

Role of ultrasound assessment and harness treatment in the management of developmental dysplasia of the hip

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The effect of the introduction of a programme combining clinical hip screening supplemented by limited targeted ultrasound assessment on splintage for developmental dysplasia of the hip (DDH) was evaluated over a 3-year period.

The use of ultrasound is of both diagnostic and therapeutic value as it allows monitoring of the effects of splintage and decreases the total treatment time required. In all, 82 dysplastic hips were identified in 65 infants and the period of splintage averaged 6.3 weeks (range 3-12 weeks). The overall splintage rate can also be reduced as hips with only minor dysplasia can be assessed by serial scans until resolution or progression occurs rather than automatic treatment of all abnormal hips and in this series the rate was 6 per 1000 (0.6%).

The Wheaton-Pavlik harness is a dynamic light-weight splint which is user friendly, easy to apply and adjust, and with no major complications being encountered in this series. Unnecessary exposure to radiation was reduced as plain radiographs were not performed before ossification of the capital epiphysis; prolonged splintage was prevented and a weaning period from the brace was not used. All children remained under follow-up for 1 year after the hips were confirmed to be clinically and radiologically normal and there were no cases of late re-dislocation or subluxation. There were no cases of avascular necrosis and a markedly reduced need for diagnostic arthrograms, with only two being performed during the 3 years.

This regimen has resulted in a low rate of late presenting DDH requiring surgery of 0.28/1000, as well as a low splintage rate of 6/1000 (0.6%). Most of the improvement in the results can be attributed to the

more accurate evaluation of DDH by ultrasound, but the absence of avascular necrosis and other complications is likely to be due to the shorter period of time spent in a dynamic splint without the use of excessive abduction.

Clinical examination for congenital or developmental dysplasia of the hip (DDH) is notoriously inaccurate and can result in a 'late' dislocation rate of up to 1.6/1000 births (1). There have also been concerns expressed over the repeated application of the Barlow and Ortolani tests which have been suggested to be contributory factors in the development of such late dislocation (2). These cases may subsequently require extensive surgery, consisting of open reduction by Ferguson or anterolateral approaches and, in infants, femoral derotation, femoral shortening and pelvic osteotomies may be necessary. The traditional Von Rosen splint is moulded to fit around the hips and shoulders of the child but it has proven difficult to control the position of the hips without the use of extreme static abduction resulting in pressure effects on the skin. Splintage for DDH when using extreme abduction, such as the Lorenz position or frog plasters, has led to avascular necrosis of the femoral head in up to 69% of cases (3).

The aim of any preventative programme should be the early, accurate diagnosis of DDH, allowing the commencement of successful treatment during the neonatal period, thus reducing the need for later surgery. Recent technological advances have made this goal easier with the introduction of ultrasound as a non-invasive method of assessing acetabular development and dynamic stability of the hip (dysplasia, dislocatability and dislocation).

The Wheaton brace is a development of the conventional Pavlik harness. It is dynamic, and uses Velcro®

fastenings, rather than buckles and straps, making it lighter and easier to fit and adjust. The hips can be reduced and maintained in the 'Human' position or safe zone of Ramsay, thus leading to a reduction of pressure effects on the skin and the avascular necrosis rate. Successful maintenance of reduction can be confirmed by regular ultrasound examination, with the minimisation of splintage times and no requirement for a weaning period.

This study was instituted to assess the effect of the introduction of the programme using these techniques on the treatment of developmental dysplasia of the hip in the Blackburn area.

Materials and methods

The study was performed at Blackburn Royal Infirmary which is a district general hospital in an area with an average birth rate of 3600 live births per annum. As part of the comprehensive post-natal examination, the hips of all children born in the district are evaluated for stability immediately after birth by the paediatric department using the Barlow and Ortolani tests (primary clinical screening). Secondary clinical hip screening is performed during routine assessments undertaken in the community by general practitioners and clinical medical officers (CMOs) at a recommended age of 6 weeks, 6–9 months and 15–21 months.

