AVASCULAR NECROSIS AND THE PAVLIK HARNESS

THE INCIDENCE OF AVASCULAR NECROSIS IN THREE TYPES OF CONGENITAL DISLOCATION OF THE HIP AS CLASSIFIED BY ULTRASOUND

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We analysed the incidence of avascular necrosis in 101 hips of 90 infants with congenital dislocation treated with the Pavlik harness and followed up for more than one year. Using ultrasonography in the flexed-abducted position the hips were classified as type A when the femoral head was displaced posteriorly, but within the socket and making contact with the posterior inner wall of the acetabulum; type B when it was in contact with the posterior margin of the acetabulum, with its centre at this level or anterior to it; and type C when it was displaced out of the socket, with its centre posterior to the posterior rim of the acetabulum.

Eighty-seven hips were reduced by the harness (86%), and seven of these developed avascular necrosis (8%). All 69 hips with type-A dislocation were reduced, and only one (1.4%) showed slight avascular necrosis. Eighteen (78.3%) of 23 hips with type-B dislocation were reduced, and six developed avascular necrosis (33.3%). In one hip, the femoral head was severely damaged. None of the nine hips with type-C dislocation was reduced in the harness.

We conclude that the Pavlik harness is indicated for type-A, but not for type-B or type-C dislocations.

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The Pavlik harness allows all hip movements except extension, making care of the infant relatively easy, and permitting spontaneous reduction of the femoral head without forcible manipulation. It is widely used to treat congenital dislocation of the hip (CDH), but does not always give good results: not all dislocated hips are reduced and avascular necrosis may occur. The latter remains a serious problem since a severely involved hip may develop early degenerative arthritis.

In 1993, Suzuki described the ultrasonic classification of CDH into three types, and found that the incidence of reduction in a Pavlik harness was closely related to the type. We have used this classification to assess the incidence of avascular necrosis after wearing the harness, in an attempt to identify those hips which are likely to develop this complication.

PATIENTS AND METHODS

From December 1988 to October 1993, we treated 104 congenitally dislocated hips in 93 patients (10 boys and 83 girls) using the Pavlik harness. We excluded patients who had had previous treatment elsewhere, who had been treated initially by a different method, or who had teratological or neuromuscular types of dislocation. All hips were diagnosed as having CDH by both ultrasonography (Suzuki et al 1991) and radiography before treatment with the harness. Three patients (three hips) were lost to follow-up, leaving 101 hips in 90 patients (nine boys and 81 girls) who were treated and followed up for more than one year. At the beginning of treatment, their ages ranged from 8 days to 10 months.

All patients were admitted and ultrasonography was used to grade the residual displacement of the femoral head in the flexed and abducted position. Three types were recognised on the criteria previously described by Suzuki (1993).

Type A. The femoral head is displaced posteriorly, but is within the socket, and there is contact between it and the posterior inner wall of the acetabulum.

Type B. The femoral head is in contact with the posterior margin of the acetabulum, with its centre either at this level or anterior to it.

Type C. The head is completely displaced out of the socket, with its centre posterior to the posterior rim of the acetabulum.
There were 69 type-A hips, 23 type-B and nine type-C. After ultrasound examination, each child was placed in skin traction with the hips in 10° of abduction and 30° of flexion. The initial traction weight was 1 to 1.5 kg. This was gradually increased according to the child's tolerance; the maximum weight averaged 2 kg. Radiographs were taken every other week to assess the position of the femoral head. On a radiograph, the distance from the middle point of the proximal metaphyseal border of the femur to the Y-line was defined as distance a (Yamamuro and Chene 1975; Suzuki and Yamamuro 1990). Traction was maintained until distance a was over 8 mm and the hip could be flexed and abducted to about 70°. The mean duration of this traction was 16 days (0 to 54), being 10 days (0 to 41) in type-A, 26 days (10 to 49) in type-B and 40 days (25 to 54) in type-C dislocations.

The Pavlik harness was then applied with the hip in 100° of flexion, and ultrasonography was performed with the hip flexed and abducted to assess any change in the type of dislocation. During the time in the harness, small pillows were placed under the legs to prevent abduction beyond the safe zone (Ramsey, Lasser and MacEwen 1976).

