Ultrasonography of clinically unstable hips

A prospective study of 143 neonates at birth and early follow-up

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We evaluated the ability of ultrasonography to reduce the treatment rate of hips with clinical instability or uncertain findings at birth. Among 9,514 live births during the period 1988–1990, unstable hips were detected in 143 neonates by the Ortolani and Barlow tests, whereas the physical examination was inconclusive in 59 cases. These 202 neonates were also examined by ultrasound and instability was confirmed in 108 neonates who were treated with the Frejka pillow. The mean femoral head coverage (FHC) was 37%, indicating slight subluxation in the majority of unstable hips.

The remaining 94 infants had normal ultrasonographic findings and were not treated. Their mean FHC was 53% and all these hips developed normally, except in 2 girls, who were treated with an abduction splint from age 4–5 months because subluxation developed.

We conclude that ultrasound improved the reliability of the neonatal hip evaluation, thus markedly reducing the number of treated infants. Sonography also reduced the use of radiography during follow-up.

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Ultrasonography has been introduced in neonatal hip examination during the last decade and most authors agree that it has improved the quality of the screening (Terjesen et al. 1989a, Tschauner et al. 1990, Tönnis et al. 1990). There are, however, several unanswered questions, and one is the relation between clinically unstable hips and ultrasound findings.

We evaluated this relationship, in order to improve decision-making as regards the need for treatment.

Subjects and methods

During the 3-year period 1988–1990, there were 9,514 live births at our hospital. All newborns were examined clinically by a pediatrician with the Ortolani (1976) and Barlow (1962) tests on the first day after birth. As part of a prospective, randomized study that started in January 1988, 4,449 neonates were also examined clinically and with ultrasound by an orthopedic surgeon 1–3 days after birth. In addition, the orthopedic surgeons examined 524 newborns because of abnormal or suspicious clinical findings or risk factors for hip dysplasia. Thus, 4,973 newborns were examined with ultrasound.

To evaluate the usefulness of grading clinical instability, most (122) unstable hips were classified by the orthopedic surgeons, before the ultrasound examination, into 3 grades: slight instability (positive Barlow test), medium instability and pronounced instability. The latter 2 grades had a ptöitive Ortolani test.

We used real-time sonography with a 5 MHz linear transducer. With the baby in the supine position, the hip was examined with a transverse and a longitudinal scan, according to Terjesen et al. (1989a). Both scans were used for subjective assessment of hip anatomy and stability. On the longitudinal scan, the femoral head coverage (FHC) was calculated as the percentage of the distance from the medial tangent of the femoral head to the level of the lateral bony acetabular rim in relation to the transverse diameter of the femoral head (Figure 1). For neonates with hip instability and reduced head coverage, reduction of the femoral head into the acetabulum was achieved with the hip flexed and abducted. The FHC was measured in this abducted scan, and a normal coverage indicated a normal acetabulum (Figure 2).

All infants with instability or inconclusive findings on physical examination and subluxation or instability on ultrasound were treated with a Frejka pillow for 4 months (group A). The treatment started immediately after the ultrasound examination.

Neonates with clinical instability or inconclusive findings and normal ultrasound findings were not treated (group B), but were followed.

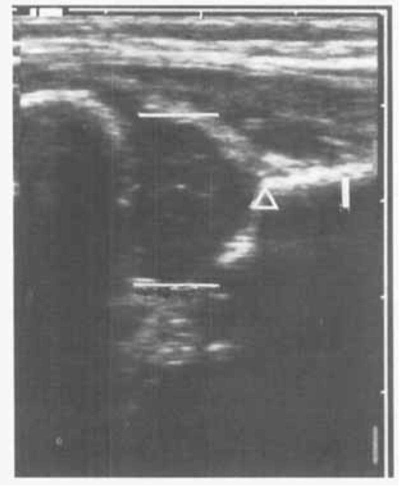

Figure 1. Ultrasonogram of a normal hip in a newborn. Note that the anatomic structures are seen 90° rotated in relation to those on a conventional radiograph. I is os ilium. The acetabular floor and the lateral joint capsule are marked by lines and the lateral bony rim of the acetabulum is marked by a triangle. Femoral head coverage (FHC) is the percentage of the vertical distance from the acetabular floor to the level of the acetabular rim in relation to the vertical distance from the acetabular floor to the joint capsule (the distance between the horizontal lines).

