HIP ABNORMALITIES DETECTED BY ULTRASOUND IN CLINICALLY NORMAL NEWBORN INFANTS

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WE have followed the natural progress of newborn infants in whom ultrasound examination showed abnormalities in hips which appeared to be clinically normal. Over six years we saw 306 such children out of 9952 examined (31 per 1000 live births). The examination was repeated at two to three months and those who still showed an abnormality were followed up further.

At four to five months a standard radiograph was obtained, and treatment began if this and another ultrasound scan were both abnormal. At this stage, 291 infants had normal hips. In the 15 infants with abnormal hips there was no pronounced deterioration, none developed a frank dislocation, and all became normal after treatment in an abduction splint.

Newborn infants with abnormal and suspicious ultrasound findings who are normal on clinical examination do not need treatment from birth; most of these hips will settle spontaneously. Treatment can be postponed until the age of four to five months unless clinical instability develops or ultrasound shows dislocation. The criteria for treatment should be based on measurements by both ultrasound and radiography: both should show an abnormality before intervention is considered necessary.

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After birth, abnormalities in development can be detected by ultrasound in clinically normal hips (Berman and Kleinerman 1986; Clarke, Clegg and Al-Chalabi 1989; Terjesen, Bredland and Berg 1989a; Castelein et al 1992; Graf, Tschauer and Klapsch 1993), but it is not clear whether such children need treatment from birth (Tönnis, Storch and Ulbrich 1990; Ganger, Grill and Leodolter 1992; Graf et al 1993) or whether an expectant attitude can be followed to see if they will develop normally (Castelein et al 1992).

To clarify this we have followed a series of sonographically abnormal but clinically normal hips in newborn infants. We wished to ascertain how many of these potentially pathological hips would become normal spontaneously, how long we should observe those which did not become normal before initiating treatment, whether delay in treatment prejudices the outcome and what criteria should be used in assessing whether or not treatment is needed.

PATIENTS AND METHODS

Between 1987 and 1992 we examined the hips of 9952 newborn infants by ultrasound. Clinical examination was performed by an experienced paediatrician on the first day and by an orthopaedic surgeon within a few days of birth. The Ortolani and Barlow tests were carried out and abduction of the hips was assessed; 60° or more was considered normal (Ryder, Mellin and Caffey 1962).

The orthopaedic surgeon carried out ultrasonography at the same time as the clinical examination using the technique described by Terjesen et al (1989a). With the infant supine and the hip in slight flexion but otherwise in a neutral position, longitudinal and transverse scanning was performed from the lateral aspect. Subjective dynamic evaluation of hip stability and measurement of the femoral-head coverage (FHC) were made. We measured the distance from the medial wall of the acetabulum to the level of the lateral bony acetabular rim (a) and to the medial border of the lateral joint capsule (b) perpendicular to the baseline of the ultrasound image (Fig. 1). The FHC is the percentage $\frac{a}{b} \times 100$. In the presence of subluxation, the measurements are taken from the medial tangent of the cartilaginous femoral head instead of from the acetabular floor (Fig. 2). The hip was considered to be potentially abnormal if the FHC was less than 50% and/or the joint seemed unstable during manipulation.

Infants with hips which were normal on clinical examination but whose ultrasound findings provoked suspicion were followed up. No treatment was given.

The first follow-up examination was performed at two to three months of age using the same methods. When the
ossification centre of the femoral head had appeared (Fig. 3), we measured the distance from the lateral tangent of the ossification centre to the lateral bony acetabular rim (Terjesen, Rundén and Tangerud 1989b) to define the lateral head distance (LHD) which expresses the degree of uncovering of the femoral head. When the whole ossification centre is medial to the lateral acetabular rim, the LHD has a minus value.

If the hips were normal at the age of two to three months no further follow-up was needed but if abnormal ultrasound findings were still present a second follow-up was carried out at four to five months of age, and a standard antero-posterior radiograph obtained. On this, the acetabular index (AI) was measured and the distances l and m were used for calculation of the metaphyseal percentage (MeP; l/m × 100) (Fig. 4), which expresses the percentage of the femoral metaphysis lateral to Perkins’ line. The distances e and f express the position of the proximal femur in relation to the acetabulum. Distance e was measured from the medial corner of the bony acetabular roof to the vertical projection of the most proximal and lateral point of the femoral metaphysis, and distance f was from the same point of the metaphysis to Hilgenreiner’s line. When the ossification centre of the femoral head was visible, the lateral head distance by radiography (LHDR) was measured in a similar way as described for ultrasound.
All hips were assessed independently by ultrasound and radiography (Terjesen et al. 1989b) and classified into four groups: normal, dysplastic, subluxed or dislocated. The criteria are given in Table I. The shape of the lateral bony rim of the acetabular roof was noted. The normal bony rim is sharp or slightly rounded, whereas the dysplastic rim is markedly rounded or flat. The displacement of the femur was used for the diagnosis of subluxation and dislocation.

