, along the femora intersect the acetabula or their roof, then the femoral head must be well located. False positive and false negative results are expected but it is very helpful in the first 6 months of life. A standing AP view of the pelvis can also be obtained in an older child using the wall cassette. This gives a better assessment of the lateral subluxation.

Antero-posterior view: This should be taken with hips in neutral rotation and extension and normally aligned lower extremities. This is critical since abnormal position can considerably alter diagnostic value of the lines. The ossification center of the head normally appears at 4-6 months of age. It is typically seen earlier in females than in males, and there is a wide normal variation for the time of appearance [1,3,4]. It is delayed in development and its maturation may be irregular and is smaller than the other normal hip in unilateral DDH [3-5]. The ossification of ischio-pubic synchondrosis is retarded as compared with the normal side [5]. The U-figure or teardrop shadow of Kohler becomes visible when the infant is 6 to12 months old [3]. It consists of three lines: a lateral semicircular line corresponding to the cortical surface of the acetabular fossa, a medial line corresponding to the medial cortex of the pelvic wall, and a short curved line connecting these two lines corresponding to the semicylendrical cortex of the acetabular notch. Delay in the ossification of the teardrop may result from a lack of stimulation from a concentrically reduced femoral head suggesting DDH. On the A-P view we can also determine the following:

a) Shenton's (or menard's) lines: drawn between medial border of the neck of the femur and the superior border of the obturator foramen. Normally it is an even continuous arc. In DDH it is broken and interrupted due to proximal displacement of the femur. It is the most consistent picture of subluxation.

b) Simon's line: an arc of lateral shadow of the ilium in supra-acetabular region, that touches the outer border of the greater trochanter in a smooth arc normally, will intersect the shadow of the femur in DDH.

c) Horizontal lines through the triradiate cartilage (Helginriener's line) when intersect with vertical lines drawn downwards from the lateral rim of the acetabulum (Perkin's line), divide the hip into quadrants. The femoral ossific nucleus, or the medial beak of the femoral metaphysis, is within the inner lower quadrant normally, but in upper outer quadrant if the hip is dislocated.

d) Acetabular angle of Sharp [6-10]: is the measurement of the angle between Helginriener's line and a line through the roof of the acetabulum. In adults it is measured from the base of the teardrop. When hip is deformed the teardrop and the new acetabulsr edge are difficult to define.

e) The value of acetabular angle as an absolute estimation is doubtful. But, it is useful in unilateral dislocation and in follow up because it improves markedly during first 6 months after reduction and the difference before and after treatment is a good index of improvement by subsequent ossification of cartilagenous roof of acetabulum. Tilt of the pelvis during positioning gives changes in the measurements due to rotation of the acetabulum [7,11-15]. The normal values differ according to age. Neonates 0-3 months of age have an index of 18-37°, for infant 3-12 months is 14-30°, and for those 12-24 months is 14-24°.

f) Lateral subluxation of the femoral head is measured in comparison with the normal hip as the distance between a line dropped from the margin of the head and the lowest point of the teardrop.

g) Incongruity of the joint estimated by subtracting the narrowest measurement of joint space from the highest. It gives an impression of incongruity, but only in two dimensions. It is useful in cases of avascular necrosis.

h) Sphericity of the femoral head is gauged with mose's rings, and recorded as the maximum difference between any two radii.

i) Size of femoral head expressed as the percentage of increase of the largest diameter of the femoral head over the diameter of the normal side. It cannot be estimated in bilateral cases.

j) The C-E angle of Wiberg: The angle is measured between a perpendicular line crossing the center of the femoral head and a line running to the edge of the acetabulum. Thus, it's value is limited to the age of 3 years and over when the head is more spherical and the edge of the acetabulum is more bony. Changes in position of the head give no difference in measurement because the head after this age will continue to have a concentric relation to the acetabulum if it is well contained. The concept of C-E angle is useful in disorders of the hip, other than DDH, where subluxation may be a problem. Deformity of the femoral head and the slope of acetabbular margin in acetabular dysplasia make the evaluation difficult because the landmarks are less distinct [7,16-19].