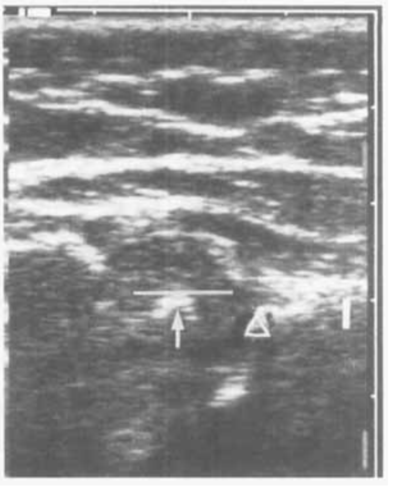

Figure 3. Ultrasonogram of the normal left hip in a 4-month-old girl (symbols as in Figure 1). The ossification center is marked with an arrow and the lateral acetabular rim by a triangle. The lateral head distance (LHD) is the distance from the lateral tangent of the ossification center (indicated by a horizontal line) to the lateral acetabular rim.

Follow-up

The first follow-up examination of all infants in both groups was performed at 2–3 months of age, with physical and ultrasound examinations. All infants in group A and those with persistent abnormal or suspicious findings in group B had further follow-up. At the second follow-up at 4–5 months, a standard pelvic radiograph was also obtained. The third and last regular follow-up of infants in group A was at 12–14 months of age, including physical examination and ultrasonography.

When the ossification center of the femoral head had appeared, the head coverage was indirectly assessed by ultrasound as the distance from the lateral tangent of the ossification center to the lateral bony acetabular rim (Figure 3). This is called the lateral head distance, LHD (Terjesen et al. 1989b). When the lateral tangent was medial to the acetabular rim, LHD was given a minus sign. On the radiographs, the corresponding distance (lateral head distance by radiography, LHDR) was measured (Figure 4). Other radiographic parameters were also measured: the acetabu-

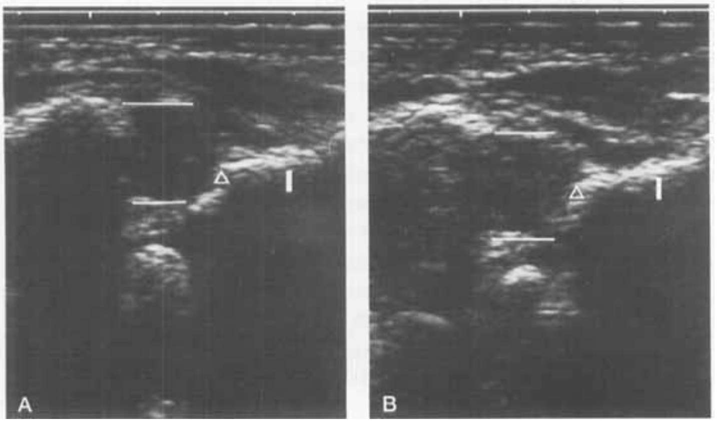

Figure 2. Ultrasonograms at birth of a girl with positive Ortolani test. The hip is subluxated in the neutral position (A) and reduced when the hip is flexed and abducted (B). On the images, the lower horizontal line marks the medial tangent of the femoral head; other symbols as in Figure 1.

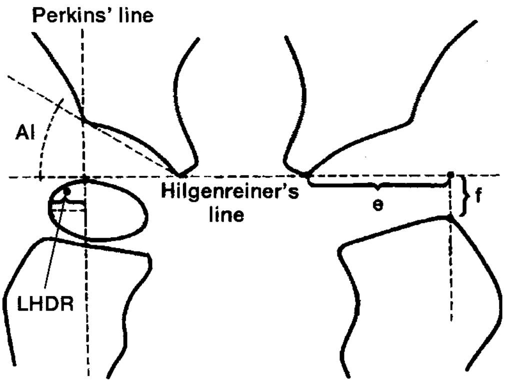

Figure 4. Radiographic measurements: AI, acetabular index; LHDR, lateral head distance on radiographs; e, distance from the lateral femoral metaphysis to the inferior bony margin of the acetabular roof along Hilgenreiner's line; f, vertical distance from the lateral metaphysis to Hilgenreiner's line.

lar index and the distances e and f, which indicate the position of the femoral metaphysis in relation to the acetabulum.

During follow-up, treatment of infants in group B was initiated only if both the ultrasound and radiographic measurements were abnormal. For infants with subluxation and/or acetabular dysplasia, a dynamic abduction splint was used.

Statistics

Sensitivity and positive and negative predictive values were used to compare clinical and ultrasound findings. One-way analysis of variance, t-tests and the chi-square test were used to evaluate differences in the ultrasound parameters between affected and unaffected hips and between groups A and B. P-values below 0.05 were considered significant. The limit of agreement (Bland and Altman 1986) and Pearson's correlation coefficient (r) were used to compare the lateral head distance by ultrasound and radiography.

