PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Clinical Practice Guideline: Early Detection of Developmental Dysplasia of the Hip

Committee on Quality Improvement, Subcommittee on Developmental Dysplasia of the Hip

Pediatrics 2000;105;896

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ABSTRACT. ***Developmental dysplasia of the hip*** **is the preferred term to describe the condition in which the femoral head has an abnormal relationship to the acetabulum. Developmental dysplasia of the hip includes frank dislocation (luxation), partial dislocation (subluxation), instability wherein the femoral head comes in and out of the socket, and an array of radiographic abnormalities that reflect inadequate formation of the acetabulum. Because many of these findings may not be present at birth, the term *developmental* more accurately reflects the biologic features than does the term *congenital*. The disorder is uncommon. The earlier a dislocated hip is detected, the simpler and more effective is the treatment. Despite newborn screening programs, dislocated hips continue to be diagnosed later in infancy and childhood,[1–11] in some instances delaying appropriate therapy and leading to a substantial number of malpractice claims. The objective of this guideline is to reduce the number of dislocated hips detected later in infancy and childhood. The target audience is the primary care provider. The target patient is the healthy newborn up to 18 months of age, excluding those with neuromuscular disorders, myelodysplasia, or arthrogryposis.**

ABBREVIATIONS. DDH, developmental dysplasia of the hip; AVN, avascular necrosis of the hip.

BIOLOGIC FEATURES AND NATURAL HISTORY

Understanding the developmental nature of developmental dysplasia of the hip (DDH) and the subsequent spectrum of hip abnormalities requires a knowledge of the growth and development of the hip joint.[12] Embryologically, the femoral head and acetabulum develop from the same block of primitive mesenchymal cells. A cleft develops to separate them at 7 to 8 weeks' gestation. By 11 weeks' gestation, development of the hip joint is complete. At birth, the femoral head and the acetabulum are primarily cartilaginous. The acetabulum continues to develop postnatally. The growth of the fibrocartilaginous rim (the labrum) that surrounds the bony acetabulum deepens the socket. Development of the femoral head and acetabulum are intimately related, and normal adult hip joints depend on further growth of these structures. Hip dysplasia may occur in utero, perinatally, or during infancy and childhood.

The acronym DDH includes hips that are unstable, subluxated, dislocated (luxated), and/or have malformed acetabula. A hip is *unstable* when the tight fit between the femoral head and the acetabulum is lost and the femoral head is able to move within (subluxated) or outside (dislocated) the confines of the acetabulum. A *dislocation* is a complete loss of contact of the femoral head with the acetabulum. Dislocations are divided into 2 types: teratologic and typical.[12] *Teratologic dislocations* occur early in utero and often are associated with neuromuscular disorders, such as arthrogryposis and myelodysplasia, or with various dysmorphic syndromes. The *typical dislocation* occurs in an otherwise healthy infant and may occur prenatally or postnatally.

During the immediate newborn period, laxity of the hip capsule predominates, and, if clinically significant enough, the femoral head may spontaneously dislocate and relocate. If the hip spontaneously relocates and stabilizes within a few days, subsequent hip development usually is normal. If subluxation or dislocation persists, then structural anatomic changes may develop. A deep concentric position of the femoral head in the acetabulum is necessary for normal development of the hip. When not deeply reduced (subluxated), the labrum may become everted and flattened. Because the femoral head is not reduced into the depth of the socket, the acetabulum does not grow and remodel and, therefore, becomes shallow. If the femoral head moves further out of the socket (dislocation), typically superiorly and laterally, the inferior capsule is pulled upward over the now empty socket. Muscles surrounding the hip, especially the adductors, become contracted, limiting abduction of the hip. The hip capsule constricts; once this capsular constriction narrows to less than the diameter of the femoral head, the hip can no longer be reduced by manual manipulative maneuvers, and operative reduction usually is necessary.

The hip is at risk for dislocation during 4 periods: 1) the 12th gestational week, 2) the 18th gestational week, 3) the final 4 weeks of gestation, and 4) the postnatal period. During the 12th gestational week, the hip is at risk as the fetal lower limb rotates medially. A dislocation at this time is termed teratologic. All elements of the hip joint develop abnor-

The recommendations in this statement do not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

The Practice Guideline, "Early Detection of Developmental Dysplasia of the Hip," was reviewed by appropriate committees and sections of the American Academy of Pediatrics (AAP) including the Chapter Review Group, a focus group of office-based pediatricians representing each AAP District: Gene R. Adams, MD; Robert M. Corwin, MD; Diane Fuquay, MD; Barbara M. Harley, MD; Thomas J. Herr, MD, Chair; Kenneth E. Matthews, MD; Robert D. Mines, MD; Lawrence C. Pakula, MD; Howard B. Weinblatt, MD; and Delosa A. Young, MD. The Practice Guideline was also reviewed by relevant outside medical organizations as part of the peer review process.
PEDIATRICS (ISSN 0031 4005).

mally. The hip muscles develop around the 18th gestational week. Neuromuscular problems at this time, such as myelodysplasia and arthrogryposis, also lead to teratologic dislocations. During the final 4 weeks of pregnancy, mechanical forces have a role. Conditions such as oligohydramnios or breech position predispose to DDH.[13] Breech position occurs in ~3% of births, and DDH occurs more frequently in breech presentations, reportedly in as many as 23%. The frank breech position of hip flexion and knee extension places a newborn or infant at the highest risk. Postnatally, infant positioning such as swaddling, combined with ligamentous laxity, also has a role.

