



ROLE OF ULTRASOUND IN EVALUATION OF DEVELOPMENTAL DYSPLASIA OF THE HIP IN INFANTS

Radiology

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ABSTRACT

Role of ultrasound in evaluation of developmental dysplasia of the hip in infant

Aim : The aim of the study is to evaluate the role of ultrasonography in the evaluation of developmental dysplasia of hip in infants and diagnose it early to prevent permanent complications.

Materials and Methodology : This is a prospective study conducted in government medical college and new civil hospital, surat in which 50 infants between ages 1-6 months were included. patients were referred from orthopedics opd in our hospital for USG-hip, based on clinical assessment (mainly barlow & ortolani maneuvers). then the patient's hips were examined in USG scan. After that, dynamic (coronal and transverse) & static ultrasound views evaluated using graf's criteria.

RESULTS :

Out of the 50 referred patients, most of them were found to have stable hips (Graf Type I and Type II a+). Infants with unstable hips based on Graf's criteria (Type II a-, II b, II c and Type III a, Type IV, Type D) were approximately 20% of the study population.

Conclusion : Delayed treatment rates of DDH and complications could be reduced by the usage of the USG after the first month of life. In addition to physical assessment, USG for high-risk infants will provide more accurate diagnosis and minimize complications.

Discussion : Hip ultrasound has been extensively used for the diagnosis and management of neonatal hip instability and dysplasia. Ultrasound allows imaging of the hip morphology by displaying the acetabulum, which is not seen on a radiograph.

Once the diagnosis of neonatal hip instability and dysplasia has been made, ultrasound is very useful in monitoring the treatment and maturation of hip joint. Ultrasound seems to lead a shorter duration of treatment, which in some studies has been associated with reduction of complications, particularly Avascular necrosis.

KEYWORDS

INTRODUCTION:

- Developmental dysplasia of the hip (DDH) denotes aberrant development of the hip joint and results from an abnormal relationship of the femoral head to the acetabulum.
- Female predominance, and it usually occurs from ligamentous laxity and abnormal position in utero.
- It needs monitoring throughout childhood, adolescence, and even during adulthood. DDH represents the most frequent inborn deformity of the locomotor apparatus. Ultrasonographic techniques provide a more detailed visualization of anatomic features of the hip that are often not revealed by the radiographic examination.
- Plain radiography was the gold standard for the radiological diagnosis of developmental dysplasia of the hip (DDH) in all age groups.
- However, exposure to radiation and difficulties in the precise anatomical definition of the relationship between the cartilage femoral head and the cartilage and bony acetabular roofs were the two main disadvantages of the use of plain radiography during early infancy in DDH. Reinhard Graf from Stolzalpe, Austria developed his technique in the late 1970s and published his initial experiences concerning the use of hip ultrasonography for the early radiological diagnosis of DDH in the early 1980s.
- It is an acknowledged fact that earlier treatment for hip dysplasia carries a higher probability of success. Ideally, therefore, the condition should be diagnosed within the first six weeks of life. Ultrasonography can detect the hip problems that can be missed by clinical and radiographic examinations. As early and accurate diagnosis of DDH is believed to be the most important point for satisfactory treatment, hip ultrasonography has become the most commonly used diagnostic tool for DDH during early infancy, and for many years.
- It is possible to make a multiplanar examination and to determine the position of the femoral head with respect to the acetabulum by using a real-time ultrasonography.

view of the flexed hip with and without stress. This enables an assessment of hip position, stability, and morphology when the study is correctly performed and interpreted. It should be noted that additional views and maneuvers can be obtained and that these may enhance the confidence of the examiner.

- Morphology is assessed at rest. The stress maneuvers follow those prescribed in the clinical examination of the hip and assess femoral stability.
- The attempts to dislocate the femoral head or reduce a displaced head are analogous to the Barlow and Ortolani tests used in the clinical examination. It is important that the infant is relaxed when hips are assessed for instability. It is acceptable to perform the standard examination with the infant in a supine or lateral position
- Coronal/neutral view
- Performed from the lateral aspect of the joint with the plane of the ultrasound
- Beam oriented coronally with respect to the hip joint.
- The femur is maintained with a physiologic amount of flexion. The transducer is placed on the lateral aspect of the hip, and the hip is scanned until a standard plane of section is obtained.
- The plane must precisely demonstrate the midportion of the acetabulum, with the straight iliac line superiorly and the inferior tip of the os ilium seen medially within the acetabulum. The echogenic tip of the labrum should also be visualized.
- The acetabular roof should have a concave configuration and cover at least half the femoral head. The cartilage of the acetabular roof is hypoechoic and extends lateral to the acetabular lip, terminating in the labrum, which is composed of fibrocartilage and is echogenic.
- When a hip becomes subluxed or dislocated, the femoral head gradually migrates laterally and superiorly, with progressively decreased coverage of the femoral head. In hip dysplasia the acetabular roof is irregular and angled, and the labrum is deflected superiorly and becomes echogenic and thickened. When the hip is frankly dislocated, the labrum may be deformed. Echogenic soft tissue is interposed between the femoral head and the bony acetabulum. A combination of deformed labrum and fibrofatty tissue (pulvinar) prevents the hip from being reduced.

