American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Developmental Dysplasia of the Hip—Child**

Variant 1: **Patient younger than 4 months of age, positive physical findings (Ortolani or Barlow maneuvers).**

Radiologic Procedure	Rating	Comments	RRL*
US hips bilateral	7	Prefer to wait until the patient is at least 2 weeks of age to perform the US.	None
X-ray hips bilateral	2	AP view.	Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: **Patient younger than 4 months of age, equivocal physical findings.**

Radiologic Procedure	Rating	Comments	RRL*
US hips bilateral	8	Prefer to wait until the patient is at least 2 weeks of age to perform the US.	None
X-ray hips bilateral	2	AP view.	Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 3: **Patient younger than 4 months of age, breech presentation or positive family history. Without physical findings.**

Radiologic Procedure	Rating	Comments	RRL*
US hips bilateral	6	Prefer to wait until the patient is at least 2 weeks of age to perform the US.	None
X-ray hips bilateral	2	AP view.	Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 4: **Patient 4 months of age or older, clinically suspicious for DDH (limited abduction or abnormal gait).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray hips bilateral	8	AP view.	Med
US hips bilateral	3		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Developmental Dysplasia of the Hip—Child**

Variant 5: **Clinically suspicious for teratogenic dysplasia.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray hips bilateral	8	AP view.	Med
US hips bilateral	5		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

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Summary of Literature Review

Definition

Developmental dysplasia of the hip (DDH), formerly known as congenital dislocation of the hip, comprises a spectrum of abnormalities including abnormal acetabular shape (dysplasia) and malposition of the femoral head, ranging from dislocatable hip and mild subluxation to fixed dislocation.

Incidence

DDH affects 1.5 per 1,000 of the American Caucasian population; it less frequently affects African Americans. It is four to eight times more common in females. It is also more common in patients with a family history of DDH, in first-borns, in large infants, and in infants with a history of oligohydramnios. It is three times more common in the left hip than the right, likely due to the normal left occiput anterior position in utero, which places the left hip against the mother's spine and limits its abduction.

Etiology

The origin and pathogenesis of DDH are probably multifactorial. Abnormal laxity of the ligaments and hip capsule is seen in patients and families with DDH. The maternal hormone relaxin may also be a factor. Mechanical factors of reduced in utero space and movement restriction are thought to be causative in conditions such as oligohydramnios and being first born. Extreme hip flexion with knee extension, as in breech position, tends to promote femoral head dislocation and leads to shortening and contracture of the iliopsoas muscle.

Natural History

The natural history of DDH depends on the type and degree of hip abnormality. Mild dysplasia may never manifest clinically or become apparent until adult life, whereas severe dysplasia is most likely to present clinically during childhood. Most DDH identified during the newborn period represents hip laxity and immaturity. Sixty to eighty percent of abnormalities identified by physical examination and more than 90% that are identified by ultrasound (US) resolve spontaneously [1-5]. Untreated subluxed and dislocated hips can lead to early degenerative joint disease and impaired function.

Diagnosis

The diagnosis of DDH may be made by clinical examination or by imaging methods such as radiography or US. The timing and the selection of patients requiring imaging evaluation are controversial.

Clinical Evaluation

The clinical evaluation of the hips for DDH should be performed at each well-baby visit. The American Academy of Pediatrics recommends a well-baby visit at 1-2 weeks, and at 2, 4, 6, 9, and 12 months of age. As part of the clinical evaluation, it is important to elicit risk factors for DDH. Examination findings suggesting DDH include a positive Ortolani or Barlow test, asymmetric skin folds, and shortening of the thigh observed on the dislocated side. The Ortolani test consists of abducting and gently lifting the flexed thigh and pushing the greater trochanter anteriorly; this test is designed to enable the already dislocated hip to be detected by causing the femoral head to slip into the acetabulum; a "clunk" should be felt or heard. The second test, introduced by Barlow, consists of a gentle maneuver, with the thumb of one hand placed over the femoral neck and the fingers placed over the greater trochanter to try to 1) gently adduct the thigh and dislocate the femoral head posteriorly, and then 2) gently lift the thigh upward while abducting the leg with the fingers over the greater trochanter, endeavoring to relocate the femoral head in its socket. The Barlow test aims to elicit a dislocation followed by reduction and identifies unstable hips missed by the Ortolani test. Both tests are designed to detect instability between the femoral head and acetabulum, indicating ligamentous or capsular laxity.

In children older than 3 months of age, these tests are less likely to be positive. In the over 3-month age group, limitation of hip abduction and asymmetric thigh folds secondary to shortening are more useful clinical signs of DDH. Once a child is walking, there is a typical limp, and the child often toe-walks on the affected side. If both hips are dislocated, increased lumbar lordosis, prominent buttocks, and a waddling gait pattern are present. The physical exam may reveal a stable "clicking" hip—that is, a hip with no laxity but with a "click" elicited by the physical exam. The sensitivity and specificity of the

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clinical examination depend on the expertise of the evaluator. Effectiveness of clinical screening varies, depending on whether an orthopedic surgeon, experienced pediatrician, or intern performs the examination [6-8].