The true incidence of dislocation of the hip can only be presumed. There is no "gold standard" for diagnosis during the newborn period. Physical examination, plane radiography, and ultrasonography all are fraught with false-positive and false-negative results. Arthrography (insertion of contrast medium into the hip joint) and magnetic resonance imaging, although accurate for determining the precise hip anatomy, are inappropriate methods for screening the newborn and infant.

The reported incidence of DDH is influenced by genetic and racial factors, diagnostic criteria, the experience and training of the examiner, and the age of the child at the time of the examination. Wynne-Davies[14] reported an increased risk to subsequent children in the presence of a diagnosed dislocation (6% risk with healthy parents and an affected child, 12% risk with an affected parent, and 36% risk with an affected parent and 1 affected child). DDH is not always detectable at birth, but some newborn screening surveys suggest an incidence as high as 1 in 100 newborns with evidence of instability, and 1 to 1.5 cases of dislocation per 1000 newborns. The incidence of DDH is higher in girls. Girls are especially susceptible to the maternal hormone relaxin, which may contribute to ligamentous laxity with the resultant instability of the hip. The left hip is involved 3 times as commonly as the right hip, perhaps related to the left occiput anterior positioning of most nonbreech newborns. In this position, the left hip resides posteriorly against the mother's spine, potentially limiting abduction.

PHYSICAL EXAMINATION

DDH is an evolving process, and its physical findings on clinical examination change.[12,15,16] The newborn must be relaxed and preferably examined on a firm surface. Considerable patience and skill are required. The physical examination changes as the child grows older. No signs are pathognomonic for a dislocated hip. The examiner must look for asymmetry. Indeed, bilateral dislocations are more difficult to diagnose than unilateral dislocations because symmetry is retained. Asymmetrical thigh or gluteal folds, better observed when the child is prone, apparent limb length discrepancy, and restricted motion, especially abduction, are significant, albeit not pathognomonic signs. With the infant supine and the pelvis stabilized, abduction to 75° and adduction to 30° should occur readily under normal circumstances.

The 2 maneuvers for assessing hip stability in the newborn are the Ortolani and Barlow tests. The Ortolani elicits the sensation of the dislocated hip reducing, and the Barlow detects the unstable hip dislocating from the acetabulum. The Ortolani is performed with the newborn supine and the examiner's index and middle fingers placed along the greater trochanter with the thumb placed along the inner thigh. The hip is flexed to 90° but not more, and the leg is held in neutral rotation. The hip is gently abducted while lifting the leg anteriorly. With this maneuver, a "clunk" is felt as the dislocated femoral head reduces into the acetabulum. This is a positive Ortolani sign. The Barlow provocative test is performed with the newborn positioned supine and the hips flexed to 90°. The leg is then gently adducted while posteriorly directed pressure is placed on the knee. A palpable clunk or sensation of movement is felt as the femoral head exits the acetabulum posteriorly. This is a positive Barlow sign. The Ortolani and Barlow maneuvers are performed 1 hip at a time. Little force is required for the performance of either of these tests. The goal is not to prove that the hip can be dislocated. Forceful and repeated examinations can break the seal between the labrum and the femoral head. These strongly positive signs of Ortolani and Barlow are distinguished from a large array of soft or equivocal physical findings present during the newborn period. High-pitched clicks are commonly elicited with flexion and extension and are inconsequential. A dislocatable hip has a rather distinctive clunk, whereas a subluxable hip is characterized by a feeling of looseness, a sliding movement, but without the true Ortolani and Barlow clunks. Separating true dislocations (clunks) from a feeling of instability and from benign adventitial sounds (clicks) takes practice and expertise. This guideline recognizes the broad range of physical findings present in newborns and infants and the confusion of terminology generated in the literature. By 8 to 12 weeks of age, the capsule laxity decreases, muscle tightness increases, and the Barlow and Ortolani maneuvers are no longer positive regardless of the status of the femoral head. In the 3-month-old infant, limitation of abduction is the most reliable sign associated with DDH. Other features that arouse suspicion include asymmetry of thigh folds, a positive Allis or Galeazzi sign (relative shortness of the femur with the hips and knees flexed), and discrepancy of leg lengths. These physical findings alert the examiner that abnormal relationships of the femoral head to the acetabulum (dislocation and subluxation) *may* be present.

Maldevelopments of the acetabulum alone (acetabular dysplasia) can be determined only by imaging techniques. Abnormal physical findings may be absent in an infant with acetabular dysplasia but no subluxation or dislocation. Indeed, because of the confusion, inconsistencies, and misuse of language in the literature (eg, an Ortolani sign called a click by some and a clunk by others), this guideline uses the following definitions.

- A *positive examination* result for DDH is the Barlow or Ortolani sign. This is the clunk of dislocation or reduction.
- An *equivocal examination* or *warning signs* include an array of physical findings that may be found in children with DDH, in children with another orthopaedic disorder, or in children who are completely healthy. These physical findings include asymmetric thigh or buttock creases, an apparent or true short leg, and limited abduction. These signs, used singly or in combination, serve to raise the pediatrician's index of suspicion and act as a threshold for referral. Newborn soft tissue hip clicks are not predictive of DDH[17] but may be confused with the Ortolani and Barlow clunks by some screening physicians and thereby be a reason for referral.

