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Ultrasound in the early diagnosis of congenital dislocation of the hip: the significance of hip stability versus acetabular morphology

K. Rosendahl, T. Markestad, R. T. Lie

Departments of Diagnostic Radiology and Pediatrics, and Section for Medical Informatics and Statistics, University Hospital, Bergen, Norway

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Abstract. Recent studies have suggested that ultrasound examinations may improve diagnostic accuracy in congenital dislocation of the hip, but there is differing opinion whether ultrasound diagnosis should be based on morphology or stability. Ultrasound was added to the routine clinical screening in 1503 newborns (1291 girls and 212 boys). Hip morphology was classified according to Graf (type 1–4), while sonographic stability was based on a modified Barlow maneuvre, and classified as stable, elastic deflection (normal finding), unstable (provocating a gap between the femoral head and the acetabulum) and dislocated. Among 80 morphologically dysplastic hips, 73 (91 %) were sonographically unstable or dislocated, while seven dysplastic hips were stable. On the other hand, in 49 % of the sonographic unstable hips (69 out of 142) the acetabulum was either normal or just physiologically immature. 38 of these hips were left untreated and normalized spontaneously. There was a close correlation between sonographically and clinically determined hip stability (gamma = 0.95). Our study shows that the majority of morphologically dysplastic hips is sonographically unstable or dislocated, but also that morphologically dysplastic hips may be stable. Morphologically normal hips showing minor sonographic instability do probably not require treatment, and thus morphology seems to be an important diagnostic criterion.

Early diagnosis of congenital dislocation of the hip (CDH) is of essential importance for the management and later prognosis of the disease [1–2]. Routine clinical screening of newborns with the Ortolani/Barlow maneuvres [3] has for decades been the established method for detecting CDH, but several reports have shown that the sensitivity as well as the specificity of the clinical tests may be unsatisfactory [4–5].

Correspondence to: K. Rosendahl, Department of Pediatric Radiology, University Hospital, N-5021 Bergen, Norway

Recent studies have suggested, however, that ultrasound examinations may improve diagnostic accuracy, and provide a more reliable basis for identification of infants who need treatment [6–9]. During early infancy the hip joint is largely formed by cartilage which is not visualized on plain radiographs. With ultrasound, however, the morphology as well as the stability of the joint may be evaluated. Graf has described morphologic variants ranging from normal to highly dysplastic and eccentric patterns [6]. His strictly standardized method and classification system has been followed by dynamic variants based on various projections and different criteria for CDH [10–12]. Based on ultrasound, the incidence of infants judged to be in need of treatment differ considerably for various reports, indicating that the diagnostic methods as well as the criteria for initiating treatment need to be addressed [6, 7, 10].

The aim of the present study was to compare ultrasound mobility with ultrasound morphology and clinical stability.

Material and methods

A total of 1503 newborns (1291 girls and 212 boys) were evaluated consecutively by ultrasound. The study population comprised all girls, while boys were only examined if they had recognized risk factors for CDH, such as breech presentation, a family history of CDH, or clinical findings compatible with CDH. Preterm babies weighing less than 1500 g, were excluded.

The ultrasound examinations were conducted by one radiologist (KR), using a Toshiba Sal 30 A with a 5 MHz linear transducer. According to Graf [6], two coronal scans of each hip were obtained, and great emphasis was placed on producing the correct standard section, as shown in Fig. 1. Based on morphological features and the alfa and beta angles, the hips were divided into 4 morphological groups (and subgroups), as listed in Table 1 [6]. Details regarding morphological aspects of the hips in the study group are reported elsewhere [13].