Radiographic Evaluation

In the first month of life, when the femoral heads are composed entirely of cartilage, radiographs are of limited value unless a dislocation is present. Instability may be undetectable, and evaluation of acetabular development is influenced by the infant's position at the time the x-ray is taken. By 4 to 6 months of age, radiographs become more reliable. They are readily available and relatively low in cost. Radiographs may be performed on patients with neuromuscular disorders, myelodysplasia, or arthrogryposis (teratologic dislocation) to assess other bony abnormalities.

Radiography of the pelvis should be obtained with hips in neutral position. The von Rosen view, with legs at a 45-degree angle, abduction, and thighs internally rotated, may be helpful in accentuating a dislocated hip that may not be apparent on routine views. Frog-leg view may be obtained to assess reduction when neutral view is abnormal.

Dislocation or subluxation of the femoral head can be recognized by evaluating the relationship of the ossific nucleus of the femoral head and metaphysis to the acetabulum. The nucleus of the femoral head ossifies at approximately 4 months (50^{th} percentile), with a normal range of 2 to 8 months [9]. The ossified femoral head nucleus allows easy evaluation of the relationship of the femoral head to the acetabulum. However, if the nucleus of the femoral head is not ossified, its position can be estimated. In addition to evaluating the relationship of the ossific nucleus of the femoral head, the relationship of the proximal femoral metaphysis to the acetabulum must also be evaluated [10].

As the child grows, adaptive changes of the hip joint and femur become more evident on routine radiography. In DDH, the roof of the acetabulum is vertically oriented, and often there is a delay in the appearance and growth of the ossific nucleus of the femoral head, as compared to the normal hip.

The radiographic evaluation consists predominantly of a visual assessment; however, measurement of the acetabular index is an objective parameter that may be used in the diagnosis and follow-up of patients with DDH. The 95% tolerance interval for intraobserver variability is 8.35 degrees, with interobserver variability exceeding intraobserver variability; this measurement error casts doubt on the reliability of the acetabular index based on a single reading [11,12].

Ultrasound Evaluation

A high-frequency linear array transducer should be used for US evaluation of the hip. Two methods have emerged: an acetabular morphology method proposed by Graf and a dynamic stress technique.

In 1980, Graf [13] described a method of static US imaging in the coronal plane. In normal hips, the round, hypoechoic, speckled femoral head lies centered in the acetabulum. The Graf method is based on a single coronal image. The position of the femoral head, appearance of the bony acetabulum, and configuration of the cartilaginous acetabular rim, position of the cartilaginous labrum, and shape and echogenicity of the cartilaginous roof are all assessed, and the hip is assessed visually. An important adjunct in the evaluation of the hips by this method is the alpha angle. This angle is obtained by drawing a line along the lateral aspect of the ilium and another line from the lower iliac margin in the acetabular fossa to the lateral edge of the bony acetabular roof [14,15].

Graf developed a morphologic and geometric hip classification scheme (types I-IV) using an alpha angle, which measures the osseous acetabular roof angle, and a beta angle, which defines the position of the echogenic fibrocartilaginous acetabular labrum. The hips are categorized according to the following classification:

- Type I hips are normal and require no treatment and no follow-up; the alpha angle is greater than 60 degrees.
- Type II hips are further subdivided into subtypes IIa, IIb, IIc, and D. In subtype IIa, seen in infants less than 3 months of age, the hip is normally located, but the bony acetabulum is immature (the alpha angle is between 50 and 59 degrees). These patients require no treatment, but there is a small risk of delayed displacement or acetabular dysplasia in this group; therefore, follow-up is advised. Subtype IIb, IIc, and D hips all require referral for treatment.
- Type III hips (low displacement) and type IV hips (high displacement) are usually very apparent clinically, and both require immediate treatment. The alpha angle should be less than 43 degrees.

Interobserver variability of subjective evaluation and of acetabular angle measurements [16-19] raises concerns about the operator dependence of US evaluation for DDH and may explain the variability of US screen-positive rates found in the literature.

Harcke and Grissom [20] and others developed the dynamic or real-time method, which attempts to visualize the Barlow and Ortolani maneuvers on US. This technique is performed in both the coronal and transverse planes, with and without stress. The modified Barlow maneuver is performed by holding the knee with the hip

flexed 90 degrees and in adduction. The femur is pushed (pistoned) posteriorly.

In 1993, at a meeting at the Alfred I. duPont Institute in Wilmington, Delaware, a North American standard for hip US was agreed upon which combines the two techniques. The standard consists of 1) a coronal view in the Graf format and 2) a transverse view with the hip flexed, with and without modified Barlow stress maneuver [14].