IMAGING

Radiographs of the pelvis and hips have historically been used to assess an infant with suspected DDH. During the first few months of life when the femoral heads are composed entirely of cartilage, radiographs have limited value. Displacement and instability may be undetectable, and evaluation of acetabular development is influenced by the infant's position at the time the radiograph is performed. By 4 to 6 months of age, radiographs become more reliable, particularly when the ossification center develops in the femoral head. Radiographs are readily available and relatively low in cost.

Real-time ultrasonography has been established as an accurate method for imaging the hip during the first few months of life.[15,18–25] With ultrasonography, the cartilage can be visualized and the hip can be viewed while assessing the stability of the hip and the morphologic features of the acetabulum. In some clinical settings, ultrasonography can provide information comparable to arthrography (direct injection of contrast into the hip joint), without the need for sedation, invasion, contrast medium, or ionizing radiation. Although the availability of equipment for ultrasonography is widespread, accurate results in hip sonography require training and experience. Although expertise in pediatric hip ultrasonography is increasing, this examination may not always be available or obtained conveniently. Ultrasonographic techniques include *static evaluation* of the morphologic features of the hip, as popularized in Europe by Graf,[26] and a *dynamic evaluation*, as developed by Harcke[20] that assesses the hip for stability of the femoral head in the socket, as well as static anatomy. Dynamic ultrasonography yields more useful information. With both techniques, there is considerable interobserver variability, especially during the first 3 weeks of life.[7,27]

Experience with ultrasonography has documented its ability to detect abnormal position, instability, and dysplasia not evident on clinical examination. Ultrasonography during the first 4 weeks of life often reveals the presence of minor degrees of instability and acetabular immaturity. Studies[7,28,29] indicate that nearly all these mild early findings, which will not be apparent on physical examination, resolve spontaneously without treatment. Newborn screening with ultrasonography has required a high frequency of reexamination and results in a large number of hips being unnecessarily treated. One study[23] demonstrates that a screening process with higher false-positive results also yields increased prevention of late cases. Ultrasonographic screening of all infants at 4 to 6 weeks of age would be expensive, requiring considerable resources. This practice is yet to be validated by clinical trial. *Consequently, the use of ultrasonography is recommended as an adjunct to the clinical evaluation*. It is the technique of choice for clarifying a physical finding, assessing a high-risk infant, and monitoring DDH as it is observed or treated. Used in this selective capacity, it can guide treatment and may prevent overtreatment.

PRETERM INFANTS

DDH may be unrecognized in prematurely born infants. When the infant has cardiorespiratory problems, the diagnosis and management are focused on providing appropriate ventilatory and cardiovascular support, and careful examination of the hips may be deferred until a later date. The most complete examination the infant receives may occur at the time of discharge from the hospital, and this single examination may not detect subluxation or dislocation. Despite the medical urgencies surrounding the preterm infant, it is critical to examine the entire child.

METHODS FOR GUIDELINE DEVELOPMENT

Our goal was to develop a practice parameter by using a process that would be based whenever possible on available evidence. The methods used a combination of expert panel, decision modeling, and evidence synthesis[30] (see the Technical Report available on *Pediatrics electronic pages* at www.pediatrics.org). The predominant methods recommended for such evidence synthesis are generally of 2 types: a *data-driven* method and a *model-driven*[31,32] method. In data-driven methods, the analyst finds the best data available and induces a conclusion from these data. A model-driven method, in contrast, begins with an effort to define the context for evidence and then searches for the data as defined by that context. Data-driven methods are useful when the quality of evidence is high. A careful review of the medical literature revealed that the published evidence about DDH did not meet the criteria for high quality. There was a paucity of randomized clinical trials.[8] We decided, therefore, to use the model-driven method.

A decision model was constructed based on the perspective of practicing clinicians and determining the best strategy for screening and diagnosis. The target child was a full-term newborn with no obvious orthopaedic abnormalities. We focused on the various options available to the pediatrician* for the detection of DDH, including screening by physical examination, screening by ultrasonography, and episodic screening during health supervision. Because

*In this guideline, the term *pediatrician* includes the range of pediatric primary care providers, eg, family practitioners and pediatric nurse practitioners.

the detection of a dislocated hip usually results in referral by the pediatrician, and because management of DDH is not in the purview of the pediatrician's care, treatment options are not included. We also included in our model a wide range of options for detecting DDH during the first year of life if the results of the newborn screen are negative.

The outcomes on which we focused were a dislocated hip at 1 year of age as the major morbidity of the disease and avascular necrosis of the hip (AVN) as the primary complication of DDH treatment. AVN is a loss of blood supply to the femoral head resulting in abnormal hip development, distortion of shape, and, in some instances, substantial morbidity. Ideally, a gold standard would be available to define DDH at any point in time. However, as noted, no gold standard exists except, perhaps, arthrography of the hip, which is an inappropriate standard for use in a detection model. Therefore, we defined outcomes in terms of the *process of care*. We reviewed the literature extensively. The purpose of the literature review was to provide the probabilities required by the decision model since there were no randomized clinical trials. The article or chapter title and the abstracts were reviewed by 2 members of the methodology team and members of the subcommittee. Articles not rejected were reviewed, and data were abstracted that would provide evidence for the probabilities required by the decision model. As part of the literature abstraction process, the evidence quality in each article was assessed. A computer-based literature search, hand review of recent publications, or examination of the reference section for other articles ("ancestor articles") identified 623 articles; 241 underwent detailed review, 118 of which provided some data. Of the 100 ancestor articles, only 17 yielded useful articles, suggesting that our accession process was complete. By traditional epidemiologic standards,[33] the quality of the evidence in this set of articles was uniformly low. There were few controlled trials and few studies of the follow-up of infants for whom the results of newborn examinations were negative. When the evidence was poor or lacking entirely, extensive discussions among members of the committee and the expert opinion of outside consultants were used to arrive at a consensus. No votes were taken. Disagreements were discussed, and consensus was achieved.