Ultrasonography was repeated daily after the application of the harness to check reduction. Spontaneous reduction was usually seen within a few days. If the dislocation persisted for more than 10 to 14 days, the use of the Pavlik harness was discontinued and the hip was treated by over-head traction or by manual reduction. If the hip was satisfactorily reduced, the harness remained in use for 2 to 2.5 months, and was then removed for two hours each day. The time out of the harness was then gradually increased.

When the harness had been completely removed radiography was performed with the hips extended to check the position of the femoral head and its development. When the infant began to walk, a standing radiograph was obtained.

We diagnosed avascular necrosis on the criteria of Salter, Kostuik and Dallas (1969) as follows: 1) failure of appearance of the ossific nucleus of the femoral head for one year or longer after reduction; 2) failure of growth of an existing ossific nucleus for one year or longer after reduction; 3) broadening of the femoral neck during the year after reduction; 4) increased radiological density of the femoral head followed by fragmentation; and 5) residual deformity of the femoral head and neck when reossification was complete. Hips that showed temporary irregular ossification were not considered to have avascular necrosis.

The extent of avascular necrosis was recorded in four groups by the classification of Kalamchi and MacEwen (1980): group-I hips had changes affecting the ossific nucleus, group-II had lateral physeal damage, group-III had central physeal damage, and group-IV hips had damage to the entire femoral head and physis.

## RESULTS

Of the 101 hips, 87 were reduced (86%) and seven of these developed avascular necrosis (8%).

The rates of successful reduction at different ages ranged from 70% to 90%, but did not depend on the age at the beginning of treatment (Table I). No cases of avascular necrosis were detected in the hips of the patients who had been one month old or younger, or in those who were six months or older.

The incidence of avascular necrosis was considered in relation to the presence of the ossific nucleus. It was 9.5% (six of 63 successfully reduced hips) in the hips in which the ossific nucleus had not yet appeared at the onset of treatment, and 4.2% (one of 24 successfully reduced hips) in those in which the ossific nucleus was present. This difference is not significant (p = 0.37, Fisher’s exact test).

The type of dislocation classified before skin traction was not changed when assessed immediately after the application of the Pavlik harness. The rates of reduction and avascular necrosis are related to the Suzuki type of dislocation in Table II. All 69 hips with type-A dislocation were reduced in the harness; one had group-I avascular necrosis (1.4%). Of the 23 hips with type-B dislocation 18 were reduced (78.3%) and six of these developed avascular necrosis (33.3%) (five group I and one group IV).

Hips which developed avascular necrosis after reduction in the Pavlik harness are shown in Table III, and Figures 1

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### Table I. Reduction and avascular necrosis related to age in months at the beginning of treatment by number and percentage

<table>
<thead>
<tr>
<th>Age at beginning of treatment (mth)</th>
<th>Number of hips</th>
<th>Number of hips developing avascular necrosis</th>
<th>Avascular necrosis group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treated</td>
<td>Reduced</td>
<td></td>
</tr>
<tr>
<td>1 or less</td>
<td>9</td>
<td>8 (88.9)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>14 (77.8)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>13 (86.7)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>27 (90.0)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>18 (94.7)</td>
<td></td>
</tr>
<tr>
<td>6 or over</td>
<td>10</td>
<td>7 (70.7)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>101</td>
<td>87 (86.1)</td>
<td>7 (8.0)</td>
</tr>
</tbody>
</table>
to 4 show the single hip with group-IV necrosis (case 4 in Table III). None of the nine hips with type-C dislocation was reduced in the harness.

Of the five of the 23 hips with type-B dislocations which did not reduce in the harness, one was reduced after overhead traction, followed by reapplication of the Pavlik harness. The other four were reduced manually, and immobilised in a cast; none developed avascular necrosis. All nine type-C dislocations were treated by manual reduction and immobilisation in a cast; one developed group-I avascular necrosis.

**DISCUSSION**

Of the 101 hips 86% were reduced in the Pavlik harness. This incidence is similar to that in previous reports (Suzuki...
and it is known that the frequency of spontaneous reduction depends on the radiological severity of the dislocation (Kalamchi and MacFarlane 1982; Grill et al 1988; Suzuki and Yamamuro 1990). We classified the dislocations into three types using ultrasound with the hip flexed and abducted. All type-A dislocations and 18 of the 23 hips with type-B dislocation were reduced, but all of the type-C hips remained dislocated. The displacement shown by ultrasonography in hip flexion and abduction was therefore closely related to the rate of successful reduction.