All hips found to be clinically unstable at birth were assessed by ultrasound at the next available clinic, usually within 2 weeks. The factors associated with the development of DDH are well-recognised (Table I) and all 'at risk' hips and infants with any congenital abnormalities were also referred immediately after birth. Those detected at child development clinics were frequently found to be associated with decreased hip abduction and were also seen at the earliest opportunity for clinical and ultrasound examination. Ultrasound evaluation was then performed at the age of 8–10 weeks when most dysplasia owing to immaturity will have resolved spontaneously. (4). Universal screening of all children has not been instituted because of the high false-positive rate and cost implications of such a programme (1,5,6).

In 1991 ultrasound assessment of hips with suspected DDH was introduced to the district by the paediatric orthopaedic surgeon (RWP) who personally performs all the clinical and ultrasound examinations using a Dormio®

Table I. Risk factors identified in treatment group

1 Positive family history	5
2 Breech pregnancy	24
3 Fetal packaging abnormalities:	
CTEV	5
Metatarsus adductus	1
Torticollis	2
4 Conditions resulting in diffuse ligamentous laxity (congenital myopathy of limb-girdle type)	1

7.5 MHz real-time scanner. Considerable experience is required to assess the ultrasound images accurately (7) and approximately 300 scans had been undertaken before the start of this series in January 1992. Dysplasia was assessed by the Global Visual Analysis method of Zieger (8), with the hips classified as either normal or in one of three abnormal categories: dislocation, minor or major dysplasia. Instability was assessed using the technique described by Clarke *et al.* (9) and Harcke (10).

At the same time the Wheaton–Pavlik brace was also introduced because of concerns over the use of Von Rosen splints. This had been implicated in producing an unacceptably high rate of avascular femoral head necrosis owing to the tendency for positioning in excessive abduction and its static nature of action. All dislocated and dislocatable hips were treated in a Wheaton–Pavlik harness at the first clinic visit, as were those with major dysplasia. Hips with minor dysplasia were assessed by serial ultrasound examinations until progression or resolution occurred and were then treated accordingly. The splint was worn continuously for 24 h a day with the hips positioned in the safe zone of Ramsey. The child was followed up initially weekly and then on alternate weeks to ensure that the harness was fitting properly, that parents were complying with instructions and that undue difficulties were not being encountered. Repeat clinical examination and ultrasound assessment were performed at 3–6 weeks and the splint was removed without a weaning period once normal hip development had been confirmed on ultrasound.

No plain radiographs were taken until ultrasound had confirmed the presence of ossification of the femoral capital epiphysis, and none were performed before the age of 3 months. All children then remained under clinical follow-up with serial radiographs until development of the hips was deemed normal with reference to the acetabular index, metaphyseal-edge angle, Shenton's line and the shape and relationship of the femoral head to Perkins' and Hilgenreiner's lines. The child was then followed for a further year before discharge from clinic.

Results

During the 3-year period from January 1992 to December 1994 there were 10 757 live births in the Blackburn area. There were 82 abnormal hips identified in 65 children. All were treated in the Wheaton–Pavlik brace, a splintage rate of 0.6%. There were 47 females and 18 males, with the left hip affected in 25, the right in 23, and 17 cases were bilateral. A recognised risk factor for DDH was present in 38 of the children (Table I).

Three distinct pathological groups were identified by ultrasound using the global visual analysis method of Zieger:

- 1 Neonatal instability, 37 hips.
- 2 Persistent major dysplasia, 35 hips.
- 3 Late referrals, over 12 weeks of age with major dysplasia and decreased abduction, 10 hips.

The average age at presentation was 4.7 weeks (range 3 days to 24 weeks) and the mean age at application of the harness was 6.9 weeks (range 1–24 weeks). The average length of treatment was 6.3 weeks (range 3–12 weeks). All hips subsequently developed normally and there were no cases of failed reduction, re-subluxation or avascular necrosis of the femoral head.

There were 10 late referrals at over 12 weeks of age in whom the clinical presentation was of limited abduction of the hip. Ultrasonography diagnosed major dysplasia (Zieger) in all cases and these were treated successfully by splintage. In total, 27 of the children in the series were noted to have limited hip abduction and ultrasound scans in each of these cases confirmed major dysplasia, suggesting this to be a sensitive sign.