The available evidence was distilled in 3 ways. First, estimates were made of DDH at birth in infants without risk factors. These estimates constituted the baseline risk. Second, estimates were made of the rates of DDH in the children with risk factors. These numbers guide clinical actions: rates that are too high might indicate referral or different follow-up despite negative physical findings. Third, each screening strategy (pediatrician-based, orthopaedist-based, and ultrasonography-based) was scored for the estimated number of children given a diagnosis of DDH at birth, at mid-term (4–12 months of age), and at late-term (12 months of age and older) and for the estimated number of cases of AVN incurred, assuming that all children given a diagnosis of DDH would be treated. These numbers suggest the best strategy, balancing DDH detection with incurring adverse effects.

The baseline estimate of DDH based on orthopaedic screening was 11.5/1000 infants. Estimates from pediatric screening were 8.6/1000 and from ultrasonography were 25/1000. The 11.5/1000 rate translates into a rate for not-at-risk boys of 4.1/1000 boys and a rate for not-at-risk girls of 19/1000 girls. These numbers derive from the facts that the relative risk—the rate in girls divided by the rate in boys across several studies—is 4.6 and because infants are split evenly between boys and girls, so $.5 \times 4.1/1000 + .5 \times 19/1000 = 11.5/1000$.[34,35] We used these baseline rates for calculating the rates in other risk groups. Because the relative risk of DDH for children with a positive family history (first-degree relatives) is 1.7, the rate for boys with a positive family history is $1.7 \times 4.1 = 6.4/1000$ boys, and for girls with a positive family history, $1.7 \times 19 = 32/1000$ girls. Finally, the relative risk of DDH for breech presentation (of all kinds) is 6.3, so the risk for breech boys is $7.0 \times 4.1 = 29/1000$ boys and for breech girls, $7.0 \times 19 = 133/1000$ girls. These numbers are summarized in Table 1.

These numbers suggest that boys without risk or those with a family history have the lowest risk; girls without risk and boys born in a breech presentation have an intermediate risk; and girls with a positive family history, and especially girls born in a breech presentation, have the highest risks. Guidelines, considering the risk factors, should follow these risk profiles. Reports of newborn screening for DDH have included various screening techniques. In some, the screening clinician was an orthopaedist, in

TABLE 1. Relative and Absolute Risks for Finding a Positive Examination Result at Newborn Screening by Using the Ortolani and Barlow Signs

Newborn Characteristics	Relative Risk of a Positive Examination Result	Absolute Risk of a Positive Examination Result per 1000 Newborns With Risk Factors
All newborns	...	11.5
Boys	1.0	4.1
Girls	4.6	19
Positive family history	1.7	
Boys	...	6.4
Girls	...	32
Breech presentation	7.0	
Boys	...	29
Girls	...	133

TABLE 2. Newborn Strategy*

Outcome	Orthopaedist PE	Pediatrician PE	Ultrasonography
DDH in newborn	12	8.6	25
DDH at ~6 mo of age	.1	.45	.28
DDH at 12 mo of age or more	.16	.33	.1
AVN at 12 mo of age	.06	.1	.1

* PE indicates physical examination. Outcome per 1000 infants initially screened.

others, a pediatrician, and in still others, a physiotherapist. In addition, screening has been performed by ultrasonography. In assessing the expected effect of each strategy, we estimated the newborn DDH rates, the mid-term DDH rates, and the late-term DDH rates for each of the 3 strategies, as shown in Table 2. We also estimated the rate of AVN for DDH treated before 2 months of age (2.5/1000 treated) and after 2 months of age (109/1000 treated). We could not distinguish the AVN rates for children treated between 2 and 12 months of age from those treated later. Table 2 gives these data. The total cases of AVN per strategy are calculated, assuming that all infants with positive examination results are treated.

Table 2 shows that a strategy using pediatricians to screen newborns would give the lowest newborn rate but the highest mid- and late-term DDH rates. To assess how much better an ultrasonography-only screening strategy would be, we could calculate a cost-effectiveness ratio. In this case, the "cost" of ultrasonographic screening is the number of "extra" newborn cases that probably include children who do not need to be treated. (The cost from AVN is the same in the 2 strategies.) By using these cases as the cost and the number of later cases averted as the effect, a ratio is obtained of 71 children treated neonatally because of a positive ultrasonographic screen for each later case averted. Because this number is high, and because the presumption of better late-term efficacy is based on a single study, we do not recommend ultrasonographic screening at this time.

RECOMMENDATIONS AND NOTES TO ALGORITHM (Fig 1)

1. **All newborns are to be screened by physical examination**. The evidence† for this recommendation is good. The expert consensus‡ is strong. Although initial screening by orthopaedists§ would be optimal (Table 2), it is doubtful that if widely practiced, such a strategy would give the same good results as those published from pediatric orthopaedic research centers. **It is recommended that screening be done by a properly trained health care provider** (eg, physician, pediatric nurse practitioner, physician assistant, or physical therapist). (Evidence for this recommendation is strong.) A number of studies performed by properly trained nonphysicians report results indistinguishable from those performed by physicians.[36] The examination after discharge from the neonatal intensive care unit should be performed as a newborn examination with appropriate screening. **Ultrasonography of all newborns is not recommended.** (Evidence is fair; consensus is strong.) Although there is indirect evidence to support the use of ultrasonographic screening of all newborns, it is not advocated because it is operator-dependent, availability is questionable, it increases the rate of treatment, and interobserver variability is high. There are probably some increased costs. We considered a strategy of "no newborn screening." This arm is politically indefensible because screening newborns is inherent in pediatrician's care. The technical report details this limb through decision analysis. Regardless of the screening method used for the newborn, DDH is detected in 1 in 5000 infants at 18 months of age.[3] The evidence and consensus for newborn screening remain strong.

†In this guideline, evidence is listed as good, fair, or poor based on the methodologist's evaluation of the literature quality. (See the Technical Report.)

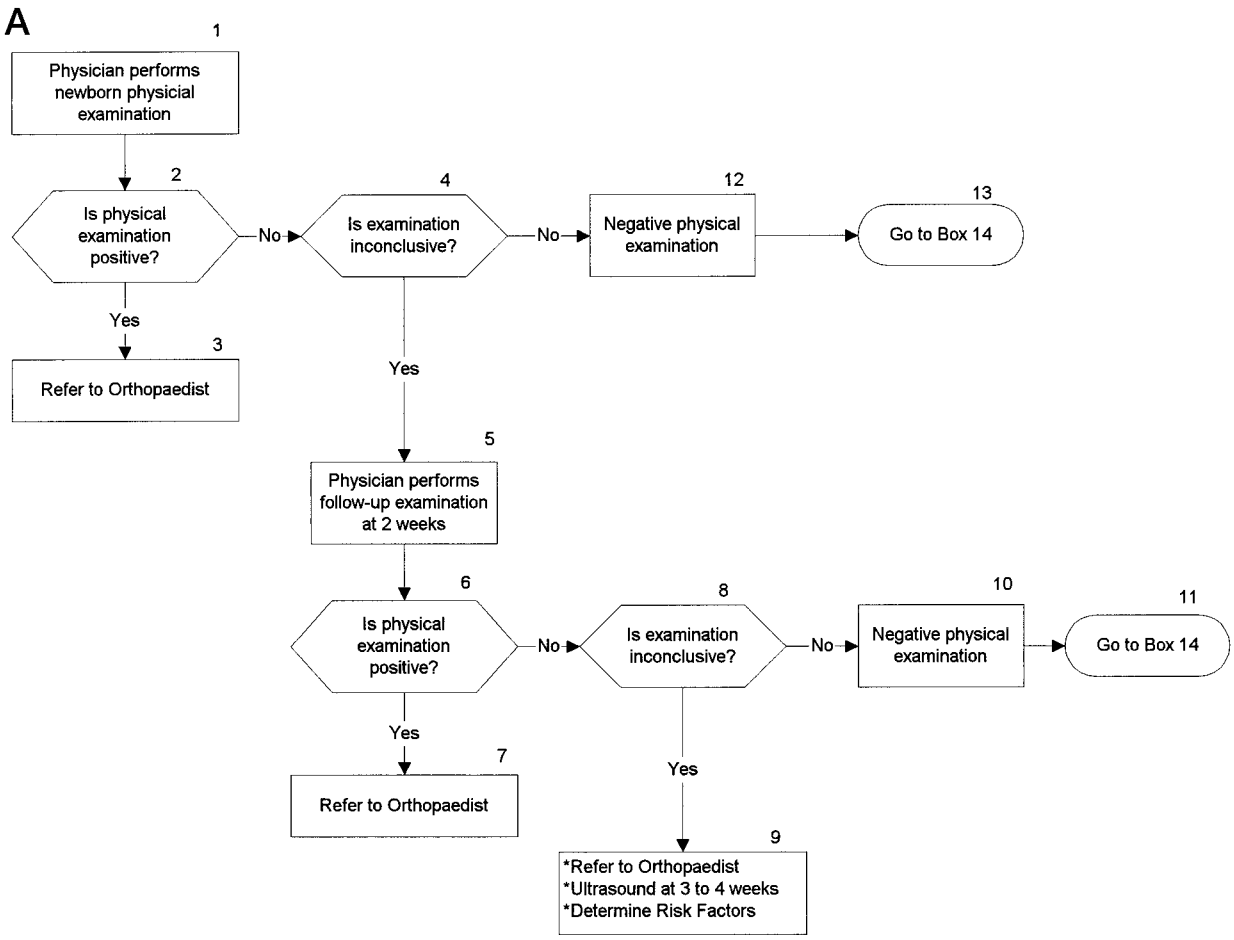
‡Opinion or consensus is listed as *strong* if opinion of the expert panel was unanimous or *mixed* if there were dissenting points of view.

§In this guideline, the term *orthopaedist* refers to an orthopaedic surgeon with expertise in pediatric orthopaedic conditions.

