Ultrasonographic Findings in Developmental Dysplasia of the Hip in Infants

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ABSTRACT:

BACKGROUND:

Ultrasound (U/S) is valuable modality for evaluating the hip in infants because it enables direct imaging of the cartilaginous portion of the hip that cannot be seen on plain radiographs. Furthermore, U/S examination enables dynamic study of the hip with stress maneuvering. U/S is the preferred imaging modality which used to study the hip disorders like developmental dysplasia of hip (DDH), because it is sensitive indicator of malposition, instability and lack of acetabular development. U/S accomplishes all of these without exposing the infant to ionizing radiation, not expensive, non-invasive and available.

OBJECTIVE:

The aim of our study is to determine the effectiveness and sensitivity of ultrasound examination of neonates to confirm the early clinical diagnosis of developmental dysplasia of hip (DDH) especially in the high risk groups of neonates and young infants.

METHODS:

We conducted a retrospective review of ultrasonographic imaging in 60 neonates and young infants (36 females and 24 males ; age range, 1-9 months, median age , 4 months). U/S examination of the hip joint were evaluated for, percent bony coverage (PBC), which indicates the percentage of the femoral head that covered by the bony acetabulum, normally, 50% or over of the femoral head should be covered by bony acetabulum. And evaluated for Graf angles, alpha angle which defines the bony acetabulum and normally it is more than 60 degree and beta angle which indicates the cartilaginous development and it is normally less than 55 degree. Also evaluate the femoral head flattening which usually associated with delayed ossification , shortening and anteverting of the femoral neck .

RESULT:

DDH is more common in the female patients (F:M = 3:1). Instability and dislocation is usually unilateral, this is seen in 30 patients (50%), (unilateral :bilateral = 3:1). Left hip is more commonly affected, this is seen in 24 patients(40%),(L:R = 4:1). Children born by caesarian section are more likely to have associated instability or dislocation of the hip, 10 patients(25%). First born baby are more affected, 4 patients(10%) and usually these children are more likely to have been breech presentation during their gestation, 14 patients (35%). Family history of DDH is seen in 6 patients(15%).

CONCLUSION:

The U/S is the preferred modality for evaluating the hip in infants who are younger than 6 months. U/S of infant's hip can be used in the diagnosis of DDH and also in monitoring of treatment or follow-up the improvement in the acetabular maturity and morphology, as well as the location of femoral head can be documented to assist in the guidance of therapy plan.

KEYWORDS: infant hip joint, developmental dysplasia, ultrasound

INTRODUCTION:

Developmental dysplasia of the hip (DDH) describes a spectrum of disorders affecting proximal femur and acetabulum that leads to : 1.Acetabular dysplasia 2.Hip subluxation and 3.Hip dislocation . Early diagnosis & treatment is important because failure to diagnose DDH in neonates and young infants can result in significant morbidity [1] .

Pathophysiology:

DDH is a result of disruption of normal anatomical relationship that exists between the femoral head and the acetabulum without adequate contact between

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them neither develops normally. At birth, the acetabulum has small bony and large cartilaginous contents, and the percentage of femoral head covered by acetabulum is less than any other time in development. Therefore, the first 6 weeks of infant's life are critical to healthy hip joint formation [2].

DDH has superseded congenital dislocation of the hip(CDH) as the appropriate term to be used. This is because as our knowledge of the natural history for both normal and abnormal hip development has improved, it has become apparent that dislocation of the hip is a dynamic process encompassing the antenatal, perinatal and postnatal periods.

DDH incorporates:

1. *Ligamentous laxity*: A transient ligamentous laxity that is thought to be an effect of Trans placental maternal hormones (estrogen and relaxin).

2.*Acetabular dysplasia*: A consequence of incomplete bony modeling leaving a shallow, flattened socket.

3.*Subluxation*: An incompletely covered femoral head.

4.*Frank dislocation* : Dislocation occurs when the femoral head losses contact with the acetabulum and rides postero-laterally over the fibro-cartilaginous rim [2,3].

Risk factors include:

Female sex, Breech presentation during gestation, First degree relative with DDH. Oligohydramnios, first born baby, twin pregnancy, caesarean section, congenital abnormalities as talipes, torticollis & neuromuscular abnormalities (spinal dysraphism, myelodysplasia and arthrogryposis) and racial factors[3,4] .

Two types of dislocations occur : Teratologic & Typical. *Teratologic dislocations* occur in infants with underlying neuromuscular disorders such as myelodysplasia and arthrogryposis. Teratologic dislocations occur in utero and therefore, they are truly congenital. Most cases of DDH involve *typical dislocation*. They occur in neurorologically intact infants in a perinatal period and therefore, they are developmental.

