Ultrasonography in Legg-Calvé-Perthes disease

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Abstract. Ultrasonography was found to be a valuable investigation in the assessment and management of Legg-Calvé-Perthes disease (LCPD). It was used to assess 23 patients with LCPD in 25 affected hips and was compared with radiographs obtained at the same time. A chronological five-part staging of LCPD is proposed, expressing the degree of flattening and fragmentation as well as reconstitution of the femoral head as seen on ultrasound examination. Thickening of articular cartilage was documented, and associated findings of synovitis and lateral extrusion of the femoral head were evaluated. An intraarticular hip effusion was present in 74% of cases in stages I-II. Lateral extrusion increased from stage II onwards until the healing stage. The phase of reconstitution (stage IV) demonstrated both resorption of the necrotic bone and formation of new immature osteoid tissue. Lateral extrusion and the start of the healing phase can be shown earlier by ultrasonography than by radiography.

Avascular necrosis of the femoral head in children (Legg-Calvé-Perthes disease, LCPD) follows a characteristic pattern from first recognition to complete revascularisation of the femoral head. After the initial avascular necrosis, the femoral head collapses, becomes fragmented and finally is reconstituted by a long-lasting reformation process [1]. The clinical outcome and the development of early osteoarthritis are related to the extent of the necrosis [2, 3] and the lateral extrusion and deformity of the femoral head [4-8]. These features usually require serial radiographs for their documentation and evaluation.

Experience with ultrasonography in LCPD is limited. There are few reports describing the ultrasonographic appearance of the shape of the femoral head in Perthes' disease [9-12]. Ultrasonography is well established for the diagnosis and follow up of neonates and infants with congenital hip dysplasia [13, 14]. The mainly cartilaginous structure of the hip joint at that age makes accurate measurement of the lateral extrusion of the femoral head possible, with direct visualisation of the cartilaginous margins of the joint [13]. It is also possible to assess the degree of lateral extrusion in older children with advanced ossification using the bony margins as reference points [15].

In this study the relevance of ultrasonography for Perthes' disease was evaluated in 23 patients who were investigated in different stages of the disease. The typical ultrasonographic appearances of the femoral head during the course of LCPD are outlined in five stages. Ultrasonography also provides additional information by demonstrating synovitis, early lateral extrusion of both the bony and the cartilaginous portions of the femoral head, and the onset of reconstitution of the femoral head.

Materials and methods

From July 1989 to March 1992, 23 patients (19 male, 4 female) with 25 hips affected by LCPD in initial to late stages were evaluated using ultrasonography at the Adelaide Children's Hospital. There were 15 left and 10 right hips. The average age of all patients at the onset of symptoms was 6 years, with a range from 3.5 to 10 years.

In this study, 51 ultrasonographic and radiological examinations of both the affected hips in different stages of LCPD and unaffected hips were evaluated.

Ultrasonographic evaluation

Symmetrical ultrasound views were taken with both hips extended and in a neutral rotational position with the patient supine. Using a 4.5 cm 5 MHz high-resolution linear array transducer (Ultramark 9, Advanced Technology Laboratories, Seattle, Washington, USA) two planes, (a) a longitudinal anterior approach following the alignment of the femoral neck and (b) a coronal approach just above the greater trochanter, were used.

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The longitudinal anterior approach showed the degree of synovitis, irregularity, flattening and fragmentation of the epiphyses and the thickness of the articular cartilage. It also demonstrated osteoid tissue formation and recalcification in the healing phase. The coronal approach gave information about the lateral extrusion and the amount of flattening of the femoral head.

Three measurements were made in millimetres:
1. Distance between the femoral neck and the hip joint capsule (neck-capsule distance, NCD) was made for objective evaluation of the capsular distention.
2. Thickness of the articular cartilage was measured as the greatest width of cartilage and was recorded as the difference between both hips.
3. Lateral extrusion of the femoral head was measured as the shortest distance between the lateral bony acetabular rim and a tangential line along the lateral cartilaginous margin of the femoral head and was recorded as the difference between both hips.

In bilateral cases measurements were referred to the mean values for normal hips.