Newborn Physical Examination and Treatment

2. **If a positive Ortolani or Barlow sign is found in the newborn examination, the infant should be referred to an orthopaedist**. Orthopaedic referral is recommended when the Ortolani sign is unequivocally positive (a clunk). Orthopaedic referral is not recommended for any softly positive finding in the examination (eg, hip click without dislocation). The precise time frame for the newborn to be evaluated by the orthopaedist cannot be determined from the literature. However, the literature suggests that the majority of "abnormal" physical findings of hip examinations at birth (clicks and clunks) will resolve by 2 weeks; therefore, consultation and possible initiation of treatment are recommended by that time. The data recommending that all those with a positive Ortolani sign be referred to an orthopaedist are limited, but expert panel consensus, nevertheless, was strong, because pediatricians do not have the training to take full responsibility and because true Ortolani clunks are rare and their management is more appropriately performed by the orthopaedist.

If the results of the physical examination at birth are "equivocally" positive (ie, soft click, mild asymmetry, but neither an Ortolani nor a Barlow sign is present), then a follow-up hip examination by the pediatrician in 2 weeks is recommended. (Evidence is good; consensus is strong.) The available data suggest that most clicks resolve by 2 weeks and that these "benign hip clicks" in the newborn period do



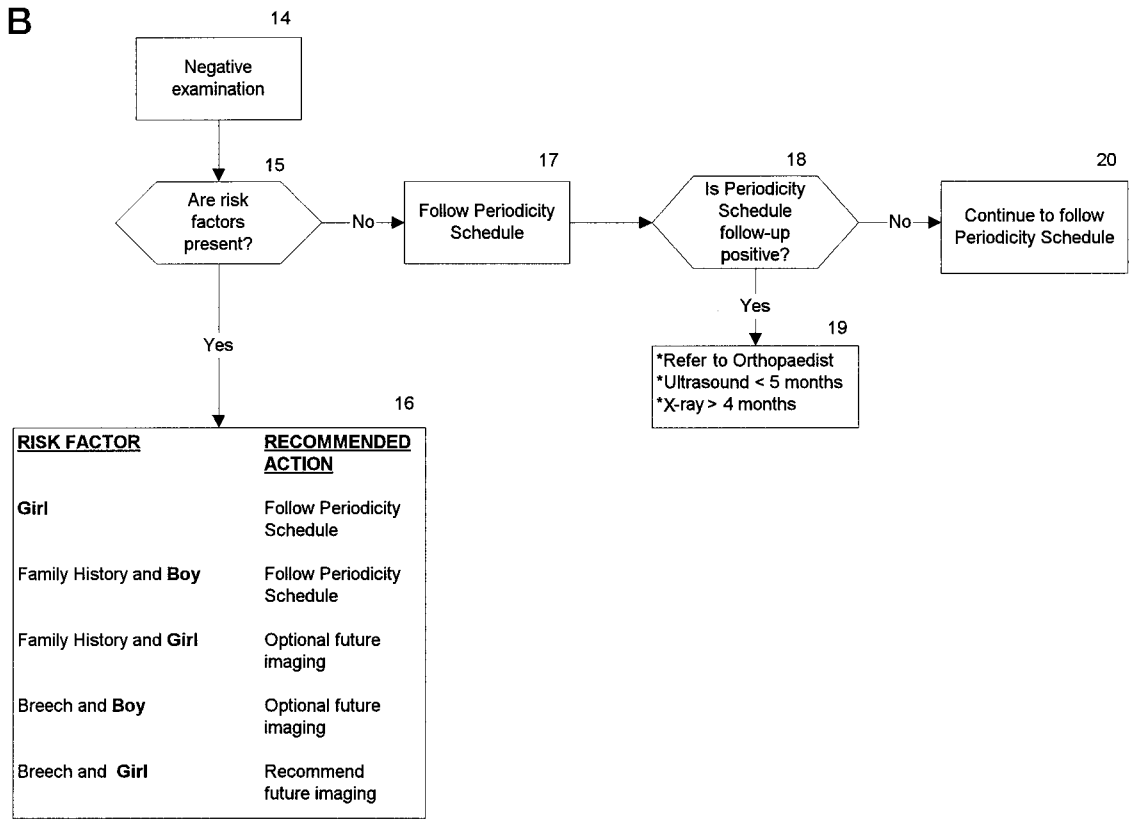


Fig 1. Screening for developmental hip dysplasia—clinical algorithm.

not lead to later hip dysplasia.[9,17,28,37] Thus, for an infant with softly positive signs, the pediatrician should reexamine the hips at 2 weeks before making referrals for orthopaedic care or ultrasonography. We recognize the concern of pediatricians about adherence to follow-up care regimens, but this concern regards all aspects of health maintenance and is not a reason to request ultrasonography or other diagnostic study of the newborn hips.

3. **If the results of the newborn physical examination are positive (ie, presence of an Ortolani or a Barlow sign), ordering an ultrasonographic examination of the newborn is not recommended**. (Evidence is poor; opinion is strong.) Treatment decisions are not influenced by the results of ultrasonography but are based on the results of the physical examination. The treating physician may use a variety of imaging studies during clinical management. **If the results of the newborn physical examination are positive, obtaining a radiograph of the newborn's pelvis and hips is not recommended** (evidence is poor; opinion is strong), because they are of limited value and do not influence treatment decisions.

