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American College of Radiology
ACR Appropriateness Criteria®

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

Variant 1: **Patient younger than 4–6 months of age, positive physical findings (Ortolani or Barlow maneuvers).**

Radiologic Procedure	Rating	Comments	RRL*
US hips	8	This procedure is preferably used in patients 4–6 weeks of age.	O
X-ray pelvis	2		☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 2: **Patient younger than 4–6 months of age, equivocal physical findings.**

Radiologic Procedure	Rating	Comments	RRL*
US hips	8	This procedure is preferably used in patients 4–6 weeks of age.	O
X-ray pelvis	2		☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 3: **Patient younger than 4–6 months of age, female with breech presentation (primiparae most at risk), or positive family history without physical findings.**

Radiologic Procedure	Rating	Comments	RRL*
US hips	8	This procedure is preferably used in patients 4–6 weeks of age.	O
X-ray pelvis	2		☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 4: **Patient 4–6 months of age or older, clinically suspicious for DDH (limited abduction or abnormal gait).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray pelvis	8	In this procedure, consider using no shield for the first examination only. A single AP view is usually sufficient.	☢☢
US hips	3	This procedure can be used if the femoral heads are not yet ossified.	O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

DEVELOPMENTAL DYSPLASIA OF THE HIP—CHILD

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Summary of Literature Review

Introduction/Background

Definition

Developmental dysplasia of the hip (DDH), formerly known as congenital dislocation of the hip, comprises a spectrum of abnormalities that include abnormal acetabular shape (dysplasia) and malposition of the femoral head, ranging from dislocatable hip and mild subluxation to fixed dislocation [1,2].

Incidence

It is difficult to assess the true incidence of DDH, as the definition varies and there is no gold-standard test. Incidence varies from 1.5 to 20 in 1,000 births [3]. In the United States, DDH affects approximately 1.5 of 1,000 Caucasians but is less frequent among African Americans. It is 4–8 times more common in females, patients with a family history of DDH, first-born children, infants born in the breech presentation (particularly primiparae breech, as frank breech is the most common position and leads to the greatest risk), large infants, and infants with a history of oligohydramnios. It occurs 3 times more frequently in the left hip than in the right, likely due to the normal left occiput anterior position *in utero*, which places the infant's left hip against the mother's spine and limits its abduction [1].

Etiology

The origin and pathogenesis of DDH are multifactorial. Abnormal laxity of the ligaments and hip capsule is seen in patients with DDH. The maternal hormone relaxin may also be a factor. Causes of oligohydramnios are thought to be reduced *in utero* space, movement restriction, and being a first-born child. Extreme hip flexion with knee extension, as in the breech position, tends to promote femoral head dislocation and leads to the shortening and contracture of the iliopsoas muscle [1,2].

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. Approximately 60%–80% of abnormalities identified by physical examination and more than 90% identified by ultrasound (US) resolve spontaneously [4-7]. Untreated subluxed and dislocated hips can lead to early degenerative joint disease and impaired function.

Diagnosis

Clinical examination or imaging methods, such as radiography or US, can be used to diagnose DDH.

Clinical Evaluation

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. Findings suggesting DDH include asymmetric skin folds in the proximal thigh and shortening of the thigh on the dislocated side. Confirmatory findings include a positive Ortolani test or a positive Barlow test. The Ortolani maneuver is used to

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determine whether the femoral head shifts in and out of the acetabulum. If the femoral head is positioned out of the acetabulum in the resting position (dislocated), but can be placed into the acetabulum during the Ortolani maneuver (often with a "clunk" that can be felt), it is considered to be a positive Ortolani test. If the femoral head is located in the acetabulum at rest, but can be displaced out of the acetabulum during the Ortolani maneuver due to joint capsule laxity, it is considered to be a positive Barlow test.

In children >3 months of age, these tests are unlikely to be elicited. 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 sensitivity and specificity of the clinical examination depend on the expertise of the evaluator. An inexperienced examiner may have difficulty differentiating the "clunk" felt during the Ortolani maneuver in a dislocated hip and a nonspecific "click" felt during the same maneuver. This "click" may be related to the psoas tendon, ligamentum teres, or fascia lata in extremes of abduction but is not reflective of an unstable hip. Effectiveness of clinical screening varies, depending on whether an orthopedic surgeon, experienced pediatrician, or intern performs the examination [1,2,8-10].

Radiographic Evaluation

Radiographs are readily available and relatively low in cost. The main limitations are radiation exposure and radiography's inability to demonstrate the cartilaginous femoral head. Radiographs are of limited value during an infant's first 3 months of life, when the femoral heads are composed entirely of cartilage, but they become more reliable for use in infants 4–6 months of age, with the appearance of femoral head ossification [1,2].

Radiographs may be performed to assess the hips in children with a clinical diagnosis of DDH, to monitor hip development after treatment, and to assess longer-term outcomes. Radiographs are also valuable for assessing other bony abnormalities in patients who have neuromuscular disorders, myelodysplasia, or arthrogryposis (teratologic dislocation) [1,2]. The imaging assessment (radiographic and sonographic) of hip dysplasia in this population is similar to the assessment of variants of DDH in an otherwise healthy child.

An anteroposterior (AP) radiograph of the pelvis should be obtained with the hips in a neutral position. To visualize all structures in a young child, consideration should be given to taking the first radiograph without a shield. In a child with developed ossified epiphyseal nuclei and a widened joint space (subluxated but not a frankly dislocated hip), an abduction internal rotation view may be obtained to confirm that the femoral head can be positioned deeply within the acetabulum. On the AP pelvis radiograph, measurement of the acetabular index is an objective parameter that can be used in the diagnosis and follow-up of patients with DDH. However, interobserver variability casts doubt on the reliability of the acetabular index based on a single reading [11,12].

Ultrasound Evaluation

US evaluation of the hip is performed using a high-frequency linear array transducer. Two methods have emerged: a static acetabular morphology method proposed by Graf and a dynamic stress technique proposed by Harcke [13-15].

The Graf method is based on a single coronal image. 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 different categories can be grouped into 3 types [15]:

- *Normal hip*: Type I hips are normal and require no treatment. The alpha angle is greater than 60°.
- *Immature hip:* Type IIa hips are seen in infants <3 months of age. The hip is normally located, but the bony acetabulum promontory is rounded and the alpha angle is 50°–59°. These patients require no treatment, and there is a small risk of delayed DDH. Follow-up is recommended to confirm normal development.
- *Abnormal hip:* Type IIb has similar features to type IIa, but it is detected in children >3 months of age. Types IIc, D, III, and IV represent progressive abnormal hips with frank subluxation in types III and IV. The alpha angle is <50° in types IIc and D and <43° in types III and IV.

Interobserver variability [14,16-18] raises concerns about the operator dependence of US evaluation for DDH and could explain the variability of US screen-positive rates reported in the literature.

Harcke [19] developed the dynamic or real-time method, using US to attempt to visualize the Barlow and Ortolani maneuvers. 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° and in adduction. The femur is pushed (pistoned) posteriorly. The ACR guidelines for hip US combine the static and dynamic techniques [13].

US during an infant's first 4 weeks of life often reveals the presence of minor degrees of instability and acetabular immaturity in a normal hip; however, nearly all of these resolve on follow-up. To increase the reliability of this test, it is recommended that US studies be performed when infants are 4–6 weeks of age [1].

Other Imaging Modalities

Computed tomography (CT) and magnetic resonance imaging (MRI) can be used to evaluate DDH in patients with casts, following surgery for closed reduction, to confirm that the hip has been successfully reduced [20]. CT and MRI can also be used to evaluate complex hip dislocations, for presurgical planning, and for evaluation of avascular necrosis (AVN) [21,22].