In order to determine hip stability by ultrasound, a modified Barlow maneuvre was performed with the baby in a lateral position. According to Graf [6], the slightly flexed and adducted position of the hip is the optimal position for a systematic ultrasound-examination. However, in this position the hip is exposed to a mechanical, lateral force. To reassure that the femoral head was centered in the acetabulum at the start of the provocation-test, the hip joint was adjusted in a position of neutral hip abduction-adduction. When examining the

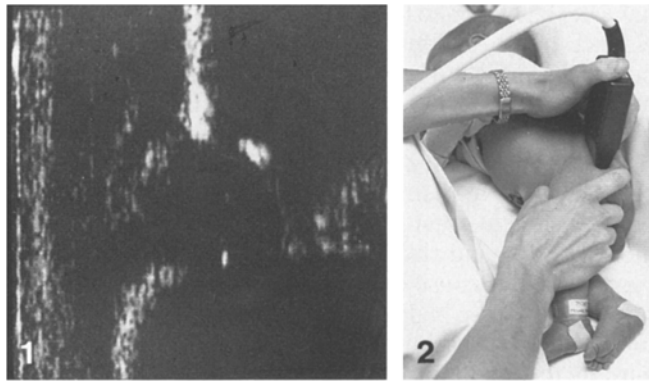

Fig. 1. Coronal view of a morphological normal left hip. Graf's standard section through the deepest part of the acetabulum, containing the lower margin of the ilium, the bony acetabular promontory and the labrum

Fig. 2. Provocation test using a modified Barlow maneuvre with the baby in a lateral position. The examinar holds the probe and steadies the infant's pelvis with the left hand, while pressing the femoral head in the lateral-cranial-dorsal direction with the right hand

left hip, the examiner held the probe and simultaneously steadied the infant's pelvis with the left hand placing the fingers under the sacrum, as shown in Fig. 2. While keeping the standard coronal scan on the monitor, the flexed and slightly adducted leg was held in the palm of the examiners right hand with the third digit placed on the lesser trochanter. The second digit was placed on the larger trochanter/sacrum [14]. Stability was evaluated qualitatively on the basis of the cranial, dorsal and lateral movement of the femoral head, and classified into four categories (Table 2). Additionally, the neutral and the maximum lateral displacement was documented on polaroid film, and the difference was recorded measuring the distance between the y-joint and the capsule near the greater trochanter (the mean value of 3 measurements). The difference was also transformed into per cent of the femoral head diameter [15].

The hips were examined clinically within 24–48 h of birth, by one of 8 physicians with at least 2 years training in pediatrics. Each hip was classified into one of 4 clinical groups: stable (includes minor instability), unstable (significant movement, but not dislocatable out of the acetabulum – i. e. no distinct "clunck"), dislocatable and dislocated. Stable "clicks" were considered normal. The findings were unknown to the radiologist who reported the subsequent ultrasound results to the pediatricians the next morning. In cases of ultrasound pathology, as well as suspicion of clinical pathology, a senior pediatrician performed a second clinical examination on the same day.

Treatment with an abduction splint was initiated independently of ultrasound findings when hips were judged to be persistently dislocatable or dislocated on clinical examination, but not on the basis of less pronounced instability. Likewise, hips with a dysplastic morphology were treated even if they were clinically stable. Hips with ultrasound instability alone were left untreated. Written, informed consent was obtained from all participating mothers, and the study was approved by the Regional Commitee for Medical Research Ethics.

In accordance with existing practice, neonates with normal hips were referred for an X-ray of the hips at 4–5 months of age if they were born after breech presentation or if they had a family history of CDH.

Results

There was a high correlation between sonographic hip stability and morphology (gamma = 0.95, Table 3). Based on both ultrasound-stability and morphology, our study revealed three different categories of pathological hips: dysplastic, but stable (7 hips in 6 girls), dysplastic and unstable (73 hips in 55 newborns) and morphologically normal or immature, but unstable (69 hips in 58 newborns). When considering the worst hip in each infant (based on morphology) rather than all hips pooled, there was still a high correlation between extent of instability and morphology (gamma = 0.83).

In 49% of the sonographically unstable hips (69 out of 142), the acetabulum was either normal (Graf type 1), or just physiologically immature (Graf type 2a). Of the 69 unstable hips (in 58 infants), 38 hips (in 32 infants) were left untreated, and all developed normally. The instability was minor in 36 and major in 2 of these hips. Of the remaining 31 hips (22 with minor, 9 with major instability), 17 were treated since they were found to be pathologically unstable (6 hips) or dislocatable (11 hips) also on repeated clinical examinations, while 14 were treated because of a pathological contralateral hip.