The use of triple diapers when abnormal physical signs are detected during the newborn period is not recommended. (Evidence is poor; opinion is strong.) Triple diaper use is common practice despite the lack of data on the effectiveness of triple diaper use; and, in instances of frank dislocation, the use of triple diapers may delay the initiation of more appropriate treatment (such as with the Pavlik harness). Often, the primary care pediatrician may not have performed the newborn examination in the hospital. The importance of communication cannot be overemphasized, and triple diapers may aid in follow-up as a reminder that a possible abnormal physical examination finding was present in the newborn.

2-Week Examination

4. **If the results of the physical examination are positive (eg, positive Ortolani or Barlow sign) at 2 weeks, refer to an orthopaedist**. (Evidence is strong; consensus is strong.) Referral is urgent but is not an emergency. Consensus is strong that, as in the newborn, the presence of an Ortolani or Barlow sign at 2 weeks warrants referral to an orthopaedist. An Ortolani sign at 2 weeks may be a new finding or a finding that was not apparent at the time of the newborn examination.

5. **If at the 2-week examination the Ortolani and Barlow signs are absent but physical findings raise suspicions, consider referral to an orthopaedist or request ultrasonography at age 3 to 4 weeks**. Consensus is mixed about the follow-up for softly positive or equivocal findings at 2 weeks of age (eg, adventitial click, thigh asymmetry, and apparent leg length difference). Because it is necessary to confirm the status of the hip joint, the pediatrician can consider referral to an orthopaedist or for ultrasonography if the constellation of physical findings raises a high level of suspicion. However, if the physical findings are minimal, continuing follow-up by the periodicity schedule with focused hip examinations is also an option, provided risk factors are considered. (See "Recommendations" 7 and 8.)

6. **If the results of the physical examination are negative at 2 weeks, follow-up is recommended at the scheduled well-baby periodic examinations**. (Evidence is good; consensus is strong.)

7. **Risk factors**. **If the results of the newborn examination are negative (or equivocally positive), risk factors may be considered**.[13,21,38–41] Risk factors are a study of thresholds to act.[42] Table 1 gives the risk of finding a positive Ortolani or Barlow sign at the time of the initial newborn screening. If this examination is negative, the absolute risk of there being a true dislocated hip is greatly reduced. Nevertheless, the data in Table 1 may influence the pediatrician to perform confirmatory evaluations. Action will vary based on the individual clinician. The following recommendations are made (evidence is strong; opinion is strong):
   - **Girl** (newborn risk of 19/1000). When the results of the newborn examination are negative or equivocally positive, hips should be reevaluated at 2 weeks of age. If negative, continue according to the periodicity schedule; if positive, refer to an orthopaedist or for ultrasonography at 3 weeks of age.
   - **Infants with a positive family history of DDH** (newborn risk for boys of 9.4/1000 and for girls, 44/1000). When the results of the newborn examination in boys are negative or equivocally positive, hips should be reevaluated at 2 weeks of age. If negative, continue according to the periodicity schedule; if positive, refer to an orthopaedist or for ultrasonography at 3 weeks of age. In girls, the absolute risk of 44/1000 may exceed the pediatrician's threshold to act, and imaging with an ultrasonographic examination at 6 weeks of age or a radiograph of the pelvis at 4 months of age is recommended.
   - **Breech presentation** (newborn risk for boys of 26/1000 and for girls, 120/1000). **For negative or equivocally positive newborn examinations, the infant should be reevaluated at regular intervals (according to the periodicity schedule) if the examination results remain negative**. Because an absolute risk of 120/1000 (12%) probably exceeds most pediatricians' threshold to act, imaging with an ultrasonographic examination at 6 weeks of age or with a radiograph of the pelvis and hips at 4 months of age is recommended. In addition, because some reports show a high incidence of hip abnormalities detected at an older age in children born breech, this imaging strategy remains an option for all children born breech, not just girls. These hip abnormalities are, for the most part, inadequate development of the acetabulum. Acetabular dysplasia is best found by a radiographic examination at 6 months of age or older. A

suggestion of poorly formed acetabula may be observed at 6 weeks of age by ultrasonography, but the best study remains a radiograph performed closer to 6 months of age. Ultrasonographic newborn screening of all breech infants will not eliminate the possibility of later acetabular dysplasia.

8. **Periodicity**. **The hips must be examined at every well-baby visit according to the recommended periodicity schedule for well-baby examinations (2–4 days for newborns discharged in less than 48 hours after delivery, by 1 month, 2 months, 4 months, 6 months, 9 months, and 12 months of age)**. If at any time during the follow-up period DDH is suspected because of an abnormal physical examination or by a parental complaint of difficulty diapering or abnormal appearing legs, the pediatrician must confirm that the hips are stable, in the sockets, and developing normally. Confirmation can be made by a focused physical examination when the infant is calm and relaxed, by consultation with another primary care pediatrician, by consultation with an orthopaedist, by ultrasonography if the infant is younger than 5 months of age, or by radiography if the infant is older than 4 months of age. (Between 4 and 6 months of age, ultrasonography and radiography seem to be equally effective diagnostic imaging studies.)