The average C-E angle is 15-30° [5,20], but Severin believed that in children 6-13 years C-E angle less than 15° is definitely pathologic and 15-19° is equivocal and of more than 20° is consistent with normal development [8,21-25]. The roentgenographic parameters of acetabular dysplasia include:

1. Acetabular angle greater than 43°.
2. Acetabular depth less than 14 mm.
3. Acetabular roof slope angle less than 0°.
4. Center-edge angle under 20° [9,26].

Arthrography in DDH

The main indications of arthrography of the hip are:

1. Assessment of DDH prior to appearance of bony nucleus when it does not reduce by conservative treatment.
2. Assess adequacy of reduction by manipulation.
3. Assess cartilage model of the femoral head as when the head is grooved from joint subluxation.
4. Assess the limbus or hourglass deformity of the capsule after redislocation or subluxation.

Arthrography is not a routine examination [10,27-31]. It is an invasive procedure requiring general anesthesia and sterile conditions are mandatory. Besides, it has been largely replaced by other imaging techniques as ultrasound, CT scan and MRI.

CT scan in DDH

The role of CT scan in DDH is valuable for checking the position of the femoral head in relation to the acetabulum. It produces far less radiation than conventional rontgenography, yet is more reliable in locating the femoral head and assessing reduction while the patient in spica [6,32]. Usually the level of the hips are the same as urethral orifice in females and penoscrotal junction in males. CT scan has a role in identifying femoral head shape, anteversion, acetabular coverage and acetabular anteversion. Defects in the acetabular walls and the formation of a false acetabulum can also be viewed [11,33].

Magnetic resonance imaging (MRI) in DDH

The capability of MRI to visualize the soft tissue and cartilagenous components of infant's hip is excellent. It is a non invasive technique, does not expose the infant to radiation, and can be employed on post-operative patients and while the infant is in cast. MRI is useful in studying complicated cases, failed reduction, redislocation and doubtful concentric reduction [5,34]. MRI can show obstructing elements in failed closed reduction, whether being intraarticular or extraarticular. Gluteal muscle atrophy is also seen . MRI is useful in diagnosing osteonecrosis. It is the most reliable way of diagnosing marrow changes and bone ischemia at a comparatively early stage. The first sign is a band-like-low-intensity signal on the T1-weighted SE (and similar but high-intensity signal on the STIR image), corresponding to the interface between ischemic and normal bone. The site and size of the demarcated necrotic zone have been used to predict the progress of the lesion [35,36]. Cost and static nature of MRI makes its indiscriminate use in the initial diagnosis or evaluation of uncomplicated hip not advocated. MRI also is a time consuming technique and may demand sedation or anesthesia for the infant. It cannot be used in the presence of metalic implants. Thus, it has been largely replaced by ultrasound for the diagnosis and follow up of DDH [37,38].

Ultrasound diagnosis of developmental dysplasia of the hip

The first in depth use of ultrasound was performed by Graph, an Austrian orthopedic surgeon [12,39]. He used an articulated arm B-scan unit and developed a technique of evaluation based on a coronal image of the hip. Scanning was performed from the lateral approach with the femur in its anatomic position. His method established ultrasound's ability to distinguish between the cartilage, bone and soft-tissue structures that compose the immature hip joint [12,13,40]. With real time equipment, sonographers have experimented with different views, and this led to an alternative approach to hip sonography- one that emphasizes dynamic assessment of the hip in multiple positions. Although two basic philosophies, morphologic and dynamic, evolved, it is recognized that the two methods, in fact, have common features. Both approaches recognize the need for critical landmarks of the femur and acetabulum. The dynamic technique in addition to stressing positional relations and stability, includes a limited assessment of critical acetabular landmarks [14,41,42]. The morphologic approach describes a limited dynamic assessment [13,43-50].