There was also a high correlation between sonographically and clinically determined hip stability (gamma = 0.95, Table 4). Sixteen hips (in 15 girls) showing major sonographical instability were consistently judged as stable by the pediatricians on repeated clinical examination. Fourteen of these girls were treated because of morphological dysplasia on ultrasound, and one because of a clinically dislocatable contralateral hip. One girl with a morphologically immature, but sonographically major unstable hip recovered spontaneously without treatment.

Fifteen sonographically stable hips (in 10 infants) were judged to be persistently dislocatable on clinical examination, and were subsequently treated. Only three of these hips (in 3 infants) were morphologically dysplastic, the others had normal or just immature acetabulae.

The qualitative classification of sonographic stability was also closely related to absolute measures of lateral dis-

Table 1. Graf's classification according to morphology

Type 1 a/b:	normal hips
Type 2 a:	physiological retardation of the acetabular ossification
Type 2 c:	critical zone hip
Type 2 d:	decentering hip
Type 3 a/b, 4:	eccentric hips

Table 2. Classification of hip instability by US. The baby lies in the lateral position with the hips and knees flexed while the examiner performs the Barlow/Ortolani maneuver. The standard coronal scan is used

1. Stable hip
2. Elastic hip: slight cranial deflection of the labrum. Normal finding
3. Unstable hip:
   3.1 minor instability: a gap can be visualized between the femoral head and the acetabulum
   3.2 major instability: the femoral head can be dislocated lateral to the baseline, followed by a concentric reduction into the acetabulum
4. Dislocated hip: the femoral head seen constantly lateral to the baseline

Table 3. Association between sonographic hip morphology and stability in 1503 newborns (3006 hips)

US stability	US morphology				
	1	2a	2c	2d	3a
Stable	2428	251	2	1	0
Elastic	55	123	4	0	0
Minor instability	6	52	1	10	0
Major instability	1	10	3	47	1
Dislocated	0	0	0	0	11

Table 4. Association between sonographic hip stability and clinical findings in 1503 newborns (3006 hips). The clinical grading is based on a repeat examination by a senior pediatrician for clinically unstable and sonographically immature and dysplastic hips. Infants with normal clinical as well as US findings were not reexamined clinically

	Clinical stability			
US stability	Stable	Unstable	Dislocatable	Dislocated
Stable	2665	6	12	0
Elastic deflection	179	0	3	0
Minor instability	58	2	8	1
Major instability	16	19	20	6
Dislocated	1	0	3	7

Table 5. Association between qualitatively evaluated sonographic instability and the degree of lateral movement in mm, based upon the distance between the y-joint and the capsule near the greater trochanter in neutral and maximum displaced position, in 141 hips. Confidence intervals for the mean values were not overlapping for the three groups, even when right and left hips were considered separately

Degree of instability	Lateral movement (mm)			Mean % of femoral head	
	mean	SD	*n*		SD
Minor instability	1.5	0.5	68	10.2	3.9
Major instability	2.6	1.0	62	18.0	7.6
Dislocatable	5.5	0.5	11	40.1	4.0

placement in mm or as per cent of the diameter of the femoral head (Table 5). The lateral movement was slightly smaller for the hips on the right side than for the left side compared in each group, but the confidence intervals for the two sides showed a high degree of overlap. Thus, table 5 shows the mean degree of lateral movement for both sides combined.

Two girls considered normal both clinically and by US in the neonatal period, developed slight, unilateral dysplasia diagnosed by routine radiography at 5 and 6 months of age. One of these girls had an ultrasonographically immature hip as a newborn, but was judged to be normal after 4 weeks.