In infants who had abnormal findings on both ultrasound and radiological examination, treatment by an abduction splint was begun and further follow-up arranged.

RESULTS

Of the 9952 newborn infants examined 306 (31 per 1000 live births) had abnormal or suspicious ultrasound findings but were normal on clinical examination. By two to three months, the ultrasound scans were normal in 245 of these (see Fig. 2), but in 61 the appearances were still abnormal. The scan showed subluxation of the left hip in one girl (Fig. 5) and the Ortolani test was positive. A radiograph at the age of three months confirmed subluxation and treatment by an abduction splint was initiated.

The other 60 infants were reviewed at four to five months of age, when 32 had normal hips on both ultrasound scans and radiographs, 13 had dysplasia demonstrated by either ultrasound or radiography, and 15 had dysplasia or subluxation as seen by both methods. Twelve of the 13 infants with discrepancy were further followed up without being given any treatment and their hips developed normally. One girl with dysplasia indicated by ultrasound but normal hips on radiography was treated by an abduction splint because crepitation of the right hip raised the suspicion of instability.

Of the 15 infants with pathological findings on both ultrasound and radiography, one infant with unilateral dysplasia and slightly reduced abduction was treated by physiotherapy and the hip became normal. The others were treated by abduction splints. They were all girls and all had been in cephalic presentation at birth. Four had a family history of congenital or developmental hip dysplasia. The mean birth weight was rather high at 3880 g (2620 to 4660). At birth all the hips had had abduction of 60° or more which was symmetrical in all except one. During follow-up an increasing number of infants showed asymmetrical abduction (Table II). Two developed clinical instability during follow-up and both ultrasound and radiography showed subluxation of the affected hips.

Table II gives the ultrasound findings at birth and during follow-up in the 15 infants. The FHC of the dysplastic and subluxated hips decreased from 42.0% and 43.8%, respectively, to 38.6% and 30.3%. In hips with a visible ossification centre, the LHD was increased in dysplastic hips and further increased in subluxated hips.

Radiographs showed unilateral dysplasia in six infants, unilateral subluxation in eight and bilateral abnormalities in one. The mean AI of the abnormal hips was 38° (Table III).
with no difference between dysplasia and subluxation. The LHDR, MeP and distance e, which indicate lateral displacement, all rose with increasing abnormality. Distance f was reduced in subluxated hips. There was a good agreement between ultrasound and radiography, since the correlation coefficient between the LHD and LHDR in pathological hips was 0.89.

Treatment by an abduction splint lasted from three to six months and all the hips became normal during treatment. None developed avascular necrosis or other complications. The patients began to walk at the age of 12 to 18 months. Neither at this stage nor later have there been any signs of abnormal hip function.

DISCUSSION

In the classification of the ultrasound appearance of neonatal hips of Graf et al (1993) abnormalities are divided into groups IIC, IID, III and IV. The natural history of these hips has not been properly determined and most authors simply state that treatment is required (Hauck and Seyfert 1990; Tönnis et al 1990; Ganger et al 1992; Millis and Share 1992; Graf et al 1993). Castelein et al (1992) studied the natural history of ultrasound abnormalities using Graf’s classification and found that in most of them there was normal development. We have used different ultrasound measurements but a similar strict treatment policy, and our results are similar to those of Castelein et al (1992). Most abnormal hips developed normally and treatment was necessary in only 4.9% of the ‘abnormal’ infants followed up.

Delay in beginning treatment did not affect the outcome, but if clinical instability is detected it seems reasonable to start treatment immediately. It should not be delayed if severe subluxation or frank dislocation is diagnosed by ultrasound during follow-up, but none of our infants
We consider an FHC of 50% to be the limit between normal late well with radiological findings (Terjesen et al 1989b). A 'frozen' ultrasound image on the monitor, and both measurements are easily and quickly performed on the measurement by LDH are recommended for routine use. Both HCs in hips with no ossification centre and indirect measurements are of the age of the patient. Direct measurement of the most important factor in diagnosing hip dysplasia, irrespective of the age of the patient. Direct measurement of the FHC in hips with no ossification centre and indirect measurement by LDH are recommended for routine use. Both measurements are easily and quickly performed on the ‘frozen’ ultrasound image on the monitor, and both correlate well with radiological findings (Terjesen et al 1989b). We consider an FHC of 50% to be the limit between normal and potentially abnormal hips at birth and in infancy (Terjesen et al 1989a), and this view was agreed by Millis and Share (1992).