Other Imaging Modalities

Computed tomography (CT) and magnetic resonance imaging (MRI) may be used to evaluate DDH in patients in casts following surgery or attempted closed reduction to confirm that the hip has been successfully reduced, late presentations, complex hip dislocations, or avascular necrosis. The primary use of CT in DDH is for follow-up purposes rather than for initial diagnosis. MRI may be used in complex dislocations and suspected avascular necrosis. Arthrography is used primarily in the operating room by the orthopedic surgeon to evaluate lateral displacement of the femoral head and congruity following closed reduction of the hip, and to assess for labral infolding that might prevent proper reduction.

Timing of Evaluation

The goal of a screening program is to detect all patients with DDH early on, when therapy is most effective and noninvasive, and to eliminate those patients without DDH in whom unnecessary treatment may be costly and harmful. Delayed diagnosis increases the risk of complications, and infants diagnosed after 6 months of age often require surgical correction. Two types of screening can be performed: generalized screening in which all neonates are evaluated, and selective screening in which only those at high risk are evaluated.

Generalized Screening

Clinical Evaluation

Currently, every neonate undergoes a routine physical examination that includes evaluation of the hips for stability. Despite neonatal physical examination screening programs, late presentation of DDH has not been eliminated. The incidence of late diagnosis with screening remains within the same range as that of late diagnosis without screening, albeit at the lower margin [21]. However, it seems beyond debate that these clinical tests for dislocation and dislocatability are far from accurate in identifying future cases of unequivocal dislocation of the hip.

Radiographic Evaluation

There is no established role for the use of radiographs for generalized screening for DDH.

Ultrasound Evaluation

Despite some authors' results, the routine use of US in screening all neonates and infants cannot be recommended [21-24].

The major objectives of adding US to the evaluation of patients with DDH are to reduce the incidence of late diagnosis and to reduce the number of normal hips being treated.

Two randomized trials have addressed primary US screening. When compared to clinical evaluation, US more frequently detects DDH at an early stage and decreases the number of surgical interventions. Both studies found no significant difference in the rates of detection of late DDH in infants screened with US versus those scre7ened with high-quality serial physical examinations [25,26]. However, both studies did find higher rates of abduction splinting and follow-up in the clinical evaluation group. This finding is also supported by systematic reviews of prior studies [21-24,27]. Some of these infants may be over diagnosed [21-24,27]. The long-term outcome for those who are treated for a disorder they do not have is an important consideration, since iatrogenic avascular necrosis of the femoral head may affect treated children and, in its severest forms, may lead to premature osteoarthritis [21,23].

Selective Screening

Clinical Evaluation

All infants should be evaluated by physical examination at well-baby visits during the first year of life. A normal physical examination does not preclude the development of a dysplastic hip in an infant [3,8]. Therefore, imaging (by radiography or US) should be performed despite a normal physical exam in all infants at risk. Because instability often resolves spontaneously by 2 weeks of age, evaluation for instability should not take place before then.

Radiographic Evaluation

By 6 weeks of age, radiographic changes in the acetabulum and lateral displacement of the femoral neck and metaphysis can be recognized [28]. A radiographic screening program can be successfully implemented for infants at 4 months of age who were clinically normal at the neonatal exam but are considered to be at risk for DDH [29].

Ultrasound Evaluation

Risk factors for DDH include breech presentation and positive family history. The American Academy of Pediatrics recommends hip imaging for female infants born in the breech position, and optional hip imaging for males born in the breech position or for females with a positive family history of DDH [22,24].

Selective US screening can identify DDH in children with high risk for DDH and negative physical examination

[30,31]. However, selective US screening has not been shown to significantly reduce diagnosis of late DDH [2,30,32-34].

In a 10-year prospective study of 34,723 British infants, 2,578 with clinical instability or risk factors were imaged with US. Instability was present in 77, of whom only 31% had a risk factor. The authors concluded that selective US examination may be justified for infants with clinical instability, family history of DDH, breech presentation, or postural foot deformity [35]. In an Irish study of 52,893 infants, US examination was performed on 5,485 infants who had a first-degree relative with DDH, breech presentation, or a persistent "click" in an otherwise stable hip. Eighteen (0.33%) were found to have dislocated hips, and 153 (2.78%) were found to have dysplastic hips. Based on the finding that 3.2 of 1,000 infants required treatment, the authors conclude that US screening in infants with such risk factors is worthwhile [30].

The value of selected US screening in infants with positive physical examinations was addressed in a 33-center study by the United Kingdom Hip Trial [36]. The study found that the use of US examinations in infants with clinically detected hip instability allowed a reduction in abduction splinting and was not associated with an increase in abnormal hip development or higher rates of surgical treatment [36]. This policy was found to reduce costs [37].

Treatment

It is widely assumed that early treatment results in improved outcome. Although there is agreement in the literature that patients with dislocation should be treated and that those with stable "clicking" hips should be followed clinically, there is some disagreement regarding the treatment of patients with unstable (lax, but not displaced) hips. Some advocate early treatment for every patient with instability [38]. Others prefer clinical observation [39], because a significant number of these patients (80%) progress spontaneously to clinically normal status [40].

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations	
Relative Radiation Level	**Effective Dose Estimate Range**
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

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