Discussion

Ultrasound studies have contributed substantially to our knowledge of the normal and abnormal hip joint. The different morphological variants first described by Graf, have been confirmed by others [9, 16, 17], although the incidence of the various types, as well as the incidence of newborns judged to be in need of therapy, differ considerably. We have previously published details on clinical findings and ultrasound morphology on the present population [13]. In summary, we found a significant relationship between the two methods (gamma = 0.56), even though the decision to treat was based on ultrasound findings alone in 38%, and on clinical findings alone in 25% of the cases. A major cause for such discrepancies must be that both methods are highly operator dependent [5, 6]. Graf's morphological method requires detailed knowledge regarding the anatomical features of the hip joint, precision in obtaining the standard section, and attention to the subtle morphological differences between the various types. Likewise, both the technique of eliciting an existing instability, as well as the subsequent interpretation of the findings, represent pitfalls in the clinical evaluation of hip stability.

Methodological difficulties as those mentioned above, must also be taken into consideration when using ultrasound in the detection of instability. In a recent work based on a dynamic, anterior approach, Dahlström reported that normal hips at birth had a lateral-dorsal mobility of up to 4% of the femoral head diameter (0.6 mm), while the average movement in 8 abnormal hips was 19% (2.8 mm). In the present study hips showing minor sonographic instability had a mean lateral movement of 1.5 mm (10.2% of the femoral head diameter), while hips showing major instability had a mean lateral movement of 2.6 mm (18.0% of the femoral head diameter). Based on ultrasound-instability alone, our treatment rate obviously would have been higher, since 32 newborns with sonographically unstable, but morphologically normal hips recovered without treatment. Using an essentially dynamic approach to define CDH, Gomes et al. reported a treatment rate of approximately 3.5%. However, the population was selected because 500 of the 1700 neonates were clinically suspected of having CDH. Another study, using a different dynamic approach on 2075 consequtive newborns [18], resulted in a treatment rate of 0.77%, and a fairly good correlation between ultrasound and clinical findings, when both techniques were used by the same surgeon. However, despite the actual screening programme, the reported incidence of late cases in that district was 1.9 per 1000. From a screening programme of newborns at risk for CDH, Clarcke et al., using a dynamic method described by Harcke et al. [19], concluded that ultrasound did not reduce the incidence of late cases [20].

Our results confirm that the majority of morphologically dysplastic hips (type 2c or worse) is sonographically unstable or dislocated, a finding which earlier has been noted by Graf [6]. However, 7% of the treated infants would have been missed on basis of a strictly dynamic ultrasound method since they were dysplastic but stable. Whether these hips would have developed normally or not without treatment remains unknown. Based on the clinical examination alone, 36 of the 55 newborns in the dysplastic/unstable group, none of the 6 in the dysplastic/stable group, 20 of the 58 morphologically normal, but unstable, and 7 with persistently dislocatable, but sono-

graphically normal hips would have been treated. Compared with ultrasound, clinical examination obviously defines a somewhat different group of newborns to be in need of treatment.

In the present series, a number of hips with sonographically minor instability, but morphologically normal or just slightly immature hips were left untreated. All of them recovered spontaneously, as demonstrated by others [21]. In contradiction to Dahlström [15], our results lend support to the idea that dysplasia together with instability, rather than instability alone, is the major predisposing factor for late CDH.

The natural course of the morphologically normal or just immature hips with major sonographic instability remains unknown, as 91 % of them, on basis of persistent clinical instability, were all treated from birth.

There is general agreement that the majority of clinically unstable hips at birth undergoes a spontaneous cure [14], but there are no proven tools for predicting which hips will remain dysplastic, or develop dysplasia or dislocation. In the present study, all infants who had sonographically unstable, but morphologically normal or just immature hips, developed normally without treatment, as long as they were not clearly dislocatable on clinical examination, indicating that sonographic instability alone does not have clinical significance. The natural course of dysplastic, but clinically stable hips, and clinically dislocatable, but morphologically normal hips, remains unanswered. Infants with such findings were treated from birth since it was not felt justified to withhold the simple treatment of a Frejka pillow for these groups until further experience with ultrasound assisted diagnosis was gained.

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