**Radiological evaluation**

Two different classifications were used for the radiological assessment – the extent of the necrotic area of the affected femoral head (Catterall, [2]) and Waldenström's time-related staging of the femoral head appearances [1]. The radiological evaluation of the lateral extrusion of the femoral head was performed after the method of Dickens and Menelaus [5] on an anteroposterior pelvic radiograph. The difference in the measurements between the affected and the unaffected side was recorded. In bilateral cases each side was related to the mean of the data for all normal hips.

For comparison, normal values for the neck-capsule distance, the thickness of the articular cartilage and the lateral extrusion were obtained from the data of all investigations in the unaffected hips. The normal NCD was $5 \pm 0.8$ mm and the normal lateral extrusion was $2.2 \pm 2$ mm on radiograph and $3.1 \pm 1.6$ mm on ultrasonography.

The data were analysed statistically using a paired Student's t-test for linear correlations. Furthermore linear regression models were established using the formula $y = \beta_0 + \beta_1X$. Values are given as a correlation coefficient $r$ for paired observation or as a regression coefficient $r^2$ at a significance level of $p < 0.05$. The mean values ± standard deviation (m ± s) are given.

**Results**

The capsular distention demonstrating the degree of synovitis, the degree of irregularity in outline, flattening and fragmentation of the femoral head, together with the amount of bone resorption and newly formed osteoid, were rated (Table 1).

The ultrasonographic findings clearly differ in the various stages in Perthes' disease. This has led to a chronologically staging of this condition based on ultrasonography (Table 2).

**Stage I**

The first changes observed in the shape of the femoral head were a slight flattening of the epiphysis and some irregularity of the outline of the femoral head (Fig. 1a–c). However, the most striking ultrasonographic finding was synovitis with increased capsular distention (Fig. 1d). In only 1 of 11 patients was synovitis absent at that stage. There was a 16% increase in the thickness of the articular cartilage in comparison with the unaffected side. Occasionally, a subchondral fracture was identified and visualised ultrasonographically (Fig. 2a, b).

**Stage II**

There was increased flattening of the femoral head and a very irregular, almost fragmented-looking surface of the femoral epiphysis (Fig. 3). The evidence of synovitis was still present.

In stages I and II, 74% of the ultrasound examinations performed revealed an intra-articular joint effusion and only one hip was without any evidence of synovitis.

As the flattening of the femoral head progressed a marked increase in lateral extrusion of the head occurred, with a mean difference compared with the normal side of 4 mm. The thickness of articular cartilage showed a 30% increase in comparison with the normal side (Fig. 4a, b).

**Stage III**

Further progression of the disease showed increased fragmentation of the femoral head which, depending on the severity of the disease, was usually associated with marked flattening of the epiphysis (Fig. 5a, b). In this

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**Table 1. Evaluation of sonographic findings**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Capsular distention</th>
<th>Flattening</th>
<th>Fragmentation</th>
<th>Bone resorption</th>
<th>Osteoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Synovial thickening</td>
<td>Minor</td>
<td>Minor Irregularity</td>
<td>Little</td>
<td>Little</td>
</tr>
<tr>
<td>+ +</td>
<td>Small effusion</td>
<td>Moderate</td>
<td>Beginning</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>+ + +</td>
<td>Large effusion</td>
<td>Severe</td>
<td>Full</td>
<td>Complete</td>
<td>Fully developed</td>
</tr>
</tbody>
</table>

**Table 2. Ultrasound staging in Perthes' disease**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Minor irregularity of the femoral head; minor flattening of the femoral head; evidence of synovitis; early thickening of articular cartilage; subchondral fracture</td>
</tr>
<tr>
<td>II</td>
<td>Moderate irregularity of the femoral head; moderate flattening of the femoral head; evidence of continuing synovitis; early lateral extrusion of the head; thickening of articular cartilage most evident</td>
</tr>
<tr>
<td>III</td>
<td>Fragmentation of the femoral head; maximal flattening and collapse of the head; maximal lateral head extrusion</td>
</tr>
<tr>
<td>IV</td>
<td>Bone resorption; newly formed osteoid visible with signs of calcification in late stages; remodeling of the femoral head</td>
</tr>
<tr>
<td>V</td>
<td>Recalcification of the femoral head complete; persisting flattening, coxa magna and femoral neck deformity, related to severity of head involvement</td>
</tr>
</tbody>
</table>

Further progression of the disease showed increased fragmentation of the femoral head which, depending on the severity of the disease, was usually associated with marked flattening of the epiphysis (Fig. 5a, b). In this