In one case, splintage was discontinued at 4 weeks owing to the development of a skin rash, but by this time the hip had already stabilised and treatment was not compromised. Two children suffered from chaffing behind the knee which responded to alteration of the harness straps and application of simple topical creams. Only two children required arthrograms during the early part of the study period after equivocal radiographs and ultrasound scans. These confirmed satisfactory reduction of the hip requiring no further treatment, and no arthrograms have been performed in this unit for diagnostic purposes since 1993.

Discussion

Pavlik introduced his eponymous harness in 1944 and in 1957 reported the results of its use in 1912 hips (11). Its use has become widespread in the early treatment of DDH, but the brace must be expertly applied and closely monitored to ensure that reduction has been achieved and is maintained without excessive abduction forces being applied. The aim should be to maintain the hips in 90–100° of flexion and 30–60° of abduction within the safe zone of Ramsey. It is thought that the weight of the limb gradually stretches the adductor and psoas muscles allowing the femoral head to move anteriorly into the acetabulum, thus achieving concentric reduction. As the child continues to move and kick, the reduction is maintained and the congruity of the femoral head within the acetabulum promotes normal acetabular and femoral head development and moulding (12).

Many complications have occurred after treatment in the Pavlik harness, with a reported avascular necrosis rate of 0–28% in the treated hip (13,14) and also rarely in the previously normal contralateral hip (15). Other complications include irritable hip, femoral nerve palsy, inferior dislocation, medial knee instability, iliotibial band contracture and posterior acetabular deficiency (16–18). No such complications were encountered in this series.

The analysis of the results obtained in this series of patients was undertaken to assess the effects of the introduction of a policy utilising targeted ultrasound assessment to complement the existing primary and

secondary screening programmes for DDH in conjunction with the use of the Wheaton–Pavlik harness. Most of the improvement in the results is due to the use of ultrasound in both a diagnostic and therapeutic role as a guide to stabilisation and development of the hip. This has allowed early diagnosis and commencement of treatment with splintage for shorter periods and without the need for weaning from the brace. This has produced a very low rate of ‘late’ dislocation requiring surgery of 0.28/1000 in the period January 1992–December 1994, with the only other comparable trial resulting in a rate of 0.22/1000 (1).

The use of ultrasound prevents the need for plain radiography before ossification of the femoral capital epiphysis and no radiographs were taken before 3 months of age. Ultrasound scans are initially difficult to perform and evaluate with a definite learning curve, but in experienced hands it has been shown to have 100% sensitivity and specificity. This makes it an effective tool for the diagnosis of dysplastic hips and the monitoring of their subsequent development (12,19), while also being non-invasive with no radiation risk or need for sedation. The pros and cons of the technique used for ultrasound assessment are complex and controversial but represent a separate issue outwith the scope of this paper. We have found the method described by Zieger useful in the clinical setting (8,20) and it is likely that the use of arthrograms may become unnecessary in the future.

The Wheaton–Pavlik harness has proven popular with staff and parents and is well tolerated, with only minor complications being encountered in this series. It appears to be an excellent method of splintage without the potential complications experienced with using other methods such as the conventional Pavlik, the Von Rosen or ‘Frog’ plasters. The use of ultrasound assessment permits monitoring of treatment to ensure that concentric reduction has been achieved and is being maintained and scanning can be performed without removing the harness. Its use has also prevented the need for a weaning period from the brace, thus reducing the period of splintage to an average of 6.3 weeks (range 3–12 weeks). This has contributed to the absence of avascular necrosis in the patients in this series and there were no late cases of redislocation or subluxation, with all patients being followed up for a further year after the hips were confirmed to be clinically and radiologically normal.

Before the introduction of this regimen the annual operative rate for DDH in the Blackburn district was 1.2/1000 (1956–1991). Only three children born during the study period have required surgery for late presentation with irreducible hips, a rate of only 0.28/1000, which is among the lowest in the world literature (4). The overall level of splintage of 0.6% is also low and compares favourably with other series, Jones and Powell (20) reporting a rate of 1.08% and Tonnis *et al.* (5) 3%. The use of this combined approach using ultrasound both as a means of diagnosis and to guide treatment with the Wheaton–Pavlik harness has resulted in increased accuracy with decreased complications and has produced low rates of both splintage and surgery.

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