Physical signs & symptoms include :

Asymmetric thigh or gluteal folds, shortened leg, prominent greater trochanter, limited abduction and abnormalities of walking or gait [4].

Diagnostic imaging modalities of DDH:

1.Ultrasound (U/S):

U/S is the preferred modality for evaluating the hip of infants who are 6 months or younger. U/S enables direct imaging of the cartilaginous portion of the hip that cannot be seen on plain radiographs and U/S enables dynamic study of hip with stress maneuvering , available imaging modality, non-invasive examination, cheap and without ionizing radiation [5].

Indications for ultrasound examination are: Family history of DDH (CDH), neonatal hip instability, limb shortening, limitation of hip abduction in flexion, breech presentation during gestation, first born child, caesarean section, associated other congenital abnormalities, excessive fetal moulding [6].

An Austrian orthopedist, professor Reinhard Graf, first introduced U/S examination of the hip in 1980. The technique of professor R.Graf included the calculation of numerous angles, a complicated classification system of hip subtypes and the orientation of B-Mode images, so that all hips were displayed on right coronal projections. Proponents of static scanning cite that it is fast, easy to perform, and reproducible. Widespread usage in western Europe has reduced the incidence of undetected DDH requiring open reduction to the lowest in the world .

With advent of real time US, in 1984, Dr. H. Theodor Harcke & associates at the DuPont institute in Willington , Delaware, introduced a dynamic approach to studying the hip. Dr. Harcke is the principal drafter of the American college of radiology (ACR) standard, and his dynamic approach is predominantly used in U/S examination . Some problems are recorded in both technique, the Graf 's technique may have some reliability weakness while the Harcke's technique is tend to be more subjective.

Limitation of techniques:U/S examination is operator dependent and requires training and experience for confident evaluation of the infant hip. Because U/S is highly sensitive in hip imaging, minor abnormalities, or normal early laxities may be revealed ; these may not be significant clinically, but they may be mistakenly over diagnosed and over treated [2,7].

Other imaging modalities used in DDH are:

2.X-RAY : Plain radiographs of the pelvis are most helpful when significant ossification of the capital femoral epiphysis has occurred & when adequate U/S evaluation cannot be performed. The capital femoral epiphyses begin to ossify when an infant is aged 2-8 months. As the size of ossification centers enlarge, the plain radiography then becomes the preferred

modality of evaluating the hip. Plain radiographs are typically obtained in the frontal pelvis, with the legs in neutral position. If the hips are displaced or dysplastic, a second view may be obtained, with the hips in flexion & external rotation(frog-leg position) to look for reduction.

3.CAT scan : CT is useful for evaluating complicated dislocations, as well as postoperative evaluation of the hip. CT can depict osseous blocks to relocation, as well as iliopsoas tendon capsule constriction, a thick ligament. CT also can be used to evaluate femoral and acetabular anteversion .

4.MRI :MRI can be useful in the preoperative and postoperative evaluation of a hip with many complications. MRI can be used to distinguish the labrum, capsule & acetabular cartilage. MRI is useful for detecting the complications of DDH and treatment, such as a vascular necrosis of the femoral head and joint effusions.

5.Arthrography : Can be performed to assess the dislocated hip; often , it is performed at the time of surgical reduction, particularly if the reduction appears to be difficult to maintain. Now it has limited use, restricted for demonstration of any mechanical impediment to reduction such as inverted labrum. The indication for arthrography are fewer with better sonography, advent of MRI, and the availability to confirm reduction in spica casts with CT scanning [8,9,10,11,12,13] .

PATIENTS & METHODS:

This prospective study was conducted in 60 neonates and young infants (36 females & 24 males), so, 120 hips were examined , infant's ages rang from 1-9 months (median age, 4 months). They were referred from orthopedic and pediatric clinics as a clinically suspected cases of DDH. All neonates and infant's parents were asked about the risk factors and clinical manifestations. The equipments which used in the study were (SIEMENS /omnia and versa pro.), using a linear transducer of 7.5 MHz frequency.

American College of Radiologists (ACR) standards of U/S examination of the infant's hip is performed in two planes, coronal & transverse. The infant may be examined in supine or lateral decubitus positions with hip in 90 degree flexed. The unossified cartilaginous femoral head appears as a speckled ball in the acetabular fossa. Once ossification begins, it appears as a central area of increased echogenicity in the centre of cartilaginous femoral head. An ancillary sign of instability of the hip is asymmetry in ossification of femoral head.