On radiographs a reasonable limit between normality and dysplasia is the mean value of the normal AI plus 2SD. Previous studies (Tönnis 1976; Scoles, Boyd and Jones 1987; Terjesen et al 1989b) have indicated that an upper normal limit of 32° at the age of four to five months, as used in our study, is correct. The diagnosis of hip dysplasia, however, should not be based solely on a high AI (Ryder et al 1962; Komprda 1984). Disturbance of the ossification of the lateral rim of the acetabular roof, leading to bony defects, is also an important sign.

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REFERENCES


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**Table III.** Ultrasound and radiological measurements (mean ± SD) in the 15 infants treated by an abduction splint

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Radiological diagnosis</th>
<th>Normal</th>
<th>Dysplasia</th>
<th>Subluxation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound:</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>FHC (%), birth</td>
<td>46.6 ± 4.6</td>
<td>42.0 ± 6.2</td>
<td>43.8 ± 6.0</td>
<td></td>
</tr>
<tr>
<td>FHC (%), 2 to 3 months</td>
<td>51.6 ± 5.8</td>
<td>42.7 ± 4.2</td>
<td>36.0 ± 7.8</td>
<td></td>
</tr>
<tr>
<td>FHC (%), 4 to 5 months</td>
<td>52.4 ± 4.8</td>
<td>38.6 ± 6.3</td>
<td>30.3 ± 2.1</td>
<td></td>
</tr>
<tr>
<td>LHD (mm) 4 to 5 months</td>
<td>0.5 ± 2.1</td>
<td>3.7 ± 1.6</td>
<td>5.5 ± 0.9</td>
<td></td>
</tr>
<tr>
<td>Radiography 4 to 5 months:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHDR (mm)</td>
<td>0.6 ± 1.1</td>
<td>3.5 ± 2.3</td>
<td>5.2 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>AI (degrees)</td>
<td>30.3 ± 2.2</td>
<td>37.4 ± 2.8</td>
<td>38.1 ± 4.4</td>
<td></td>
</tr>
<tr>
<td>MeP (%)</td>
<td>52.7 ± 12.0</td>
<td>70.0 ± 11.1</td>
<td>84.3 ± 11.5</td>
<td></td>
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<tr>
<td>Distance e</td>
<td>19.5 ± 1.2</td>
<td>20.1 ± 1.4</td>
<td>22.7 ± 1.0</td>
<td></td>
</tr>
<tr>
<td>Distance f</td>
<td>9.0 ± 1.0</td>
<td>8.3 ± 1.5</td>
<td>6.7 ± 1.8</td>
<td></td>
</tr>
</tbody>
</table>

showed these abnormalities. For relatively mild degrees of dysplasia or moderate subluxation four to five months of age is an appropriate time to start treatment. Further delay may cause some hips to deteriorate.

Clinical findings such as instability and restricted abduction suggest abnormality. Asymmetrical abduction arouses suspicion but we do not consider this to be abnormal as long as there is 60° of abduction or more on both sides.

Ultrasound has become the standard method of imaging in infants below the age of three months. For older infants many centres rely almost entirely on ultrasound (Graf et al 1993) and radiography in infants below the age of one year has become a rarity in German-speaking countries. Garvey et al (1992) feel, however, that radiography remains the ‘gold standard’ in infants over four months of age. Others advocate a combination of ultrasound and radiography (Terjesen et al 1989b; Polanauer, Harcke and Bowen 1990; Castelein et al 1992). The aim should be not to abandon radiography but to reduce its application to the necessary minimum.

Hips which will recover spontaneously should not be treated. Reliance on the ultrasound appearances will lead to overtreatment as shown by published treatment rates of 6.5% (Tönnis et al 1990) and 9% (Ganger et al 1992).

We consider that the coverage of the femoral head is the most important factor in diagnosing hip dysplasia, irrespective of the age of the patient. Direct measurement of the FHC in hips with no ossification centre and indirect measurement by LDH are recommended for routine use. Both measurements are easily and quickly performed on the ‘frozen’ ultrasound image on the monitor, and both correlate well with radiological findings (Terjesen et al 1989b).