The use of ultrasound in determining the initiation of treatment in instability of the hip in neonates

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We have evaluated the effect of the use of ultrasound in determining the initiation of treatment in neonatal instability of the hip. A total of 99 newborn infants (1.5% of all live births) with neonatal hip instability did not have treatment from birth, but were re-examined at eight to 15 days. In the 31 who had persisting clinical instability and ultrasound abnormality, treatment was then started with a Frejka pillow. The hips in the remaining 68 infants showed spontaneous clinical stabilisation and improvement of the ultrasound findings. Treatment was therefore withheld. There was a marked trend towards normal development in mildly unstable hips, whereas no hips with severe instability did so spontaneously.

Further follow-up showed normal development in all the hips which had been treated, and in all except five of the 68 untreated infants. These five infants showed persistent hip dysplasia on both ultrasound and radiological examination at four to five months of age. Treatment with an abduction splint was then started and their hips developed normally.

Ultrasound is very useful in deciding on treatment if the examiners have adequate experience with the method. Its use substantially reduces the rate of treatment. Spontaneous resolution occurred in more than half of the unstable hips. Since five of the untreated infants developed hip dysplasia a strict follow-up is essential to identify and treat these cases.

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Treatment from birth for neonatal hip instability (NHI) has been advocated by many authors.1-8 Since the incidence is higher than that of true hip dysplasia, this policy leads to over-treatment which may result in serious complications such as avascular necrosis of the femoral head.

Several reports have commented on the tendency for instability of the hip to resolve spontaneously in newborn infants,9-12 but this does not imply that they have become normal. When clinically unstable hips (Ortolani-positive) were left untreated, about half progressed normally while the rest developed dysplasia.13,14 It is difficult to decide which hips will develop normally and which will need treatment. Better diagnostic tools are required and real-time ultrasonography has become the most promising method for the assessment of hips in infancy.15-18

We have evaluated the role of ultrasound in helping to decide the indications for and timing of the treatment of NHI and the relationship between sonography and the clinical grading.

Patients and Methods

Between 1991 and 1992 there were 6425 live births at our hospital. All the newborn infants were examined by an experienced paediatrician using the Ortolani and Barlow tests on the first day of life. Those with unstable hips were also examined clinically and by ultrasonography by an orthopaedic surgeon two to three days after birth. Clinically, the instability was classified into three grades. Those classified as mild had a positive Barlow test; those which were moderate and severe had a positive Ortolani test. Newborn infants with clinical instability and abnormal ultrasound findings were not treated from birth, but were re-examined at eight to 15 days.

The ultrasound examination was carried out as described previously.17,19 The child was placed in the supine position. A 5MHz linear ultrasound transducer was used. With the transducer placed on the lateral aspect of the hip region, longitudinal and transverse scans were made. Both scans were used for dynamic evaluation of stability. The longitudinal scan through its centre was used for measurement of femoral head coverage (FHC). The aim was to keep the transducer parallel to the long axis of the child. The leg was slightly flexed to visualise the femoral
metaphysis in a neutral position of rotation and ab/adduction. To assess the FHC, the distance from the lateral bony rim of the acetabulum (a) and the lateral joint capsule (b) were measured to the acetabular floor (Fig. 1a). Both measurements were taken perpendicular to the long axis of the transducer and thus perpendicular to Perkins’ line when the transducer was correctly positioned. The FHC was calculated as a/b × 100; this expresses the percentage of the femoral head covered by the bony acetabulum. The ultrasound measurements in hips with NHI differ from those in stable hips; the measurements are taken from the medial tangent of the femoral head rather than from the acetabular floor (Fig. 1b).

A further ultrasound and clinical examination was carried out by an orthopaedic surgeon one to two weeks after birth. If persistent clinical instability and a reduced FHC were found, treatment with a Frejka pillow was undertaken for four months (group 1). For infants with clinically stable or mildly unstable hips and an FHC of 45% or above, no treatment was given (group 2) (Fig. 2).

**Follow-up.** The same protocol was used for both groups. Clinical and ultrasound examinations were carried out at two to three months, four to five months, and 12 to 14 months. At the four-to-five-month examination, a standard pelvic radiograph was also taken. A few infants with doubtful findings had an additional follow-up at around eight months of age.