Arthrography

Following closed reduction of the subluxated or dislocated hip, the orthopedic surgeon uses arthrography to confirm concentric position of the femoral head and assess the depth and stability of the reduction and shape of the labrum for infolding. If the closed reduction does not result in a stable congruent joint, the surgeon may move to an open reduction to improve hip alignment.

Ultrasound Screening for Developmental Dysplasia of the Hip

There is no consensus on the best screening method for DDH [3,23]. The goals of a screening program are early detection in all patients who have DDH, when therapy is most effective and noninvasive, and identification of patients without DDH, for whom unnecessary treatment could be costly and harmful. Delayed diagnosis increases the risk of complications, and infants diagnosed after 6 months of age often require surgical correction. However, screening carries potential harm. Most of the clinically and US-detected cases of DDH will resolve spontaneously [4-7]; therefore, screening can lead to overtreatment. The most common and serious complication of nonsurgical treatment is AVN [1-3,23]. Choosing the best method of screening is a complex decision, as evidenced by a recent United States Preventive Services Task Force that was "unable to assess the balance of benefits and harms of screening" for DDH [3]. Two types of screening can be performed: universal screening, in which all neonates are evaluated, and selective screening, in which only those at high risk are evaluated [1-3,23].These types of screening apply to both physical and sonographic assessment.

Universal Ultrasound Screening

Universal US screening for DDH in newborns is performed in some European countries [24]. Universal screening increases DDH detection, which leads to higher rates of treatment with abduction splinting; however, there is no evidence that it reduces the time to diagnose DDH [1-3,25-28]. This may lead to increased expense, unnecessary treatment, and increased post-treatment complications of AVN [1,3,23]. For these reasons, the American Academy of Pediatrics did not recommend universal screening [1].

Selective Ultrasound Screening

Risk Factors

Risk factors for DDH include breech presentation, positive family history, and female gender. Additional risk factors include maternal primiparity, oligohydramnios, and congenital anomalies [1,2]. 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 females with a positive family history of DDH [1,26].

Selective US screening can identify DDH in children at high risk for DDH who have had a negative physical examination [29,30]. However, selective US screening has not been shown to significantly reduce the time to diagnose DDH [4,29,31-33].

Positive Physical Examination

The American Academy of Pediatrics guideline published in 2000 did not recommend US screening after a positive physical examination. However, recent studies have shown that 41%–58% of abnormal findings from a physical examination were negative when US was used, thus leading to unnecessary treatment [34,35]. A prospective 33-center United Kingdom Hip Trial [36] addressed the value of selected US screening in infants following a positive physical examination. It found that US examinations in infants with clinically detected hip

instability allowed for 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. There is agreement in the literature that patients who have a hip dislocation should be treated and that those who have stable, "clicking" hips should be followed clinically; however, there is some disagreement regarding the treatment of patients who have unstable (lax, but not displaced) hips ("Barlow-positive"). Some authors advocate early treatment for every patient who has instability [38]. Others prefer clinical observation [39] because a significant number of these patients (80%) progress spontaneously to a clinically normal status [40].

Summary

- Recent studies show that 41%–58% of abnormal findings from physical examinations were negative in US studies, thus confirming the value of US evaluation.
- A study by the United Kingdom Hip Trial [36] found that US screening was associated with reduced abduction splinting in infants with a clinically detected hip instability and was not associated with an increase in abnormal hip development or higher rates of surgical treatment.
- Performing hip US in children following a positive physical examination was found to reduce costs [36].
- Based on a thorough review of the literature, Children's Hospital of Boston, Massachusetts, published a decision-tree analysis. Fold-back analysis and sensitivity analysis were performed. Researchers concluded that the optimum strategy, associated with the highest probability of having a nonarthritic hip at 60 years of age, was to use physical examination to screen all neonates for hip dysplasia and use hip US selectively for infants who are at high risk for DDH [23].
- The American Academy of Pediatrics guideline published in 2000 did not recommend US following a positive physical examination.

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. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). 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*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".		

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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