Developmental Dysplasia of the Hip: Diagnosis and Treatment in Children Younger Than 6 Months

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Early diagnosis and treatment of developmental dislocation of the hip (DDH) in infants provides the best chance for normal hip development and a lifetime of normal hip function. Recently, the nomenclature describing hip instability has been changed because hips that are normal at birth can be found to be abnormal later. Because “congenital dislocation of the hip” implies present at birth, the term congenital has been replaced by the term developmental.

Today, the term DDH is used to describe a spectrum of disorders affecting both the proximal femur and the acetabulum. DDH realistically indicates a dynamic condition, occurring prenatally or postnataally and potentially capable of getting better or worse. DDH can be considered a continuum of pathology with multiple possible outcomes. These include (1) stabilize and become normal, (2) progress to dislocation, and (3) stabilize but retain dysplastic radiographic findings.

The untreated dysplastic or dislocated hip will develop an inequality of leg length, an abnormal gait, pain, and, finally, osteoarthritis. The patient who has a partially dislocated and dysplastic hip has pain and arthritis in adolescence. The patient who has a completely dislocated hip may not have pain until middle age.

The spectrum of DDH includes (1) fixed teratologic hip dislocations associated with neuromuscular disorders such as arthrogryposis, (2) primary acetabular dysplasia in which the acetabulum is shallow and does not contain the femoral head, (3) subluxatable hips in which the femoral head contacts only a portion of the acetabulum, (4) dislocatable hips in which the femoral head articulates in the acetabulum but can be manually pushed out of it, and (5) dislocated hips in which the femoral head does not articulate with the acetabulum but can be manually reduced into it. This article focuses on subluxatable, dislocatable, and dislocated hips in the perinatal period not associated with syndromes, neuromuscular disorders, or connective tissue disorders.
EPIDEMIOLOGY

The prevalence of DDH varies depending on which aspects of the condition are examined. In one large screening study of 7,000 infants conducted during a 2-year period, the prevalence of a dislocated hip was 1.3 per 1,000 births, the prevalence of a dislocatable hip was 2.5 per 1,000 births, and the prevalence of a subluxatable hip was 14 per 1,000 births. The prevalence of DDH also varies by race. DDH is more common in Lapps and Native Americans and less common in blacks, Koreans, and Chinese. Females are affected approximately six times more often than males. The left hip is involved in approximately 60% of cases, the right hip in 20%, and both hips in 20%.

ETIOLOGY

The etiology of DDH is multifactorial and includes mechanical, physiologic, and genetic factors. Mechanical factors include the small intrauterine space of the primipara, breech presentation, oligohydramnios, congenital dislocation of the knee, congenital muscular torticollis, and metatarsus adductus. In addition, in Native Americans, the postnatal practice of strapping a child’s hips in extension contributes to DDH. Physiologic factors include ligamentous laxity in female infants. This laxity stems from the influence of the maternal hormones estrogen and relaxin and may explain why DDH is six times more common in females. A genetic influence on DDH is supported by studies of family history, siblings, and twins.

NEONATAL SCREENING PROGRAMS

Early diagnosis and prompt treatment of DDH is vital for optimum results. Therefore, neonatal screening programs using physical examination for DDH are highly recommended. Screening programs must be dynamic with pediatricians, family practitioners, and nurse practitioners performing repeat hip examinations during well-baby visits until children are of walking age. Unfortunately, although neonatal screening programs have resulted in improved early detection...
of unstable hips, a few late cases of dislocation and acetabular dysplasia persist.

The use of ultrasound in routine neonatal hip screening is not recommended today.\textsuperscript{9,10} Although ultrasound is more accurate than clinical examination of the newborn hip for DDH, universal routine ultrasound examination is not cost effective or practical.\textsuperscript{13} In addition, ultrasound may be too sensitive, leading to an increased rate of treatment while only minimally reducing the incidence of late cases of DDH.\textsuperscript{12}

**PHYSICAL EXAMINATION**

The child should be relaxed, warm, and comfortable, with diaper removed. A crying child will contract hip and leg muscles, which may disguise hip instability. From birth to approximately 2 months of age, the Barlow test\textsuperscript{13} and the Ortolani sign\textsuperscript{14} are helpful in diagnosing hip instability.

The Barlow (dislocation) test is provocative, and attempts to dislocate a located but unstable hip (Fig. 1). Both of the patient's hips are flexed to 90° and abducted. While one hip is kept in the abducted position to stabilize the pelvis, the other hip is gently adducted and pushed posteriorly. The unstable hip will be felt to dislocate or "clunk" (not "click") as the hip moves out of the acetabulum. A positive result on the Barlow test identifies a dislocatable hip.

The Ortolani (relocation) maneuver attempts to relocate a dislocated hip—a hip that is resting posterior to the acetabulum. Again, one hip is held at 90° of flexion and in abduction to stabilize the pelvis (Fig. 2). The hip to be examined is flexed to 90° and the examiner's long finger is placed posteriorly on the greater trochanter. The examiner lifts the hip anteriorly at the greater trochanter while moving the hip into abduction. If a palpable "clunk" (not "click") is felt, the result of the Ortolani maneuver is positive and the dislocated hip has been returned to the acetabulum.

A positive result on the Barlow test demonstrates that a hip is reduced but dislocatable, and a positive result on the Ortolani maneuver demonstrates that a hip is dislocated but reducible. Both of these tests demonstrate a "clunk" or "thud" sensation on physical examination. On the other hand, hip "clicks" are innocent findings related to soft tissue clicking from the ligamentum teres, iliopsoas tendon, labrum, or tensor fascia and do not indicate hip pathology.\textsuperscript{15} Therefore, the term hip click is a misleading diagnostic term and should not be used to describe hip instability.

In the child older than approximately 2 months of age, the Barlow test and the Ortolani
maneuver are less useful because the muscles around the involved hip contract and the hip becomes fixed in the dislocated position. Limitation of hip abduction becomes a more important physical finding (Fig. 3). Other important findings on physical examination at this age include asymmetric skin folds in the groin and apparent femoral shortening with uneven knee heights (Galeazzi sign; Fig. 4). After the age of 2 months, bilateral hip dislocations can be difficult to identify because asymmetry is absent. Bilateral limited hip abduction is present, however.

IMAGING STUDIES
In the infant, ultrasound or radiographs are not needed when the result on clinical examination is positive. However, in the equivocal case, imaging studies are recommended. Ultrasound has replaced radiographs as an aid in the diagnosis of hip instability in the neonate (Figs. 5 and 6). The femoral head does not ossify until the age of 4 to 6 months. Until this age, ultrasound is more accurate than a radiograph in defining abnormality of the infant's hip because ultrasound shows the cartilaginous components of the proximal femur and acetabulum not shown on radiographs. Ultrasound is safe, is reliable, and avoids radiation. In addition, ultrasound can be used in the static mode to document the structure of the femoral head and acetabulum and in the dynamic mode to determine stability.

In addition, as an adjunct to the clinical examination in an equivocal case, ultrasound is helpful in monitoring the hip that is being treated with a Pavlik harness. For example, while the hip is in the Pavlik harness, ultrasound can accurately define success or failure of reduction of the hip, whereas a radiograph can be inaccurate because the majority of the femoral head is not yet ossified. By the age of 4 to 6 months, after the femoral head has begun to ossify, radiographs demonstrate the hip and acetabulum accurately and ultrasound is not needed (Fig. 7). In fact, ultrasound becomes less accurate at this age because the ossification of the femoral head obstructs visualization of the acetabulum.
TREATMENT

Ideal treatment of DDH involves diagnosing the condition early, obtaining a concentric reduction of the hip, maintaining hip stability for normal growth and development, and avoiding the complication of avascular necrosis. A concentric reduction is one in which the femoral head cartilage articulates centrally and directly with the cartilage surface of the acetabulum without intervening soft tissue. Avascular necrosis refers to injury to the blood supply of the femoral head leading to abnormalities in growth of the head and potential later osteoarthritis.

In 1958, Pavlik reported the results of treating 1,912 infants who had DDH with a harness that he designed.22 Today the Pavlik harness is widely used as the initial treatment of DDH in infants up to the age of approximately 6 months (Fig. 8). The Pavlik harness is effective and safe. Specifically, treatment with the Pavlik harness stabilizes 85% of unstable hips and has a rate of avascular necrosis of approximately 2%.20,22,23

Our treatment algorithm for DDH in the newborn is as follows: Subluxatable hips are observed for 3 weeks. Most subluxatable hips stabilize on their own. If subluxation persists at a second examination 3 weeks later, the Pavlik harness is applied. Patients with dislocatable or dislocated hips are treated with the Pavlik harness at the time of diagnosis. The harness is often applied in the newborn nursery.

The Pavlik harness is composed of shoulder and chest straps combined with leg stirrups (Fig. 8). The chest strap is applied at the infant’s nipple line and the shoulder straps are fastened. The anterior leg stirrups are adjusted to flex the hips to approximately 100° of flexion. The posterior leg stirrups are adjusted to encourage, but not force, hip abduction. With proper adjustment, the knees should come no closer than 3 to 5 cm of the midline.22 Detailed parental education about DDH and the Pavlik harness at the time of application of the harness is important.

The Pavlik harness is worn full-time for 3 to 4 weeks. The harness should not be removed by the parents during this critical time of treatment. A follow-up examination is performed at 1 to 2 weeks to make strap adjustments for growth, to answer additional questions from the parents, and to ensure compliance. At 3 to 4 weeks, ultrasound is performed while the patient is in the harness, to determine the success of treatment. If the hip is located and stable at this time, the patient is weaned from the Pavlik harness: for the next month, the harness can be removed by the
parents for 1 hour per day to bathe the child and clean the harness. Monthly follow-up examinations are then performed. The Pavlik harness is continued until results on both clinical and radiographic examinations are normal. Radiographs are taken of the child out of the harness at approximately 4 months of age. During the last month of treatment, the harness is worn at night and during naps only. The typical infant treated for DDH at birth wears the harness for approximately 4 to 5 months.

The fundamental action of the Pavlik harness is to achieve a spontaneous reduction without avascular necrosis by positioning the hip in flexion and free abduction. The mechanism by which the harness produces a reduction is open to debate. Although Pavlik and others suggested that the active motion of the child's quadriceps, gluteals, and hamstrings while in the harness caused the hip to reduce, Suzuki has demonstrated, by ultrasound, that the reduction happens as a result of passive mechanical factors that occur during muscle relaxation in deep sleep.

In approximately 15% of cases, the Pavlik harness fails to reduce and stabilize the hip. The ultrasound, taken while the patient is in the Pavlik harness and after 3 to 4 weeks of treatment, will demonstrate that the hip remains dislocated. At this time, the Pavlik harness is discontinued and alternative treatment begun. Risk factors for failure of treatment with the Pavlik harness include an inability to reduce the hip (ie, a negative result on the Ortolani maneuver) prior to application of the harness, bilateral disease, age older than 7 weeks when the harness is first applied, and male gender.

Traditional treatment at this point includes skin traction for 2 to 4 weeks (Fig. 9) followed by arthrography under general anesthesia, adductor tenotomy, and closed reduction and spica casting. Skin traction can be performed in the hospital or at home. Preliminary skin traction reduces the incidence of avascular necrosis by stretching the contracted soft tissues around the hip. Recently, some authors have dismissed the value of skin traction and proceeded to an immediate arthrogram, adductor tenotomy, and closed reduction and spica casting. In a few cases, closed reduction fails to reduce the unstable hip and open surgical reduction and spica casting are required.

Following successful treatment, all patients are observed by physical and radiographic examination until skeletal maturity to identify cases of late hip deformity and dysplasia. These will potentially require future treatment.

REFERENCES
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