MINIMUM ACR STANDARD EXAMINATION FOR DDH

- The diagnostic examination for DDH incorporates two orthogonal planes: a coronal view in the standard plane at rest and a transverse

- Coronal/Flexion View
- In the coronal/flexion view the transducer is maintained in a coronal plane with respect to the acetabulum, while the hip is moved to a 90-degree angle of flexion.
- During the assessment in this view, the transducer is moved in an anteroposterior direction with respect to the body to visualize the entire hip. Anterior to the femoral head, the curvilinear margin of the bony femoral shaft is identified.
- In the midportion of the acetabulum, the normally positioned femoral head is surrounded by echoes from the bony acetabular components. Superiorly, the lateral margin of the iliac bone is seen, and the transducer position must be adjusted so the iliac bone becomes a straight horizontal line on the monitor.
- This landmark (iliac bone line: flat and straight) is a key to accurately visualizing the midacetabulum and to obtaining the maximum depth of the acetabulum. When the transducer is positioned too anteriorly, the iliac line is inclined laterally, and if positioned too posteriorly, the iliac line exhibits some concavity.
- When the plane is not correctly selected, it could be falsely concluded that the acetabulum is maldeveloped. A normal hip gives the appearance of a "ball on a spoon" in the midacetabulum.
- The femoral head represents the ball; the acetabulum forms the bowl of the spoon; and the iliac line is the handle. When the transducer is moved posteriorly and the scan plane is over the posterior margin of the acetabulum, the posterior lip of the triradiate cartilage becomes an easily recognized landmark. The bone above and below the cartilage notch is flat, and the normally positioned femoral head is not visualized.
- In subluxation the femoral head is displaced laterally, posteriorly, or both, with respect to the acetabulum. Soft tissue echoes are seen between the femoral head and the bony reflections from the medial acetabulum.
- In dislocation the femoral head is completely out of the acetabulum. With superior dislocations, the femoral head may rest against the iliac bone. In posterior dislocations, the femoral head is seen lateral to the posterior lip of the triradiate cartilage.
- The acetabulum is usually not visualized in a dislocation because the bony shaft of the femur blocks the view.



- Transverse/Flexion View
- The transverse/flexion view is accomplished by rotating the

transducer 90 degrees and moving the transducer posteriorly so it is in a posterolateral position over the hip joint.

- Sonographically, the bony shaft and metaphysis of the femur give bright reflected echoes anteriorly, adjacent to the sonolucent femoral head. The echoes from the bony acetabulum appear posterior to the femoral head, and in the normal hip, a U-shaped configuration is produced by the metaphysis and the ischium.
- The relationship of the femoral head and acetabulum is observed while the flexed hip is moved from maximum adduction to wide abduction. The sonogram changes its appearance in abduction and adduction. The deep, U-shaped configuration is produced with maximum abduction, whereas in adduction, a shallower, V-shaped appearance is observed.
- It is important to have the transducer positioned posterolaterally over the hip to see the medial acetabulum. When the transducer is not posterior enough, the view of the acetabulum is blocked by the femoral metaphysis, and the hip can appear falsely displaced. In adduction the hip is stressed with a gentle posterior push (a Barlow test).
- In the normal hip the femoral head will remain deeply in the acetabulum in contact with the ischium with stress. In subluxation the hip will be normally positioned or mildly displaced at rest, and there will be further lateral displacement from the medial acetabulum with stress, but the femoral head will remain in contact with a portion of the ischium.
- In frank dislocation the hip will be laterally and posteriorly displaced to the extent that the femoral head has no contact with the acetabulum, and the normal U-shaped configuration cannot be obtained. The process of dislocation and reduction is able to be visualized in unstable hips in the transverse/flexion view. With abduction, the dislocated hip may be reduced, and this represents the sonographic counterpart of the Ortolani maneuver.

Transverse/Neutral View

- The transition from the transverse/flexion view to the transverse/neutral view is accomplished by bringing the leg down into a physiologic neutral position. The transducer is directed horizontally into the acetabulum from the lateral aspect of the hip.
- The plane of interest is one that passes through the femoral head into the acetabulum at the center of the triradiate cartilage.
- In the normal hip the sonolucent femoral head is positioned against the bony acetabulum over the triradiate cartilage. The elements of the sonogram resemble a flower. The femoral head represents the "bloom," and the echoes (from the ischium posteriorly and pubis anteriorly) form the "leaves" at its base. The "stem" is formed by echoes that pass through the triradiate cartilage into the area of acoustic shadowing created by the osseous structures. When an ossific nucleus is present, echoes appear within the femoral head.
- In the transverse/neutral view, malpositioned hips show soft tissue echoes between the femoral head and acetabulum. With subluxation, the femoral head usually moves posteriorly and, in mild cases, remains in contact with the posterior aspect of the acetabulum. Most dislocations are lateral, posterior, and superior. Often, the dislocated head rests against some portion of the bony ilium. In this case, reflected echoes from the bone are apparent medially. Inability to find the hypoechoic gap of the triradiate cartilage distinguishes this hip from the normal hip. With some lateral dislocations, the femoral head does not rest against bone, and soft tissue echoes completely surround the sonolucent head.

Graf method

- The infantile hip ultrasonography method of Graf is the one that was defined first and is perhaps the most widely used. The Graf method should be performed by using a linear array probe in the lateral decubitus position. The sonogram reflects the position of the resting hip joint in the frontal plane and the anatomical landmarks have been clearly defined. Before starting to classify the hip joint, it is essential to identify the eight anatomical landmarks;
- 1) chondro-osseous junction,
 - 2) femoral head,
 - 3) synovial fold,
 - 4) hip joint capsule,
 - 5) acetabular labrum,
 - 6) acetabular hyaline cartilage,
 - 7) acetabular bony roof and
 - 8) acetabular bony rim

If a sonogram contains a clearly visible lower limb of the bony ilium in

the depth of the acetabular fossa, as well as an apparent acetabular labrum and a straight iliac wing contour, this means that it has a standard plane. If the anatomical identification cannot be made or the standard plane is missing in a sonogram, it is of no value and must not be used for diagnosis.

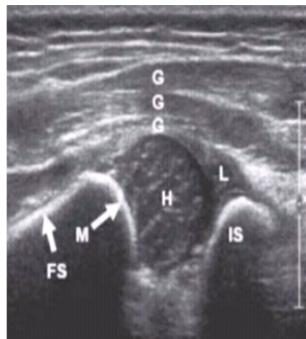
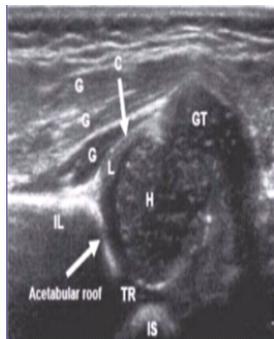
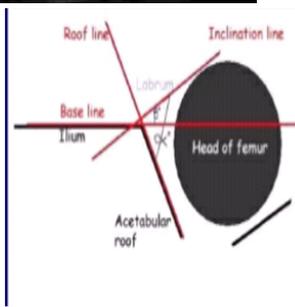
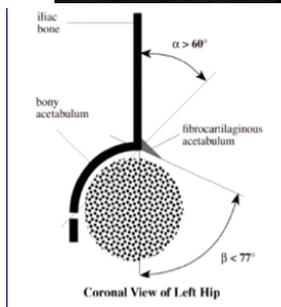
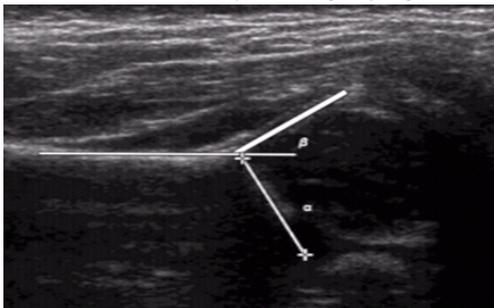
- Normally positioned femoral head is more than 50% covered by the acetabulum. DDH results in a shallow acetabulum and decreased coverage of the femoral head.

Graf α Angle :

- The Graf α angle is measured in the coronal plane and is defined as the angle formed between the vertical cortex of the ilium and the acetabular roof. An α angle less than 60° is abnormal and reflects a shallow acetabulum. The modified Graf grading classification is based on the α angle and degree of acetabular roof coverage.

Graf β Angle :

- The Graf β angle is formed by a line through the vertical ilium and the cartilaginous acetabular labrum. A Graf β angle greater than 55° is abnormal. With superolateral femoral head displacement, the labrum is elevated, thereby increasing the β angle.



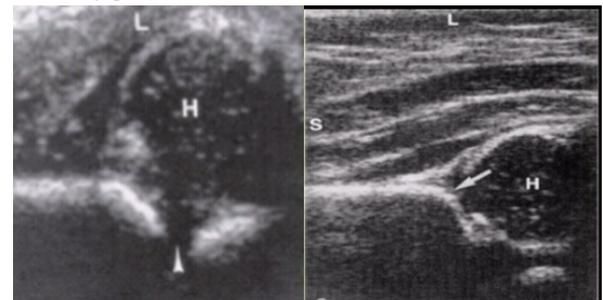
- Transverse view
- G- gluteus muscle
- H- femoral head
- IS- ischium
- L- labrum
- FS- femoral shaft
- M – femoral metaphysis
- Coronal view
- C- capsule
- G- gluteus muscle
- GT- greater trochanter
- H- femoral head
- IL- ileum
- IS- ischium
- L- labrum
- Tr- triradiate cartilage

Hip type	Description	Bony roof	Bony rim	Cartilage roof	α angle	β angle	Subtype
Type I	Mature hip	Good	Angular/ blunt	Covers the femoral head	$\geq 60^\circ$	$< 77^\circ$	Ia: $\beta \leq 55^\circ$ Ib: $\beta > 55^\circ$
Type Ila	Physiologically immature (age ≤ 3 months)	Deficient	Rounded	Covers the femoral head	$50^\circ - 59^\circ$	$> 55^\circ$	Ila+: $\alpha = 55^\circ - 59^\circ$ (at 6 weeks of age) Ila-: $\alpha = 50^\circ - 54^\circ$ (at 6 weeks of age)
Type Iib	Delay of ossification (age > 3 months)	Deficient	Rounded	Covers the femoral head	$50^\circ - 59^\circ$	$> 55^\circ$	
Type Iic	Critical hip	Severely deficient	Rounded to flattened	Still covers the femoral head	$43^\circ - 49^\circ$	$< 77^\circ$	Iic stable: under pressure $\beta < 77^\circ$ Iic unstable: under pressure $\beta > 77^\circ$
Type D	Decentring hip	Severely deficient	Rounded to flattened	Displaced	$43^\circ - 49^\circ$	$> 77^\circ$	
Type III	Dislocated hip	Poor	Flattened	Pressed upwards, perichondrium slopes cranially	$< 43^\circ$		IIIa: hypoechoic cartilage acetabular roof IIIb: hyperechoic cartilage acetabular roof
Type IV	Dislocated hip	Poor	Flattened	Pressed downwards, perichondrium is horizontal or dips caudally	$< 43^\circ$		

- Other methods used were :
- Harcke method : Different views are :

Frontal neutral view: frontal section of the hip joint in the neutral position.

- **Frontal flexion view:** frontal section of the hip joint in 90° flexion.
- **Transverse neutral view:** transverse section of the hip joint in the neutral position
- **Transverse flexion view:** transverse section of the hip joint in 90° flexion.
- combination of two views in perpendicular planes is essential for making the diagnosis
- **Terjesen method :** Static and dynamic scanning in the frontal and transverse planes are performed . This method includes numeric measurements as well as qualitative descriptions.
- **Suzuki method :** simultaneous examination of both hips using a large linear probe by an anterior approach
- Previously mentioned methods, except the Graf method, include mostly qualitative definitions.