Technical factors:

- Real time linear array transducers are preferred to sector scanners to cover broader field of view.

- Highest frequency transducers (e.g. 5-7.5 MHz) are used for adequate penetration.
- During examination the infant should lie supine with the feet towards the sonographer. When examining the left hip the sonographer grasps the left leg with the left hand and the transducer with the right hand and vice versa.
- The infant should be fed, relaxed, and upper body remains clothed. Usually there is no need for sedation.
- The objective of dynamic hip examination is to determine the position and stability of the femoral head as well as the development of the acetabulum.
- At birth, the proximal femur and much of the acetabulum is composed of cartilage. On sonographic examination, cartilage is hypoechoic compared with soft tissue so that it is easy to distinguish.
- At birth, ossification centers in the ilium, ischium and pubis, which are separated by the triradiate cartilage, have a Y configuration.
- The cartilagenous acetabular rim (the labrum) extends outward from the acetabulum to form the cup that normally contains the femoral head.
- It is possible to distinguish the acetabular cartilage from the femoral head (the joint line) by simply rotating the femur. More pronounced movements create echoes within the joint space (possibly microbubbles).
- At the lateral margin of the labrum the hyaline cartilage changes to fibrocartilage, and this shows increased echogenicity.
- The echogenic hip capsule, which is composed of fibrous tissue, borders the femoral head laterally.
- The ossification center of the femoral head is recognized between the second and eighth months of life. It is typically seen earlier in females than in males, and there is a wide normal variation for the time of appearance. Although some asymmetry between the left and right hips both in time of appearance and size can be normal, delayed appearance and development are associated with DDH.

MATERIALS AND METHODS

To assess criteria of selective referral for ultrasound hip examination in clinically suspicious cases of DDH.

1. Correlate the results of clinical and sonographic examination in clinically doubtful DDH infants.
2. Appraise the influences of various risk factors on the occurrence of hip abnormalities.
3. Recommend criteria for selective referral to the ultrasound unit.

Study population

During the period from January 2001 to March 2002, one hundred infants with an age range of 1 week to 5 months attending Saddam General Hospital orthopedic outpatient clinic with clinically suspicious DDH were included in the study. The criteria for inclusion are represented by one or more of the following points:

1. Click in one or both hips. "Click" is a high pitched sound (unlike the low pitched "clunk") produced by moving the hip without clear jerk of entry or exit.
2. Unilateral or bilateral limitation of abduction.
3. Asymmetrical inguinal or thigh skin folds.
4. Presence of risk factors including:

a) Female sex

b) Family history of DDH

c) Breech presentation

d) Cesarean section

e) Associated abnormality e.g. talipes equinovarus, metatarsus adductus and congenital torticollis

f) Swaddling

On the first visit, the parents are interviewed and the infant is examined. If one or more the inclusion criteria are fulfilled, a data sheet (shown below) is filled for each case and the infant's hips are examined clinically and sonographically. When abnormalities exist, the infant is treated and followed accordingly. Patients with associated neuromuscular disorders, arthrogryposis, and teratologic hip dislocation were excluded.

Ultrasound examination

Utilizing a Voluson® 53 system manufactured by the Austrian Kretz companies and programmed with software for classifying the type of the hip according to Graff's technique as follows.

With the aid of the sonographists in the ultrasound unit in Saddam General Hospital, static and dynamic ultrasound examinations were performed. The static evaluation of the hip was done in the coronal neutral plane according to the standard Graff's technique. The real time properties of the device also provided the opportunity to perform a dynamic hip assessment for sonographic stability with Barlow and Ortolani maneuvers. The results are then recorded on the data sheet in the following manner:

Static examination: The morphology of the hip joint is categorized in one of the groups mentioned above according to Graff's technique.

Dynamic examination: The hips are classified into three groups:

1. Stable: when the femoral head remains well located in the acetabulum on performing the Barlow maneuver.
2. Subluxatable: if the hip partially exits the acetabulum with Barlow and Ortolani's maneuvers. The amount of displacement should be equal or more than ¼th of femoral head diameter (≥ m).
3. Dislocatable (or dislocated): the femoral head can be brought outside it is socket completely, or is already outside it.