In infants in whom the ossification centre of the femoral head was visible, the lateral head distance (LHD) on ultrasound was used as an indirect measurement of the FHC\(^{20}\) (see Fig. 3c). A negative value indicates that the whole ossification centre is medial to the acetabular rim and a positive value that part of the ossification centre is lateral to this rim. The larger the LHD, the less is the coverage of the femoral head.

Radiological evaluation was based on the measurement of the LHD (LHDR) which was as described for ultrasound (perpendicular to Perkins’ line), and the acetabular index (AI).\(^{20}\)

**Statistics.** The Student’s \(t\)-test and the chi-squared test were used to evaluate the differences between stable and unstable hips and between the two groups. The correlation between the LHD using ultrasound and the LHDR using radiography was assessed by Pearson’s correlation coefficient (r). P values below 0.05 were considered to be significant.
Results

Neonatal examination. During the two-year period, 99 newborn infants (1.5% of live births) had NHI diagnosed clinically and by ultrasound. There were 82 girls and 17 boys. In 47 infants the instability was graded as mild (positive Barlow test) and in the remaining 52 as moderate or severe (positive Ortolani test). Hip instability was unilateral in 70 infants and bilateral in 29, giving a total of 128 unstable hips. At the first examination, the mean FHC was 50% for the 70 stable hips and 39% for the 128 unstable hips (Table I). Of the latter, 67 (52%) were classified as having mild instability and the FHC of these hips was significantly higher than that of hips with moderate (p < 0.001) or severe (p < 0.001) instability (Table I). There was also a significant difference in the FHC between hips with moderate and severe instability (p = 0.011).

At the second examination at one to two weeks, 31 infants (28 girls and three boys) showed persistent clinical instability in addition to abnormal ultrasonography. Treatment with a Frejka pillow was started (group 1). The mean FHC of the unstable hips was 39.6%, which was significantly higher than the initial FHC in this group (p < 0.001), but still abnormal (Table II). Of the 31 infants, 29 (93%) had been graded as having moderate or severe instability in one or both hips at the first clinical examination while only two had a mild degree of instability.

At the second examination, the clinical and sonographic results in 68 infants had improved to such an extent that no treatment was started (group 2). As shown in Table II the initial FHC in this group was significantly higher than that in group 1 (p < 0.001). In 62 infants the hips had spontaneously stabilised clinically at one to two weeks (Fig. 2). Five had a very mild instability and in one the diagnosis was uncertain. As shown in Table II the mean FHC had increased to 48.6%, which was significantly higher than at birth (p < 0.001) and higher than in group 1 at their second neonatal examination (p < 0.001). In group 2, 70% of the unstable hips had been classified as having mild NHI at birth, while the remainder had moderate instability.

There were significantly more cases of bilateral NHI in group 1 than in group 2 (45% v 22%) (p < 0.02). There were no significant differences between the two groups with regard to the risk factors for hip dysplasia such as family history, breech position, foot deformities, gender, and birth-weight.

Follow-up. For group 1 the results of the sonographic and radiological examinations at follow-up are shown in Table III. At two to three months all the hips were clinically

Table I. Ultrasonographic findings at the first neonatal examination in 99 newborn infants with NHI

<table>
<thead>
<tr>
<th>Clinical findings</th>
<th>Number of hips</th>
<th>Mean (± SD) FHC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable hips</td>
<td>70</td>
<td>50 ± 5.5</td>
</tr>
<tr>
<td>Unstable hips</td>
<td>128</td>
<td>39 ± 5.5</td>
</tr>
<tr>
<td>Mild</td>
<td>67</td>
<td>42 ± 5.1</td>
</tr>
<tr>
<td>Moderate</td>
<td>47</td>
<td>37 ± 4.6</td>
</tr>
<tr>
<td>Severe</td>
<td>14</td>
<td>33 ± 6.6</td>
</tr>
</tbody>
</table>
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Fig. 3a
Longitudinal ultrasound scans and schematic drawings of a hip found to be unstable at examination at birth (a) which stabilised spontaneously, with a normal ultrasound scan at two weeks (b). At follow-up after four to five months, ultrasonography showed subluxation (c) which was confirmed by radiography. The symbols are as in Figure 1. In (c) the horizontal broken line represents the lateral tangent of the ossification centre (OC). The vertical line (from the lateral tangent of the OC to the lateral acetabular rim) is the LHD.