DISCUSSION

DDH is an important term because it accurately reflects the biologic features of the disorder and the susceptibility of the hip to become dislocated at various times. Dislocated hips always will be diagnosed later in infancy and childhood because not every dislocated hip is detectable at birth, and hips continue to dislocate throughout the first year of life. Thus, this guideline requires that the pediatrician follow *a process of care for the detection of DDH*. The process recommended for early detection of DDH includes the following:

- Screen all newborns' hips by physical examination.
- Examine all infants' hips according to a periodicity schedule and follow-up until the child is an established walker.
- Record and document physical findings.
- Be aware of the changing physical examination for DDH.
- If physical findings raise suspicion of DDH, or if parental concerns suggest hip disease, confirmation is required by expert physical examination, referral to an orthopaedist, or by an age-appropriate imaging study.

When this process of care is followed, the number of dislocated hips diagnosed at 1 year of age should be minimized. However, the problem of late detection of dislocated hips will not be eliminated. The results of screening programs have indicated that 1 in 5000 children have a dislocated hip detected at 18 months of age or older.[3]

TECHNICAL REPORT

The Technical Report is available from the American Academy of Pediatrics from several sources. The Technical Report is published in full-text on *Pediatrics electronic pages*. It is also available in a compendium of practice guidelines that contains guidelines and evidence reports together. The objective was to create a recommendation to pediatricians and other primary care providers about their role as screeners for detecting DDH. The patients are a theoretical cohort of newborns. A model-based method using decision analysis was the foundation. Components of the approach include:

- Perspective: primary care provider
- Outcomes: DDH and AVN
- Preferences: expected rates of outcomes
- Model: influence diagram assessed from the subcommittee and from the methodology team with critical feedback from the subcommittee
- Evidence sources: Medline and EMBase (detailed in "Methods" section)
- Evidence quality: assessed on a custom, subjective scale, based primarily on the fit of the evidence in the decision model

The results are detailed in the "Methods" section. Based on the raw evidence and Bayesian hierarchical meta-analysis,[34,35] estimates for the incidence of DDH based on the type of screener (orthopaedist vs pediatrician); the odds ratio for DDH given risk factors of sex, family history, and breech presentation; and estimates for late detection and AVN were determined and are detailed in the "Methods" section and in Tables 1 and 2.

The decision model (reduced based on available evidence) suggests that orthopaedic screening is optimal, but because orthopaedists in the published studies and in practice would differ in pediatric expertise, the supply of pediatric orthopaedists is relatively limited, and the difference between orthopaedists and pediatricians is statistically insignificant, we conclude that pediatric screening is to be recommended. The place for ultrasonography in the screening process remains to be defined because of the limited data available regarding late diagnosis in ultrasonography screening to permit definitive recommendations.

These data could be used by others to refine the conclusion based on costs, parental preferences, or physician style. Areas for research are well defined by our model-based method. All references are in the Technical Report.

RESEARCH QUESTIONS

The quality of the literature suggests many areas for research, because there is a paucity of randomized clinical trials and case-controlled studies. The following is a list of possibilities:

1. Minimum diagnostic abilities of a screener. Although there are data for pediatricians in general, few, if any, studies evaluated the abilities of an individual examiner. What should the minimum

sensitivity and specificity be, and how should they be assessed?
2. Intercurrent screening. There were few studies on systemic processes for screening after the newborn period.[2,43,44] Although several studies assessed postneonatal DDH, the data did not specify how many examinations were performed on each child before the abnormal result was found.
3. Trade-offs. Screening always results in false-positive results, and these patients suffer the adverse effects of therapy. How many unnecessary AVNs are we—families, physicians, and society—willing to tolerate from a screening program for every appropriately treated infant in whom late DDH was averted? This assessment depends on people's values and preferences and is not strictly an epidemiologic issue.
4. Postneonatal DDH after ultrasonographic screening. Although we concluded that ultrasonographic screening did not result in fewer diagnoses of postneonatal DDH, that conclusion was based on only 1 study.[36] Further study is needed.
5. Cost-effectiveness. If ultrasonographic screening reduces the number of postneonatal DDH diagnoses, then there will be a cost trade-off between the resources spent up front to screen everyone with an expensive technology, as in the case of ultrasonography, and the resources spent later to treat an expensive adverse event, as in the case of physical examination-based screening. The level at which the cost per case of postneonatal DDH averted is no longer acceptable is a matter of social preference, not of epidemiology.

ACKNOWLEDGMENTS

We acknowledge and appreciate the help of our methodology team, Richard Hinton, MD, Paola Morello, MD, and Jeanne Santoli, MD, who diligently participated in the literature review and abstracting the articles into evidence tables, and the subcommittee on evidence analysis.

We would also like to thank Robert Sebring, PhD, for assisting in the management of this process; Bonnie Cosner for managing the workflow; and Chris Kwiat, MLS, from the American Academy of Pediatrics Bakwin Library, who performed the literature searches.

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ADDENDUM TO REFERENCES FOR THE DDH GUIDELINE

New information is generated constantly. Specific details of this report must be changed over time.

New articles (additional articles 1–7) have been published since the completion of our literature search and construction of this Guideline. These articles taken alone might seem to contradict some of the Guideline's estimates as detailed in the article and in the Technical Report. However, taken in context with the literature synthesis carried out for the construction of this Guideline, our estimates remain intact and no conclusions are obviated.

ADDITIONAL ARTICLES

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Committee on Quality Improvement, Subcommittee on Developmental Dysplasia of the Hip

Pediatrics 2000;105;896