Results

Examination at birth

Clinical instability was found in 143 newborns. Ultrasound was abnormal in 108 newborns, 94 girls and 14 boys, who comprised group A. They were treated with a Frejka pillow (treatment rate 1.1%). 36 newborns had bilateral instability, whereas 37 had right-sided and 35 had left-sided instability, giving a total of 144 abnormal hips. The mean FHC of these unstable hips was 37% (Table 1). The mean FHC with flexion and abduction of the hip was 54%, indicating reduction of the femoral head and normal anatomy of the acetabulum. The mean FHC in the unaffected hips (contralateral hip in unilateral cases) was 47%, which was significantly higher than in the unstable hips.

Table 1. Femoral head coverage (%; mean SD) on ultrasound at birth and at the first 2 follow-up examinations

Groups	Birth Neutral	Birth Abducted	2–3 months	4–5 months
Group A (n 108)				
Affected hip	37 7.9	54 5.3	57 5.4	58 5.7
Normal hip	47 8.0		59 4.6	59 5.9
Group B (n 94)				
Affected hip	53 9.2		58 5.5	59 5.2
Normal hip	53 7.7		58 4.8	61 5.2

Group A infants with neonatal hip instability, treated with Frejka pillow, group B infants with clinical instability or uncertain clinical findings, not treated from birth.

Clinical grading of instability was performed in 122 hips. 71 hips classified as having slight instability had a mean FHC of 41%, whereas 40 hips with medium instability had one of 37%, and 11 hips with pronounced instability had a mean FHC of 25%. All the differences between the 3 categories were statistically significant.

Group B comprised 94 newborns, 35 (24 girls) had clinical instability and 59 (41 girls) had inconclusive findings, but normal sonography. The frequency of girls was significantly lower than in group A. The mean FHC of affected hips as well as unaffected hips was 53% (Table 1), which was significantly higher than both affected and unaffected hips in group A.

In group A, instability was diagnosed by the pediatricians alone in 5 cases, by the orthopedic surgeons alone in 26 cases and by both in 77 cases. The pediatricians diagnosed NHI in 109 of the 202 neonates, of which ultrasound resulted in normal findings in 27 and abnormal findings in 82 cases. Thus, in relation to sonography, the sensitivity of the clinical examination by the pediatricians (true positives divided with true positives + false negatives) was 76% and the positive predictive value (true positives divided by true positives + false positives) was 75%. In the 77 neonates with clinical instability found by pediatricians and orthopedic surgeons, ultrasound confirmed instability. Thus, the positive predictive value in this group was 100%.

Follow-up

The mean FHC at 2–3 months of age was 57% for affected hips in group A, which was not significantly different from unaffected hips in group A or from the hips in group B (Table 1). The head coverage at 2–3 months was significantly higher than at birth. For in-

Table 2. Lateral head distance on ultrasound (LHD, mm) and radiographic results at age 4–5 months, mean SD

Groups	Ultrasound	Radiography			
	LHD	LHDR	AI	e	f
Group A					
Affected hip	–0.8 1.4	–1.1 1.5	23.9 3.7	17.9 1.5	9.1 1.6
Normal hip	–1.2 1.5	–1.0 1.7	24.1 3.6	17.8 1.6	9.2 1.5
Group B					
Affected hip	0.5 2.2	–0.1 1.8	25.7 5.6	18.6 1.8	9.7 1.3
Normal hip	–0.3 1.6	–0.3 1.6	24.7 4.5	17.9 1.6	9.7 1.2

LHDR lateral head distance on radiographs (mm), AI acetabular index (degrees), e and f distances (shown in Figure 4).

fants with a visible ossification center of the femoral head, the mean LHD was –1.0 to 0 mm in affected and unaffected hips in both groups. 11 infants (6 in group A and 5 in group B) had abnormal ultrasound findings, indicating dysplasia. Treatment was not started for those in group B, because we thought they might normalize spontaneously.

At 4–5 months the mean FHC was approximately 60% and there were no significant differences between groups A and B or between affected and unaffected hips (Table 1). The mean LHD was approximately the same as at the first follow-up examination. The corresponding distance by radiography (LHDR) was approximately 0 mm in most hips (Table 2). The mean (SD) difference between LHD and LHDR was 0.3 mm (1.1) and the correlation was high ($r = 0.74$). The limits of agreement (mean 2SD) were –1.9 to 2.2 mm.

The other radiographic results at age 4–5 months are given in Table 2. The mean acetabular index in group A was 24° and in group B 25–26°; the differences between the groups and between affected and unaffected hips were not significant. In group A, 5 babies had dysplasia on ultrasound and normal radiography or vice versa. The hips normalized spontaneously in 2 of these infants, whereas treatment with an abduction orthosis was started some months later in 3 infants because of persistent dysplasia. In group B, 2 girls had subluxation on both ultrasound and radiography (Figure 5). They were treated with an abduction splint and the hips developed normally. Another girl had dysplasia on radiography and normal ultrasound, and the condition normalized spontaneously.

Of the 94 neonates with normal (negative) sonography, 2 infants needed treatment later, whereas the remaining 92 infants developed normally. Thus, the negative predictive value (true negatives divided by true negatives + false negatives) was 98%.

Figure 5. Subluxation of the left hip in a 4-month-old girl in Group B. No treatment was given before this follow-up examination because of a normal ultrasound at birth.

Discussion

In our study, 1.5% of the neonates had physical findings of instability, which is in accordance with the frequency of 1–2% in other studies (Dunn 1976, Cyvin 1977, Hadlow 1988, Poul et al. 1992). In addition, 0.6% of the neonates had inconclusive findings. Without ultrasound, all neonates with instability and several of those with inconclusive findings would probably have undergone treatment with the Frejka pillow. The main value of ultrasound was that almost half of these cases seemed to have normal hips and needed no treatment. Similar findings have been reported by Berman and Klenerman (1986). The fact that 98% of the untreated hips developed normally indicates that ultrasound reliably distinguishes between hips that need treatment and those that do not. However, because 2 of 94 infants developed abnormally and needed treatment later, all children with clear or suspected instability at physical examination, but with normal ultrasound, require follow-up at 2–3 months of age.

When related to ultrasound findings, the positive predictive value of physical examination by the pediatricians was 75%. When both the pediatricians and the orthopedic surgeons agreed on instability, the positive predictive value increased to 100%. This is in accordance with Palmén (1984) who recommended clinical examinations by experienced examiners twice during the first week of life.

The mean FHC of unstable hips that were treated with the Frejka pillow was 37% in the neutral, nonstressed position and increased to 54% when reduction was achieved by flexing and abducting the leg. The latter scan showed that the acetabulum had normal depth in most unstable hips. We think this technique of detecting instability by first seeing the hip subluxated and then reduced, is better than the commoner procedure of using a stress maneuver, i.e., pushing the leg in the dorsal and/or proximal direction (Dahlström et al. 1986, Keller et al. 1988, Saies et al. 1988). The latter method depends on the force that is used and, because there is a physiological laxity in the hips of newborns, it is difficult to distinguish between normal laxity and abnormal instability (Keller et al. 1988, Saies et al. 1988). Moreover, sonographic instability detected by stress tests in clinically normal hips tends to normalize spontaneously, indicating that its clinical significance is limited (Harcke and Kumar 1991, Castelein et al. 1992).

Instability on physical examination has been divided into subluxatable (or dislocatable), subluxated, and dislocated (Clarke 1986, Bradley et al. 1987, McKibbin et al. 1988, Poul et al. 1992). Others feel that such grading is unreliable and of little practical value (Cyvin 1977); grading is subjective and no sharp limits between the different types can be established. Our classification into slight, medium and pronounced instability is hardly more reliable than the traditional one, but correlates with the ultrasound measurements. Although there was considerable overlap between the grades, slightly unstable hips had considerably higher FHC than hips with pronounced clinical instability.

FHC of unstable hips was usually in the range of 30–45%. The limit between subluxation and total dislocation is difficult to define because it is not the total displacement but its lateral component that is measured. A reasonable limit would probably be 25%, and FHC below this limit was found in only 4 hips. Based on ultrasound evaluation, the great majority of unstable hips were subluxated and very few were dislocated in the anatomical sense, which was also the experience of Clarke (1986). Therefore, the traditional physical grading should be reconsidered. Many hips that others would call "subluxatable" (positive Barlow test) and that we call "slight instability" were in fact subluxated on ultrasound. Hips that traditionally would be judged as "dislocated" (positive Ortolani test) were also usually subluxated on ultrasound. The fact that most of the unstable hips are subluxated rather than dislocated, is probably an important reason why simple abduction treatment usually is successful.

During follow-up, there was good agreement between radiographic and sonographic measurements of the lateral head distance. This indicates that LHD is a reliable parameter for assessing femoral head coverage, which confirms our previous experience (Terjesen et al. 1989b). The main benefit of ultrasound in follow-up is that the use of radiography can be substantially reduced. We use radiography only once, at 4–5 months of age, in the routine follow-up of infants with instability. A radiograph at this age is useful for assessment of acetabular dysplasia and is also valuable for comparison with radiographs later, if problems arise and additional treatment is considered. For infants with inconclusive physical findings but normal ultrasound at birth, we do not use radiography at all in the routine follow-up, but rely on sonography. Radiography is needed only when ultrasound shows abnormal or suspicious findings.

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