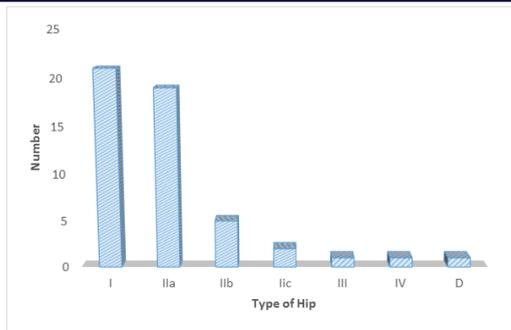
Lateral displacement of femoral head



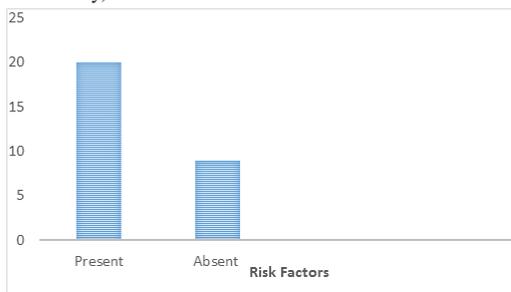
α angle appears abnormal with shallow acetabulum.

RESULTS :

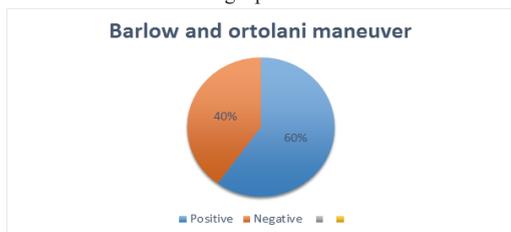
- The main clinical findings found among participants with the positive USG were clicking hip and limitation of abduction and/or positive family history as risk factors.
- Of the 50 had(32 females and 18 males) referred newborns who underwent ultrasonographic screening after orthopaedic assessment ,40 had(26 females and 14 males) one or both hips classified as type I(n = 21) or Ila (n = 19). the remaining 10 were type 2b (n = 5); type 2c (n = 2); type D (n = 1); type 3a (n = 1); or type 4 (n = 1). Among 50 patients 16 had bilateral involvement.



- Of the 29 patients with at least one hip that was type IIa or higher, 9 had no risk factors for CDH, 20 had histories of a risk factor (breech presentation at the time of delivery or throughout pregnancy, First-degree relatives with CDH, malposition in utero, Prematurity, diabetic mother).



Out of 10 patients with type IIb or higher , 6 Patients had positive Barlow or Ortolani maneuver in clinical assessment. negative results were observed for the remaining hips



- The age at diagnosis ranged from 14 to 90 days. Among 29 patients with type IIa or higher, DDH was diagnosed before the age of 3 weeks in 44.8% (n = 13) of the infants and between the ages of 3 and 8 weeks in 55.2% (n = 16). Treatment was begun at the time of diagnosis.
- After two months, ultrasound revealed spontaneous evolution towards normal bone coverage in 92% of the Graf type 2a+/2a – hips. In the remaining cases (8%), bone coverage was achieved by means of soft retractor devices.
- Type 2b, 2c, D, 3a and 4 hips were followed up after 2 month of treatment, the ultrasound examination revealed a mature hip in 4 patients out of 10 patients. Rest of 6 patients showed incomplete recovery.

DISCUSSION :

- Hip ultrasound has been extensively used for the diagnosis and management of neonatal hip instability and dysplasia . Ultrasound allows imaging of the hip morphology by displaying the acetabulum ,which is not seen on a radiograph.
- compared with clinical examination (based on the Ortolani and Barlow maneuvers), ultrasound screening techniques lead to the identification of a higher number of cases of DDH.
- For many years early screening for CDH in all parts of the world was based on the Ortolani and Barlow maneuvers.
- When a newborn without risk factors and obtaining negative clinical findings, presents a positive clinical sign for hip dysplasia, late diagnosis will invariably ensue. The aim, however, is to diagnose the disorder as early as possible. Our experience shows that early treatment of CDH, made possible by ultrasound screening, can produce complete recovery of hip stability after few months of treatment.
- Early diagnosis of hip instability is fundamental in preventing the onset of DDH.Indeed, the duration of treatment was shorter in patients treated at an early age, surgery was not required, and

complication rate were reduced. Moreover, majority of the infants started to walk at the same mean age as children without hip disorders.

- DDH refers to a broad spectrum of conditions from mild acetabular dysplasia to irreducible hip dislocation. Screening programmes for DDH still vary worldwide and more large-scale, longitudinal studies are needed to allow standardisation of policy across regions. Ultrasound imaging allows DDH classification based upon alpha/beta angles and the DCI. The appropriate management of DDH can have lasting consequences for lifetime morbidity.
- Delayed treatment rates of DDH and complications could be reduced by the usage of the USG after the first month of life. In addition to physical assessment, USG for high-risk infants will provide more accurate diagnosis and minimize complications.

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