RESULTS AND DISCUSSION

General features of the sample

Infants in the sample were collected in the orthopedic outpatient unit in Saddam General Hospital. They included infants below 6 months of age with inconclusive clinical examination for DDH. The reasons of consultation were:

1. Referral by a pediatrician due to abnormal neonatal examination, or when doing a general check up examination for infants visiting the pediatrician or the orthopedist for other health problems.
2. Suspicious mothers due to previous family history of the condition, noting unequal skin folds, abnormal posture of the legs, or difficult or painful handling while changing the diapers or other causes.

The age of the 100 infants (Tables 1 and 2) ranged from 1 to 20 weeks but more infants presented during the first week of life. Female: male ratio was about 3:2 (62 female and 38 male).

Risk factors

The presence of risk factors was considered as a criterion for inclusion in the study sample to analyze their impact on the presence and severity of DDH. A set of the more famous risk factors was considered.

Sex: Despite the fact that females outnumbered males in our study population (62 *vs.*38 respectively), but more males than females were encountered in sonographic hip type III/IV and also in the dislocatable group, a relation that was statistically significant (P 0.05). Dislocatable hips were detected in 38% of male hips as compared to 19% of female hips and also 20% males in group III/IV compared to 15% females. On the other hand, more females than males were in the stable group (56% of females *vs.* 48% of males) and in the partially subluxed category (24% of females *vs.* 13% of males). Thus denoting that although males are less frequently affected by DDH in general but they tend to have more severe pathology, particularly when associated with other musculoskeletal deformities as clubfoot and other foot anomalies, which were encountered in 11 (28%) of the male infants (Tables 3 and 4).

Presentation: Seventeen infants had breech presentation at time of delivery. Type II hips were recorded from 47% of these infants (compared to 29.5%in the head presenting infants) and sonographic dislocatability and subluxation were found in 15 hips (44%). However, no obvious effect of presentation on the ultrasound grade of hip dysplasia was observed when breech and head presentations were compared (P>0.1) (Tables 4 and 5).

Table 1: Kretz Technik Ultrasound.

Type	A angle	ß angle
Ia	≥ 60°	<55°
Ib	≥ 60°	≥ 55°
IIa/b	50-60°	-
Iic	43-49°	≤ 77°
D	43-49°	>77°
III/IV	<43°	-

Table 2: Age of presentation of patients with suspected DDH.

Age in weeks	1week	24weeks	5-8weeks	9-12weeks	13-20weeks	Total
No. of patients	27	19	19	14	14	100

Cesarean section: Cesarean section was the method of delivery in 28 infants in our study population. The cause of cesarean section was abnormal presentation in 15 infants (58%), preeclampsia in 7 infants (25%) and other causes in the remaining 6 cases. Ultrasound examination of the infants delivered by cesarean section revealed more normal hips in Ia/b category as compared to normal vaginal delivery product infants (43% *vs.* 35% respectively) and had more stable hips on dynamic examination (61% *vs.* 51% respectively). However, the relationship between type of delivery and degree of hip dysplasia was not statistically significant (Tables 6 and 7).

Birth order (parity of the mother): Firstborn infants represented

Table 3: Relation between sex and static U/S hip examination.

U/S hip type (Graf)	Sex			
	Female		Male	
	No.	%	No.	%
Ia/b	47	37.9	27	35.5
IIa/b	45	36.3	20	26.3
IIc/D	13	10.5	14	18.4
III/IV	19	15.3	15	19.7
Total	124	100	76	100

Note: OR= 0.56, P= 0.05

Table 4: Relation between sex and dynamic hip U/S examination.