The femoral head should be centered in the joint space, with half or more medial to the baseline in the coronal plane. The extent of maturity of the acetabulum also can be quantified by using angular measurements. The ACR considers the calculation of these measurements optional. The standard coronal sectioning plane must be used at the deepest portion of the acetabulum, where the ilium appears as a straight line, perpendicular to the femoral head and parallel to the surface of the transducer.

Acetabular maturity can be quantified by measurement the (alpha and beta) angles. Alpha angle is used most commonly as a measurement of the acetabullar concavity, and it is calculated as the angle between the baseline and roofline. Normal alpha angle is 60 degree or greater. Beta angle is measured between the baseline and inclination line and it indicates the acetabullar cartilaginous roof coverage, an angle of less thane 55 degree is considered normal. Percentage bony coverage (PBC) of 58% or greater is considered normal, the smaller the coverage, the greater the acetabullar maturity [14].

Mild instability may be observed in healthy neonates in their first few days of life, when the typical femoral head has a laxity of 3-4mm. on average. This amount of motion should be resolve spontaneously within the first months of life, after maternal hormonal influences diminish. The alpha angle represents the osseous development of the acetabulum while the beta angle represents the cartilaginous development of the acetabulum [15].

Degree of confidence: Some experience is helpful in assessing hip stability because some laxity is normal in infant's first months of life. Not all sonographically abnormal hips need treatment because spontaneous normalization is common by the time (usually less than 4 weeks of age). Therefore, the decision to treat is based not only on U/S findings but also on the clinical findings. Because many unstable hips may spontaneously normalize within the first 2 weeks of neonate's life, delaying the first U/S study for 2 weeks is sound advice [12]. This unnecessary exposure to ionizing radiation, however, can be avoided by performance of dynamic ultrasound examination[11,12].

RESULTS:

Table 1: Frequency distribution of study samples by gender.

Gender	Number of study samples	Percentage%
Females	36	60%
Males	24	40%
Total	60	100%

Table 2: Frequency distribution of the study samples by age.

Age (month)	Number of study samples	Percentage
1-3	24	40%
4-6	22	36.7%
7-9	14	23.3%
Total	60	100%

Table 3: Frequency distribution of study sample by affected hip.

Affected hip joint	Number of study samples	Percentage
Normal	20	33.3%
Left hip	24	40%
Right hip	6	10%
Bilateral	10	16.7%
Total	60	100%

Table 4: The relationship between the gender & the affected hip.

Gender	Left hip	Right hip	Bilateral	Normal hip	Total
Female	20	4	6	6	36
Male	4	2	4	14	24

Table 5: Frequency distribution of the study sample according to their risk factors.

Risk factor	Number of study samples	Percentage
Breech presentation	14	35%
Caesarean section	10	25%
Family history of DDH	6	15%
First born baby	4	10%
Premature infant	4	10%
Congenital anomaly	2	5%
Total	40	100%

Table 6 : Frequency distribution of the study samples by the type of DDH.

Type of DDH	Number of study samples	Percentage
I	20	33.3%
II	19	31.7%
III	12	20%
IV	9	15%
Total	60	100%

Table 7: Frequency distribution of the DDH types in relation to the gender .

DDH type	Females		Males	
	Number	Percentage	Number	Percentage
I	6	10%	14	23.3%
II	14	23.3%	5	8.3%
III	9	15%	3	5%
IV	7	11.7%	2	3.4%
Total	36	60%	24	40%

DISSCUSSION:

Ultrasound is valuable modality for evaluating the hip in infants because it enables direct imaging of the cartilaginous portion of the hip that cannot be seen on plain radiographs. Furthermore, U/S examination enables dynamic study of the hip with stress maneuvering. U/S is the preferred imaging modality which used to study the hip disorders because it is sensitive indicator of malposition, instability and lack of acetabular development. U/S accomplishes all of these without exposing the infant to ionizing radiation, it is non-invasive, not expensive and available [16].

Rosendhal et al. stated that it has been clearly shown that U/S can be used to detect some cases of DDH, that are missed by physical examination. The treatment rate was greatest in the general U/S screening groups, & the follow up rate was highest for non-treated infants in the U/S screening group because of inconclusive early findings and the late DDH was less prevalent in the general U/S screening group [17].

Andren and Borglin stated that hip instability more common in newborn females because of the increased levels of relaxin, estrogen & progesterone hormones and all these hormones increase laxity of the ligaments in the female infant's hip [18].

According to the American academy of pediatrics (AAP), the left hip is affected three times more often than the right hip, possibly this is related to the left occipito-anterior position of most neonates which may limit abduction of the left hip as it lie against the mother's spine. The bilateral involvement occur more in females than in males and this may support the hypothesis which was mentioned above that the hip instability is more common in females because of the increased levels of relaxin, estrogen and progesterone hormones [1].