Table II. Mean ultrasonographic FHC (%; ± SD) of the unstable hips at the first and second (8 to 15 days) neonatal examinations according to treatment group

<table>
<thead>
<tr>
<th>Group</th>
<th>Treatment</th>
<th>Number of infants</th>
<th>Number of hips</th>
<th>FHC (%)</th>
<th>First examination</th>
<th>Second examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frejka pillow</td>
<td>31</td>
<td>46</td>
<td>36.4 ± 6.3</td>
<td>39.6 ± 6.1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>No treatment</td>
<td>68</td>
<td>82</td>
<td>41.2 ± 4.1</td>
<td>48.6 ± 4.3</td>
<td></td>
</tr>
</tbody>
</table>

Table III. Ultrasonographic and radiological results (mean ± SD) at follow-up for the 31 treated (group 1) and 68 untreated (group 2) infants

<table>
<thead>
<tr>
<th>Age (mth)</th>
<th>Parameter</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 to 3</td>
<td>FHC (%)</td>
<td>54.5 ± 5.2</td>
<td>54.2 ± 5.9</td>
</tr>
<tr>
<td>4 to 5</td>
<td>FHC (%)</td>
<td>56.2 ± 4.7</td>
<td>57.2 ± 6.1</td>
</tr>
<tr>
<td>LHD (mm)</td>
<td>-0.9 ± 1.2</td>
<td>0.1 ± 1.4</td>
<td></td>
</tr>
<tr>
<td>LHDR (mm)</td>
<td>-0.9 ± 1.5</td>
<td>0.1 ± 1.7</td>
<td></td>
</tr>
<tr>
<td>AI (degrees)</td>
<td>24.7 ± 4.2</td>
<td>27.5 ± 4.9</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>LHD (mm)</td>
<td>1.3 ± 1.6</td>
<td>0.9 ± 1.7</td>
</tr>
</tbody>
</table>

During the first four to five months of follow-up, the hips of 63 infants in group 2 developed normally, but the dysplasia failed to resolve in five, all girls. Their FHC did not differ from that of the rest of group 2 at the two neonatal examinations. At two to three months of age their mean FHC had decreased to 39% (Table IV) which was markedly lower than that of the other infants in group 2 (Table III). At four to five months all the sonographic and radiological measurements were abnormal (Fig. 3), and treatment with an abduction splint was started.

Radiologically, one patient had slight subluxation and four had only acetabular dysplasia. With regard to risk factors such as family history, breech position, and birthweight there was no significant difference between these five infants and the others in group 2. At 12 to 14 months, after treatment had been completed, the ultrasound and radiological measurements of these five children were within the normal range. The hips of the remaining untreated infants were also normal at the one-year follow-up.

Discussion

Two studies have shown that approximately 50% of newborn infants with NHI develop normally without treat-
ment. This suggests that many infants will be treated unnecessarily if this is initiated at birth. Clinical examination alone is not sufficient to predict which infants should be treated since Barlow reported that some hips which stabilise spontaneously will still develop hip dysplasia during the first year of life. Most authors have recommended treatment from birth for all newborn infants with NHI because this is a simple practical policy for routine clinical work.

Treatment can lead to serious complications such as avascular necrosis of the femoral head and the number of infants so managed should therefore be kept as low as possible. Over-treatment can be reduced by improved diagnostic techniques and delaying the decision to initiate it. Delayed treatment, based on clinical examination, was evaluated by MacKenzie and McKibbin et al. They found that 65% and 79%, respectively, of hips classified as dislocatable at birth, with a positive Barlow test, stabilised within three weeks. None of their untreated infants was referred later with hip dysplasia. The same tendency to spontaneous resolution of clinically unstable hips was found by Barlow.