Dynamic U/S exam	Sex			
	Female		Male	
	No.	%	No.	%
Stable	70	56.5	37	48.7
Subluxatable	30	24.5	10	13.2
Dislocatable	24	19.4	29	38.2
Total	124	100	76	100

Note: OR= 0.73, P= NS

Table 5: Relation between birth presentation and DDH.

U/S hip type	Presentation			
	Head		Breech	
	No.	%	No.	%
Ia/b	64	38.6	10	29.4
IIa/b	49	29.5	16	47.1
IIc/D	27	16.3	0	0
III/IV	26	15.7	8	23.5
Total	166	100	34	100

Note: OR= 1.5, P= NS

Table 6: Relation between presentation and dynamic hip U/S.

Dynamic U/S exam	Sex			
	Female		Male	
	No.	%	No.	%
Stable	88	53	19	55.9
Subluxatable	33	19.9	7	20.6
Dislocatable	45	27.1	8	23.5
Total	166	100	34	100

Note: OR= 0.98, P= NS

Table 7: Comparison between cesarean section (C/S) and normal vaginal delivery (NVD) in relation to static hip sonography.

U/S HIP TYPE (GRAF)	Type of Delivery			
	NVD		C/S	
	No.	%	No.	%
Ia/b	50	34.7	24	42.9
IIa/b	47	32.6	18	32.1
IIc/D	21	14.6	6	10.7
III/IV	26	18.1	8	14.3
Total	144	100	56	100

Note: OR= 0.68, P= NS

the larger partition of the sample (42%). The number of infants of subsequent birth orders decreases gradually. These infants had 53 (42%) of the total 126 abnormal hips detected by static ultrasounography (Table 8).

Family history: Positive family history of DDH in a first-degree relative was positive in 11 infants. It was obvious that these infants had more sonographic hip abnormality than those with negative family history. Sonographic type IIc/D and III/IV hips comprised 41% of the infants when the family history was positive compared to 27% when it was negative. Likewise, the dynamic ultrasound examination showed a higher tendency for subluxation (45% *vs.* 15%) and, to a lesser extent, dislocation (27% *vs.* 25%) when the family history was positive. The relationship was statistically significant (P=0.01) and studying the odds ratio denoted an increased risk of having DDH when the family history is positive (OR=3.5) (Tables 9 and 10).

Club foot and other foot anomalies: Foot deformities were found in 20 infants in this study population. Ultrasound examination

Table 8: Comparison between C/S and NVD in relation to dynamic hip sonography.

DYNAMIC U/S EXAM	Type of Delivery			
	NVD		C/S	
	No.	%	No.	%
Stable	73	34.7	34	60.7
Subluxatable	39	27.1	14	25
Dislocatable	32	22.2	8	14.3
Total	144	100	56	100

Note: OR= 0.66, P= NS

Table 9: Comparison between C/S and NVD in relation to dynamic hip sonography.

U/S hip type (Graf)	Family History			
	Positive		Negative	
	No.	%	No.	%
Ia/b	5	22.7	69	38.8
IIa/b	8	36.4	57	32
IIc/D	4	18.2	23	12.9
III/IV	5	22.7	29	16.3
Total	22	100	178	100

Note: OR= 2.15, P= 0.05

Table 10: Effects of family history on DDH diagnosis by dynamic U/S.

DYNAMIC U/S EXAM	Family History			
	Positive		Negative	
	No.	%	No.	%
Stable	6	27.3	101	56.7
Subluxatable	10	45.5	30	16.9
Dislocatable	6	27.3	47	26.4
Total	22	100	178	100

Note: OR= 3.5, P= 0.01

Table 11: Club foot and other foot deformities in relation to hip dysplasia.

Club foot	Classification				Total
	Ia/b	IIa/b	IIC/D	III/IV	
Positive	7	12	9	12	40
Negative	67	53	18	22	160
Positive%	17.5	30	22.5	30	100%
Negative%	41.88	33.13	11.25	13.75	100%

Note: OR= 3.24, P= 0.001

for a concomitant hip dysplasia revealed a clear increase in the frequency and severity of hip abnormalities. Hip type IIc/D occurred in 30% of infants with positive foot deformities and only in 13% when no foot deformity was present. For hip type III/IV, it occurred in 22% of positive cases and in 11% of negative cases. The P-value was 0.001 and the odds-ratio was 3.24 pertaining to a high statistical significance (Table 11).

Swaddling: The practice of swaddling as a risk factor was recorded from 70% of the mothers in the sample. However, this factor was not analyzed because a considerable number of the cases were collected in the first few days of life, by which time, the aftermath of swaddling the infant with the hips in a position of adduction and extension, has not yet taken part in affecting hip joint development.

Clinical examination

Unequal inguinal and upper thigh skin folds: Despite the fact that unequal skin folds were recorded from 84 infants (84%), it made no significant impact on the severity of hip dysplasia. Statistical evaluation of this sign showed a high sensitivity but a low specificity (Table 12). For classification Sensitivity-82.5, Specificity-13.5, Positive predictive value-62, Negative predictive value-31. For Dynamic examination Sensitivity-84, Specificity-16, Positive predictive value-46, Negative predictive value-53.

Hip click: "Click" was found in 85 hips (42.5%) from the total 200 hips (100 infants) examined. Right side click in 43 and left side in 42 hips. Although 62 (73%) of these clicking hips were detected in the first two weeks of life, but were also positive in infants as old as 12 weeks. Ultrasound study revealed that 35% of these hips are of type IIa/b and 22% in type III/IV class. Besides, on dynamic sonography 22% of these hips were subluxatble and 33% were dislocatable. These clicks are more evident in hips with positive click than negative ones. Despite not having a high sensitivity and specificity, the test had a high positive predictive value which means that the presence of hip click can help in predicting the true positive cases of DDH (Table 13). For classification Sensitivity-47.6, Specificity-66.2, Positive predictive value-70.6, Negative predictive

Table 12: Significance of unequal skin folds in DDH diagnosis.

	Classification				Dynamic examination			Total
	Ia/b	IIa/b	IIC/D	III/IV	Stable	Sublaxatable	Dislocatable	
Positive	64	49	23	32	90	29	49	168
Negative	10	16	4	1	17	11	4	32
Positive%	38.1	29.17	13.69	19.05	17.26	17.26	29.17	100%
Negative%	31.25	50	12.5	3.13	34.38	34.38	12.5	100%

Table 13: Importance of hip clicking compared to u/s examinations.

	Classification				Dynamic examination			Total
	Ia/b	IIa/b	IIC/D	III/IV	Stable	Sublaxatable	Dislocatable	
Positive	25	30	11	19	38	19	28	85
Negative	49	35	16	15	69	21	25	115
Positive%	29.41	35.29	12.94	22.35	44.71	22.35	32.94	100%
Negative%	42.61	30.43	13.91	13.04	60	18.26	21.74	100%

Table 14: Comparison of clinical limted abduction & u/s hip examinations.

Limited abduction	Classification				Dynamic examination			Total
	Ia/b	IIa/b	IIC/D	III/IV	Stable	Sublaxatable	Dislocatable	
Positive	21	34	15	20	38	24	28	90
Negative	53	31	12	14	69	16	25	110
Positive%	23.33	37.78	16.67	22.22	42.22	26.67	31.11	100%
Negative%	48.18	28.18	10.91	12.73	62.73	14.55	22.73	100%

value-42.6. For Dynamic examination Sensitivity-50.5, Specificity-64.5, Positive predictive value-55.3, Negative predictive value-60.

Limited abduction: Limited hip abduction was found in 90 hips (48 right and 42 left) representing 45% of all hips examined. Infants 6 weeks of age or older represented 84.4% of them. However, infants as young as 2 weeks were involved with some degree of limited abduction. The frequency and severity of DDH as depicted from the results of static and dynamic ultrasound examination were increased when hip abduction was limited. Thus, hip types IIa/b, IIc/D and III/IV were recorded in 38%, 17% and 22% of hips with limited abduction respectively, compared to 28%, 11% and 13% when hip abduction was complete respectively. The high specificity of limited abduction implies its reliability in detecting DDH (Table 14). For classification Sensitivity-54.4, Specificity-71.2, Positive predictive value-76.6, Negative predictive value-84.2. For Dynamic examination Sensitivity-55.9, Specificity-64.5, Positive predictive value-57.7, Negative predictive value-62.7.

General view: On the basis of clinical suspicion depending on the presence of one or more of the risk factors and clinical signs of DDH, some degree of hip dysplasia was found in 126 hips out of the 200 hips examined (63%) (Table 15).

In a community like ours, where home deliveries still represent a good proportion of all deliveries (11% in this study group), effective clinical screening program is not well established and follow up infant checks are not strictly scheduled, large number of cases are expected to be missed. Developmental dysplasia encompasses a wide spectrum of hip problems seen in infants and older children. When on neonatal screening examination or subsequent checking, one or more of the classical signs of frank hip dislocation, including: positive Barlow, Ortolani, Galeazzi signs

Table 15: Comparison of clinical and U/S findings in doubtful cases of DDH.

	Sonographic hip type			
Side	Ia/b	IIa/b	IIIc/D	III/IV
Right	38	37	9	16
Left	36	28	18	17
Total	74	65	27	33

or severe limitation of abduction (in older children) is present, the diagnosis is straight forward and an ultrasound examination (if the infant is less than 4 months of age) or an X-ray film (for older infants), is all that is required to confirm and document the diagnosis before embarking on further management and follow up. On the other hand, when the clinical examination is completely negative and the history is devoid of any of the known risk factors, the diagnosis of DDH is almost excluded and a second follow up clinical examination is ideally required 1 or 2 months later to rule out the condition [3,15,51]. However, when minor abnormalities in the clinical examination are present (e.g. hip click, moderate limitation of abduction, or unequal skin folds), and/or positive history for one or more of the known risk factors for DDH (positive family history, breech presentation, associated club foot, metatarsus adductus, swaddling, and cesarean section), the clinical diagnosis is in doubt and a confirmative diagnostic tool is required to establish or exclude DDH. Ultrasound is a reliable tool for this purpose showing the degree of hip dysplasia and instability (with both false positive and false negative rates reported at 1% to 2%) and leading the way for further management [3,16,15,52]. Ultrasound unit in Saddam General Hospital in Mosul performs an average of 100 examinations every day, including some of the more time consuming procedures like Doppler study and ultrasound guided techniques. Thus, appraising the validity of clinical signs and risk factors of DDH would help in establishing a strategy for selective referral to this crowded unit.

Clinical examination

The clinical presentation of congenital dysplasia of the hip varies according to the age of the child. In newborns (up to 6 months) it is especially important to perform a careful clinical examination. Older writings emphasized the fact that clinical examination of the newborn is the best method for detection of DDH. The results of clinical screening programs alone, however, have been quite variable. Reports of nearly complete success with little need for late sugical intervention coexist with reports of no decrease in poor outcomes. Consequently, the accuracy of physical examination as a universal screening approach has been questioned [17,53-57].

Inguinal and thigh skinfold asymmetry: With lateral and upward displacement of the femoral head there is asymmetry of the skinfolds of the thigh and of the gluteal and popliteal creases with an apparent shortening of the extrimity and deeper and more cephalad inguinal creases of the affected side. Statistical tests for the validity of this sign revealed a high sensitivity (82.5% in the static and 84% in dynamic ultrasound examination) and a low specificity (13.5% in the static and 16% in the dynamic examination). Thus, this sign is important in suspecting the diagnosis of DDH despite the high percentage of false negative results, which can be explained by the bilaterality of the condition or the inapparent skin creases. Ando and Gotoh [18] examined 2111 patients and found that 499 had abnormal inguinal folds; all patients determined to have complete dislocation or subluxation of the hip were among these 499. They recommend inguinal fold assessment as a useful adjunct to other screening methods for congenital dysplasia of the hip in 3- to 4-month-old infants and suggest that asymmetrical or abnormally long inguinal folds are indications for further evaluation. Al-Kattan in Mosul, discriminated between unequal thigh skin creases and gluteal skin creases and demonstrated that 55.3% of DDH cases had unequal thigh skin creases compared to 2.8.7% of controls. Asymmetrical inguinal folds were found in 17.4% of cases and in 9% of controls. He explained the equality of skin folds in patients with DDH by the high fraction of bilateral cases in his series [19,58,59].