Clarke et al showed that the screening of all infants who had risk factors (e.g. breech delivery, family history of DDH, clubfoot) and all infants who had abnormality on physical examination, did not reduce the prevalence of late DDH cases [19].

Boeree and Clarke reported that breech presentation, family history of DDH and foot deformity are the highest risk factors for DDH [20].

Regarding DDH types in relation to the affected side, we found the left hip was affected more than the right in all types and the type II is highest than others, these findings are agree with Jones and Powell. Also we found that the females were affected more than the males in all DDH types except in type I(normal hip), also these findings agree with Jones and Powell [21]. In our study, the female to male ratio was (F:M 3:1). The male DDH patients having higher risk for poor prognosis and increasing severity of pathological problems comparing with the females. Bilateral dislocation of hip is an additive poor prognostic factor in the male that made the incidence of re-dislocation increasingly higher[22] .

Figure1 : Pelvic X-ray (bilateral DDH)

Figure2 : Pelvic X-Ray(dysplasia&dislocation)

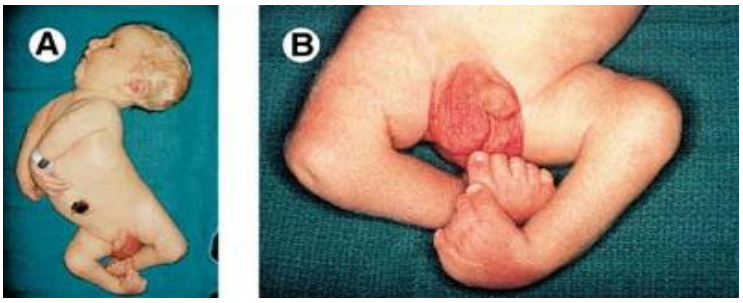


Figure3 : Infant with arthrogryposis & teratologic dysplasia

Figure4 :Infant with frank breech & perineal bruising &risk of DDH

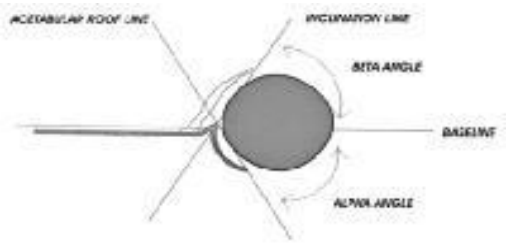


Figure 5 : Schematic draws of Graf's

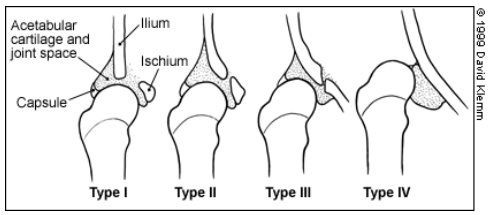


Figure 6 : Graf's types of DDH (Alpha & Beta) angles

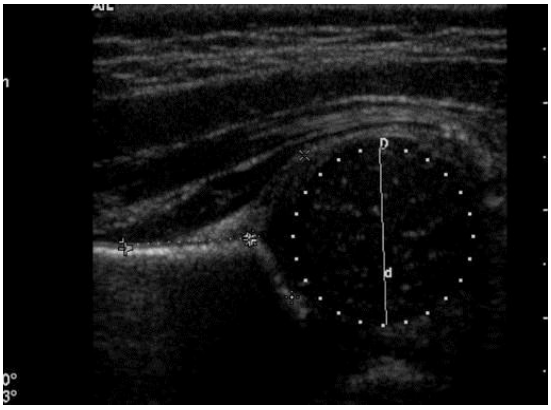


Figure 7 : U/S of normal hip, alpha angle 72 degree & 58% PBC

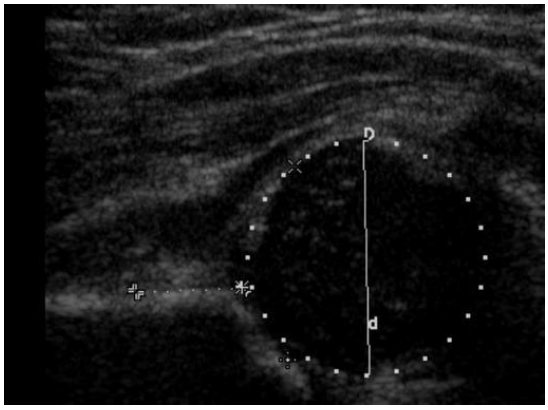
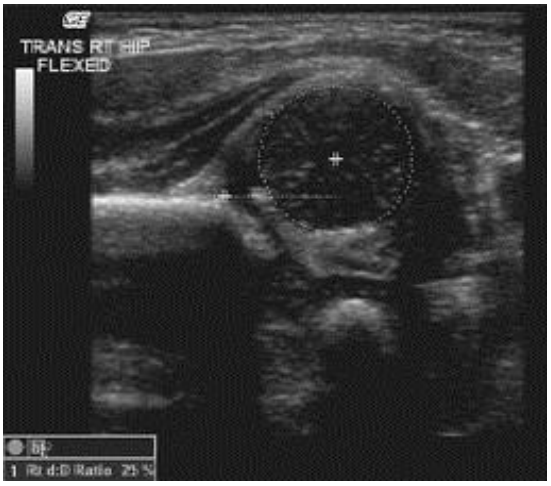


Figure 8 : U/S of 1 month old male with his mother with history of hip dysplasia. Diagnosis is left hip dysplasia.



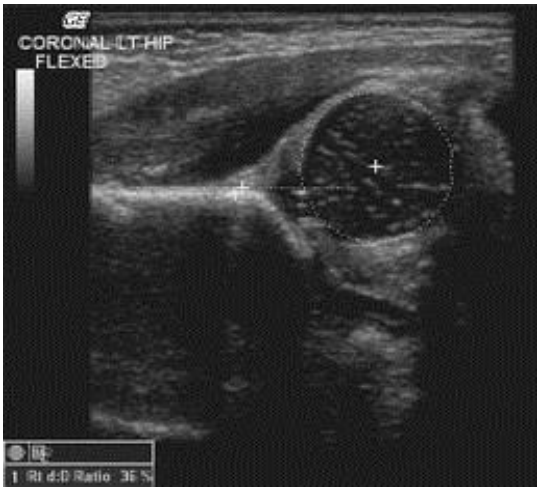


Figure 9 : Multiple U/S sections of 1 month female(coronal Lt. hip flexed & transverse Rt. hip flexed) . Rt. Hip alpha angle 58 degree, Lt. hip 55 degree. Rt.hip flexed with 25% PBC, Lt. hip 36% PBC. Lt. hip is completely subluxed. Diagnosis: Graf II dysplasia on the Lt. hip

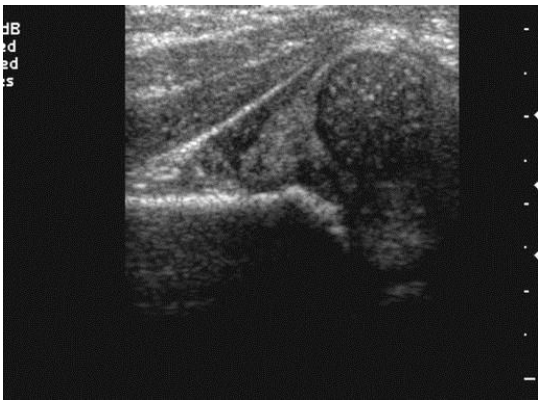


Figure 10 : Hip dislocation in coronal U/S

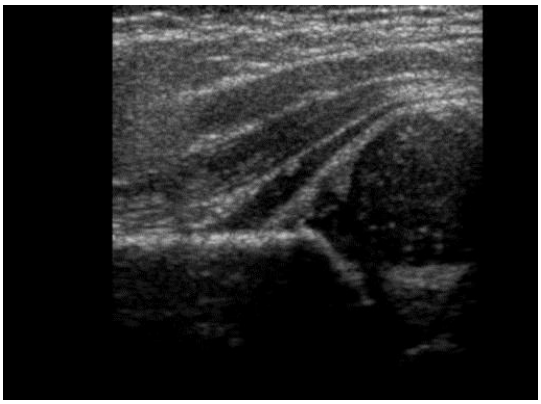


Figure 11: Hip subluxation in coronal U/S

CONCLUSION :

The U/S is the valuable and preferred modality for evaluating the hip in infants who are younger than 6 months. U/S enables imaging of the cartilaginous portions of hip and enables dynamic study of hip with stress maneuvering without exposing the infant for ionizing radiation. Furthermore it is available, not expensive and non –invasive. The value of ultrasonography diminishes as the ossification center occurs, after 8th month of infant's age and the radiography becomes more reliable usually by 1 year of the infant's age. US of infant's hip can be used in the diagnosis of DDH and also in monitoring of treatment or follow-up. The improvement in the acetabular maturity and morphology, as well as the location of femoral head can be documented to assist in the guidance of therapy. Screening with U/S increases curative rates because it is more sensitive than clinical examination alone. Late DDH is very rare if both U/S and clinical examination are normal.

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