There is no general agreement as to the classification of NHI. Many authors have used a classification into ‘dislocatable’ (positive Barlow test) and ‘dislocated’ (positive Ortolani test). Others have included ‘subluxatable’, which represents a positive Barlow test but is hard to distinguish from ‘dislocatable’. Hips with mild instability have been called ‘slidey’, ‘lax’ or ‘unstable’. These complex and rather confusing classifications reflect the spectrum of severity of unstable hips and the subjective nature of clinical evaluation. Our classification was also based on clinical evaluation by experienced examiners and was chosen for two reasons. First, when comparing ultrasound findings, we felt that it would be useful to include a moderate grade of instability in addition to the mildly unstable hips with a positive Barlow test, and those which were severely unstable, although we realised that it would often be difficult to distinguish between moderate and severe when both had a positive Ortolani test. Secondly, our previous experience using direct visualisation with ultrasound had shown that most unstable hips were subluxated rather than anatomically dislocated or dislocatable/subluxatable.

Our clinical grading corresponded well to the sonographic measurements since severely unstable hips had a considerably lower FHC than the mildly unstable. The clinical grading was also of prognostic value since most mildly unstable hips resolved spontaneously within one to two weeks. None of the severely unstable hips resolved spontaneously. In retrospect, the value of adding the moderate grade of instability seems limited. We now believe that two grades only, a positive Barlow test and positive Ortolani test, are sufficient and represent the most adequate clinical grading of NHI. Such evaluation is likely to be reliable only when carried out by experienced examiners.

Few ultrasound studies aimed at reducing over-treatment have been published. Gardiner and Dunn randomised 79 newborn infants with dislocatable hips, with a positive Barlow test, to immediate treatment or sonographic surveillance for two weeks. In the surveillance group 71% of the infants developed normally.

The aim of our study was to include hips with all degrees of instability. In most of our untreated group, the anatomy of the hip was normal since the mean FHC had increased from 41% to 48% (within the normal range) during the first two weeks. None of the hips with severe instability and markedly reduced FHC showed normal development within one to two weeks. Persistent clinical instability in patients in group 1 treated with a Frejka pillow after the second examination was associated with a persistent low FHC on sonography.

Our results can be compared with the study of Boeree and Clarke who also delayed making a decision as to whether to treat until 10 to 16 days. They found that the hips of 35% of infants with NHI subsequently developed normally. This is considerably lower than the 63% in our study. The discrepancy can probably be explained by the greater number of mildly unstable hips in our series.

Some authors have advocated that the best time for ultrasonographic hip examination is some weeks after birth since there is a rapid improvement in abnormality detected by ultrasound in the first few days after birth. We prefer to examine the hips ultrasonographically shortly after birth, when the mothers and infants are still in hospital, to avoid any cases being missed.

During the period of this study our rate of early treatment was 0.48%, rising to 0.56% when the five infants treated at four to five months are included. During the three years...
between 1988 and 1991, when all newborn infants with NHI were treated from birth, our rate of treatment was 1.2%. Previously, when clinical examination only was used it was 1.9%. Barlow and Dunn pointed out that hips which stabilise spontaneously sometimes develop dysplasia later. Five infants in our untreated group developed abnormal hips, but none had frank dislocation. An abduction splint initiated at four to five months was sufficient to allow the hips to develop normally. Lempicki, Wierusz-Kozlowska and Kruczynski found that the risk of avascular necrosis was doubled if treatment using a Frejka pillow began later than six months. Therefore it seems advisable that the start of treatment should not be unduly delayed. Reviewing the five infants treated at four to five months of age, it appeared that girls with FHC values around the lower normal limit of 45% at the one-to-two-week follow-up, and with lower FHC values at two to three months, are at special risk of failure of the dysplasia to resolve. Therefore careful follow-up including ultrasound assessment is important in this group. In infants with abnormal or uncertain findings at six months. Therefore it seems advisable that the start of treatment should not be unduly delayed. Reviewing the five infants treated at four to five months of age, it appeared that girls with FHC values around the lower normal limit of 45% at the one-to-two-week follow-up, and with lower FHC values at two to three months, are at special risk of failure of the dysplasia to resolve. Therefore careful follow-up including ultrasound assessment is important in this group. In infants with abnormal or uncertain findings at four to five months or older, radiography can be used to improve assessment.

We recommend delaying the start of treatment for NHI if the first and subsequent examinations are carried out by doctors with sufficient experience. If these requirements cannot be met, the conventional treatment from birth of all infants with unstable hips is probably a simpler and safer policy.

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References