Hip click: It is important to distinguish between the visible and palpable low pitched "clunk" characteristic of positive Ortolani and Barlow maneuvers and the high pitched "click" that may occur in flexion and extension in abducted position when examining a newborn. The translation of Lindamany and Ortolani's works has led to confusion between the two terms. However, it is sometimes difficult to distinguish between the two clinically. The cause of hip click can be the slipping of fascia lata over the greater trochanter, congenital discoid meniscus of the knee, enlarged iliopectineal bursa with iliopsoas tendon slipping over it, or an unusually large ligamentum teres [8,60].

In this series we concentrated on studying the validity of hip click as a diagnostic sign for DDH. Sonographic abnormality was detected in 71% of infants with positive clicks compared to 57% in those with negative click, and despite the moderate sensitivity and specificity of this sign (47.6% and 66.2% respectively), the high positive predictive value (70.6) makes this test valuable in detecting true positive cases of DDH.

Limited abduction: In the 3 to 12 month-old infant, there is loss ligamentous and capsular laxity with the gradual development of contracture in the adductor musculature, so that the Ortolani and Barlow tests usually disappear. In the normal 3 to 12 month old infant hip abduction should normally be 75 to 80°, while in a typical case of DDH it is 30 to 40°. Limited abduction was found in 45% of the hips in this study population, 84.4% of them in infants 6 weeks or older. The specificity of this sign (71.2%) implies its reliability in the diagnosis of DDH.

Al Kattan found this sign in 85.6% of cases with DDH and in 8.4% of controls only [19,60]. Shrrards mentions that 20% of normal children in USA go through a phase of limited abduction without any detectable abnormality of the hip joint. Considering ultrasound hip examination as the diagnostic reference standard in DDH, the overall clinical diagnostic accuracy rate of these clinical criteria was 63%.

CONCLUSION

In the light of the results of this study the following conclusions and recommendations are worth mentioning:

1. Although males are less frequently involved in DDH, but they still have to be considered at risk, particularly when they harbor other risk factors especially foot deformities.
2. Breech presentation is associated with underdevelopment of the hip joint and can predispose to DDH even in the absence of other clinical evidence for the condition. Hence, it is advised to do an ultrasound examination to detect abnormalities and avoid late presentation.
3. Cesarean section cannot be considered as a risk factor by itself unless is associated with other risk factors as breech presentation or prematurity.
4. Family history of DDH is a strong indication of ultrasound examination and follow up.
5. The first child is more prone to have a dysplastic hip than subsequent children and a meticulous clinical assessment, repeated follow up examination and ultrasound study when indicated, are important to avoid missing the diagnosis.
6. Foot deformities are associated with increased frequency and severity of DDH and a careful hip clinical and sonographic screening examination should not be overlooked.
7. Asymmetrical thigh and inguinal skin folds were found to be the most sensitive parameter. However, its low specificity makes it appropriate as an adjunct to other clinical criteria for the diagnosis of DDH and does not justify ignoring this sign.
8. Hip click should not be considered as a benign adventitial sound always. An underlying hip dysplasia might be the cause.
9. Limited abduction is the most specific sign and when present, an ultrasound evaluation is mandatory.
10. The practice of tight swaddling can jeopardize the development of a borderline hip joint. Every effort should be done to improve community knowledge, attitude and practice regarding this widely popular habit.

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