It seems possible that the rate of reduction could be increased by more prolonged preliminary treatment in skin traction, but we consider that this may not succeed. The probability of reduction has been shown to depend mainly on the location of the femoral head with the hip flexed and abducted (Suzuki 1993). Other important factors are a tight iliopsoas, a capsular isthmus and intra-articular obstruction. All these may prevent spontaneous reduction in the Pavlik harness. The tightness of the iliopsoas is probably reduced by traction, since this was continued until radiographs showed that distance $a$ was over 8 mm. We found, however, that the type of dislocation was unchanged by skin traction, which cannot influence the capsular isthmus or any intra-articular obstructions. A longer period of traction could possibly produce a slight increase in the rate of successful reduction, but is unlikely to improve reduction rates significantly in type-B and type-C dislocations.

Avascular necrosis is the most serious complication of treatment with the Pavlik harness, since the femoral head is damaged and the involved hip may develop degenerative osteoarthritis. Assessment of the risk of avascular necrosis before the start of treatment with the Pavlik harness is important. Our overall incidence in this series was 8%, similar to previous reports (Suzuki 1979; Takahashi 1985; Atar et al 1993). We found no dependence on the age of the patients or on the presence of the ossific nucleus at the onset of treatment. We did find a close relationship between the Suzuki type of dislocation and the rate of avascular necrosis. All hips were reduced and slight avascular necrosis was detected in only one hip (1.4%) in type A. In contrast, the results in type-B dislocation were not acceptable, with reduction in 78.3% and avascular necrosis in one-third. The rate of avascular necrosis after the use of the Pavlik harness has been related to the radiological severity of the dislocation (Takahashi 1985; Grill et al 1988; Suzuki and Yamamuro 1990), but we found that ultrasonography with the hip flexed and abducted was more useful.

Immobilisation in extreme abduction is accepted as one cause of avascular necrosis. Ogden (1975) described the occlusion of retinacular vessels between the femoral neck and the rim of the posterior acetabulum in extreme abduction. All our patients had small pillows placed under the legs to prevent extreme abduction, but there may be difficulty in keeping them in place. Our single patient with slight avascular necrosis in a type-A hip had kicked the pillows away during the night after the harness had been applied. The femoral head had already been reduced and the hip was in 90° of abduction when we saw the infant early the next morning. Reduction usually takes place during sleeping due to the weight of the lower extremities (Iwasaki 1983; Suzuki 1994), and it is possible therefore that without pillows a hip may fall into extreme abduction unless the child awakes and keeps adducting the hip. After this incident, early in the study period, the nursing staff regularly checked the pillow positions and there were no further similar incidents.

Excessive pressure on the femoral head may disrupt the circulation to it (Salter et al 1969), and forcible reduction, regardless of tight muscles around the hip, may compress the femoral head after reduction. In the Pavlik harness, the femoral head is usually reduced gently by the weight of the legs and in our series tight adductors were treated by horizontal traction until they could be abducted to about

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**Fig. 3**

MRI of the same patient in flexion and abduction.

**Fig. 4**

Radiograph of the same patient at the age of two years. The right femoral head has developed group-IV avascular necrosis.
70° and until distance a was more than 8 mm. These methods of eliminating undue compression on the head were used in almost all of our patients, and in type-A dislocation the femoral head is already inside the socket and in contact with the surface of the cartilage. This contact area increases after reduction to spread the force on the femoral head. This may be the reason why the rate of avascular necrosis is less in type-A dislocation.

In type-B dislocation, it seems possible that excessive pressure could be placed on the immature femoral head. Intra-articular obstructions such as the pulvinar, an inverted labrum or a hypertrophied round ligament may prevent wide contact between the femoral head and the acetabular cartilage after reduction. Local compression between the femoral head and intra-articular substances may result from forces transmitted from the muscles around the hip after reduction. Intra-articular obstructions may be one cause of avascular necrosis as Somerville and Scott (1957) and Mitchell (1972) described. Longer periods of traction may relax the muscles around the hip but it is not desirable to keep an infant lying in bed for more than one month.

We have found it useful to classify the hips ultrasonically and we conclude that the Pavlik harness is indicated for type-A dislocation, but that type-B and type-C dislocations should not be treated in this way alone. Even for hips with type-A dislocations, we recommend both the use of preliminary traction and the prevention of extreme abduction during the period in the harness.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES


