International Orthopaedics (SICOT) (2008) 32:415–419
DOI 10.1007/s00264-007-0333-x

ORIGINAL PAPER

Clinical examination versus ultrasonography in detecting developmental dysplasia of the hip

H. Dogruel · H. Atalar · O. Y. Yavuz · U. Sayli

Received: 6 January 2007 / Accepted: 13 January 2007 / Published online: 1 March 2007

Abstract Although hip ultrasonography is gaining acceptance as the most effective method for the early diagnosis of developmental dysplasia of the hip, there is still some controversy regarding the use of ultrasonography as a screening method. The purpose of this study was to investigate prospectively the capacity of clinical examination findings and associated risk factors to detect developmental dysplasia of the hip defined ultrasonographically in infants. A total of 3,541 infants underwent clinical examination and hip ultrasonography. Measured against ultrasonography as a standard, the sensitivity and specificity of clinical examination were 97% and 13.68%, respectively. Graf type IIb or more severe developmental dysplasia was found in 167 infants (208 hips), at an overall frequency of 4.71%. Graf type IIa physiological immaturity was encountered in 838 hips, and of these, 15 hips (1.78%) developed Graf type IIb dysplasia and underwent treatment. Patient characteristics that were found to be significant risk factors were swaddling use, female gender, breech delivery and positive family history. Given its low specificity, our findings suggest that clinical examination does not reliably detect ultrasonographically defined developmental dysplasia of the hip in infants being screened for this disease.

Résumé Si l'échographie est une méthode efficace pour le diagnostic précoce des dysplasie ou des luxations de hanches, son utilisation comme méthode de dépistage est controversée. Le propos de cette étude est de réaliser une étude prospective de cet examen à partir de patients présentant des facteurs de risques et d'un examen clinique (3,541 enfants). La sensibilité et la spécificité de l'examen clinique a été respectivement de 97% et 13.68%. Cent soixante-sept enfants (208 hanches) présentaient soit un type IIb de Graf ou une atteinte plus sévère soit 4.71%. Une hanche immature avec un type IIa de Graf a été présente dans 838 hanches, 15 d'entre-elles (1.78%) évoluant vers le type IIb et nécessitant un traitement. Les facteurs de risques utilisés ont été les suivants : sexe féminin, antécédent, siège. Du fait de cette spécificité basse de l'examen, nous pensons que l'examen clinique ne permet pas de mettre en évidence de façon certaine les stades de dysphonies détectés à l'échographie de la hanche chez les enfants ainsi dépistés.

This study was conducted at Fatih University Hospital, Ankara, Turkey. No funds have been received to support this study. Our institution's ethics committee approved this study.

H. Dogruel (✉)
Department of Orthopaedic Surgery, Güven Hospital,
Ankara, Turkey
e-mail: drdogruel@yahoo.com

H. Atalar · O. Y. Yavuz
Department of Orthopaedic Surgery, Fatih University,
Ankara, Turkey

U. Sayli
Department of Orthopaedic Surgery, A Klinik,
Ankara, Turkey

Introduction

In the screening of infants for developmental dysplasia of the hip (DDH), clinical examination and hip ultrasonography are the two most frequently used methods. Because clinical evaluations can differ between examiners and because plain radiographs can give inaccurate measurements of the hip joint in the first three months, the use of hip ultrasonography has become widespread in the early diagnosis and treatment of DDH. Advantages of ultrasonography are that it is non-invasive, does not involve radiation, and is easy to use.

The first investigator to direct attention to the use of ultrasound in the study of DDH in the newborn was Graf [5, 6], who used it to classify the forms of the disorder and to plan treatment. In this method, with the infant in a lateral decubitus position, coronal views are obtained, and α and β angles are measured. In terms of these angles, hip maturity is evaluated. In infants with DDH, the ability to monitor the hip during therapy is an important advantage of this method [1, 7, 22].

Although several studies support the use of hip ultrasonography as the most effective method for the early diagnosis of DDH [6, 9, 21, 23], there is still some controversy regarding the use of ultrasonography as a screening method [3, 4, 16, 19, 21]. The purpose of this study was to investigate prospectively the capacity of clinical examination findings and associated risk factors to detect DDH defined ultrasonographically in infants who participated in a screening program for this disease.

Patients and methods

The infants in this study were participants in our hospital's screening program for DDH. The initial study group included 7,321 infants who were born in our hospital between September 1997–September 2002, and who were examined clinically by the authors within the first week after birth. All infants in this group were scheduled to undergo ultrasonography in our hospital at four to six weeks of age, but because some did not return for this later visit, ultrasonography was performed on only 3,541 infants. This figure also includes infants who were born in other hospitals and whose families wanted to participate in our screening program.

During the visit at four to six weeks of age, all infants were examined clinically and underwent ultrasonography of the hip. Risk factors such as primiparity, positive family history, swaddling use, gender, breech delivery, caesarean delivery, oligohydramnios, and skeletal deformities associated with DDH were identified [10, 12, 21]. Low birth weight (<2,500 grams) and prematurity (<37 weeks gestational age) were also investigated as risk factors. Infants who had teratologic DDH or who had been diagnosed with DDH at another centre and referred to our hospital for treatment were not included in the study.

Ultrasonography was performed with a 7.5-megahertz linear transducer (Toshiba Sonolayer SSA-270A, Japan). The sonograms were classified according to Graf's method in terms of the α and β angles [6]. Infants who had mature hip joints (Graf type Ia or Ib) were exempted from follow-up. Infants with physiologically immature hips (Graf type IIa) were followed up with ultrasound until they were three months old, and if maturity was not complete at this time, the hip was classified as Graf type IIb. Infants with Graf type IIb hips as well as infants who on the initial ultrasound had Graf type IIc, type D, type III or type IV hips were assigned a diagnosis of DDH.

All clinical examinations were performed by the authors, and included the Barlow [2] and Ortolani [13] tests. To classify the participants according to hip instability, we used the following system: grade 1, slight capsular instability with no snapping sign and/or limitation of hip abduction to within 70° of the midline; grade 2, subluxatable hip (Ortolani's snapping); grade 3, dislocatable and reducible hip (dislocation sign); grade 4, fully dislocated, irreducible hip [21]. This is the system described by Tonnis [21], with an additional criterion of limited hip abduction included in grade 1.

Statistical analysis was performed to detect relations between ultrasonography findings and the risk factors for DDH mentioned above. First, the Kruskal-Wallis test was performed, and parameters that were found to be significant on this test were examined further with the chi-square, Mann-Whitney U and two-sample Kolmogorov-Smirnov tests. All analyses were performed with SPSS for Windows (version 10.0.1, SPSS, Chicago, IL). Statistical significance was defined as a p-value less than 0.05.

Results

Among 3,541 infants who underwent hip ultrasonography (7,082 hips), DDH of Graf type IIb or more severe was found in 167 infants (208 hips). This gives an overall frequency of 4.71%. By gender, frequencies were 1.91% for males and 6.92% for females. Graf type IIa physiological immaturity was encountered in 838 hips, and of these, 15 hips (1.78%) developed Graf type IIb DDH and underwent treatment. The distribution of hips by Graf type, clinical examination findings, and gender is shown in Table 1.

Of 431 hips defined as pathological according to the clinical examination, only 59 (13.68%) were defined as pathological according to ultrasonography. Of 208 hips defined as pathological according to ultrasonography (Graf type IIB or more severe), 149 (71.63%) were defined as normal according to the clinical examination. In three hips, the Ortolani test was positive, but on evaluation with ultrasonography according to the Graf method, DDH was not confirmed. In the original group of infants screened for DDH, we encountered three infants with grade 4 (irreducible) instability. However, because the DDH in these infants was due to teratological causes, they were not included in the study.

Measured against ultrasonography as a standard, the sensitivity and specificity of clinical examination were 97%

Table 1 Clinical and ultrasonographic findings in infants screened for DDH

Graf type Gender		Ia-b		IIa		IIb		IIc		D		IIIa		IIIb		IV		Total number of hips
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
Clinical exam findings	Normal	2,702	3,080	245	475	16	70	5	21	–	3	2	27	1	2	1	1	6,651
	Grade 1	101	157	30	60	10	15	3	5	–	1	1	15	1	3	–	1	403
	Grade 2	4	5	5	7	–	2	–	–	–	–	–	–	–	–	–	–	23
	Grade 3	1	1	–	1	–	–	–	–	–	–	–	2	–	–	–	–	5
Number of hips		2,808	3,243	280	543	26	87	8	26	–	4	3	44	2	5	1	2	7,082

M = male, F = female

and 13.68%, respectively. The numbers of hips defined as normal or pathological on clinical examination versus ultrasonography are shown in Table 2.

The distribution of risk factors across the infants with DDH (Graf type IIb or more severe) is shown in Table 3. Among the risk factors significantly associated with DDH, the frequency of the disease was highest in infants for whom swaddling had been used. A family history of DDH was also significantly associated with DDH in the infants in the study However, when we examined this further by the type of relative, DDH in the infant was significantly associated only with DDH in the infant's mother (p=0.025), but not in the father (p=0.686), siblings (p=0.435), or more distant relatives (p=0.155). The frequency of DDH among infants with a positive family history given in Table 3 is based on DDH in any family member, not only the mother.

Discussion

The prognosis of DDH depends on early diagnosis and treatment. It is well known that hips can appear normal on clinical examination and yet be found abnormal on ultrasonography [12, 17, 21]. Wirth et al. reported that ultrasound screening for DDH led to a reduction in late presentations, inpatient treatment, and surgical treatment [24]. However, there is still no consensus regarding the optimal method of screening for DDH in young infants [3, 16, 17, 23].

Table 2 Clinical examination versus ultrasonography in terms of numbers of hips defined as normal or pathologic

	Ultrasonography normal	Ultrasonography pathological	Totals
Clinical examination normal	6,502	149	6,651
Clinical examination pathological	372	59	431
Totals	6,874	208	7,082

The most appropriate age for hip screening with ultrasonography is four to six weeks, because most transient instability has resolved by then [7, 23]. Sucato et al. reported that in newborns younger than four weeks, ultrasonography is too sensitive [20]. For these reasons, we prefer to do ultrasonographic screening in infants who are four to six weeks of age.

The Graf method for diagnosing DDH is widely used because it is easy to apply and has been found to have low intra- and interobserver variability [8]. These advantages led us to use the Graf method in this study, which to date is the largest study of ultrasonographic screening for DDH in this country. With this method we found DDH in 4.71% of the infants screened.

Risk factors and ultrasonographic findings

Of the patient characteristics that have been studied as risk factors for DDH [3, 10, 12], the ones found to be significant in this study were swaddling use, positive family history, female gender and breech delivery.

Swaddling, the traditional practice of wrapping an infant tightly in cloths, maintains the hips in an extended and adducted position that can cause an abnormal relationship between the head of the femur and the acetabulum. The

Table 3 Risk factors in infants with DDH (Graf type IIb or more severe)

Risk factors	Number of infants	Infants with DDH	Percent	P value
Swaddling use	151	32	21.19	0.000
Positive family history	331	22	6.64	0.000
Female gender	1,803	112	6.21	0.000
Breech delivery	212	19	8.96	0.000
First born child	2,127	89	4.18	0.978
Caesarean section	2,092	71	3.39	0.846
Associated skeletal anomaly	19	1	5.26	0.812
Oligohydramnios	14	0	0	1.000
Low birth weight	253	6	2.37	0.131
Prematurity	262	7	2.67	0.198

association we found between swaddling use and DDH is consistent with previously reported findings [10].

Family history has been studied previously as a risk factor for DDH [3, 11, 12], with mixed results. Our findings suggest the possibility that DDH in an infant's mother is a stronger risk factor than DDH in other relatives, but this needs further investigation.

Female gender has been proposed as a risk factor for DDH, and as a possible mechanism for this, it has been suggested that the oestrogen that is released in mothers just before childbirth is transferred to the infant and produces in female infants the same effect of pelvic relaxation [14]. As in the study by Smaill [18], female gender was a risk factor for DDH in our series.

Breech delivery has been explained as a risk factor for DDH in terms of the intrauterine posture involved, in which leg movement is restricted and in which knee extension can stretch the hamstring and thereby increase the possibility of hip dislocation [14, 18]. Our finding of breech delivery as a risk factor for DDH is consistent with other studies [10, 12].

Other patient characteristics have been studied as possible risk factors for DDH, such as being the firstborn, the presence of skeletal anomalies associated with DDH, low birth weight, caesarean birth, oligohydramnios, and prematurity [12,14]. However, we did not find any of these to be significantly associated with DDH in the infants in our series.

Clinical examination vs. ultrasonography

Several studies have compared clinical examination and ultrasound as methods of screening infants for DDH [11, 12, 17, 21]. Marks et al. reported that ultrasound screening for DDH can detect cases of instability not diagnosed at birth by routine clinical examination and in infants who have no risk factors for DDH [11]. Tonnis et al. [21] and Rosenberg et al. [17] reported respectively that 52.2% and 50% of the ultrasonographically pathological hips in their studies had no clinical sign of instability. Omeroglu and Koparal found that ultrasonography can detect acetabular dysplasia in patients whose clinical examination findings are normal [12]. Our findings are similar to these. Of 208 hips defined as pathological according to ultrasonography (Graf type IIB or more severe), clinical examination defined 59 hips (28.37%) as pathological. This discrepancy between the two methods was apparent even among the infants with Graf type III or IV hips, with 34 hips in this group being classified as normal on the clinical examination. Other studies have also reported Graf type III and IV hips that were clinically evaluated as normal [3, 21].

Rosenberg et al. reported that in their series of 9,199 newborns, three hips appeared normal on ultrasonography, but were unstable clinically [17]. Similarly, in our study three hips appeared normal on ultrasonography, but were found to have grade 3 instability on the clinical examination; however, during follow-up these hips became clinically normal.

Riboni et al. reported 12 newborn babies whose hips appeared ultrasonographically normal at birth, but appeared abnormal on ultrasonography at three months of age [16]. As a possible mechanism for this late onset of DDH, the authors suggest persistent hyperlaxicity progressing to hip instability. They recommend ultrasonographic examination of all babies, with the first exam being performed at the end of the first month and a second exam between the third and fourth months. In our study, of 838 Graf type IIa hips, 15 later developed Graf type IIb DDH and underwent treatment. We therefore recommend close follow-up of infants who have Graf type IIa hips. If a Graf type IIa hip does not appear to be maturing, then we begin treatment before the usual three month period.

Some authors do not advocate the routine use of ultrasonography to screen all neonates for DDH [3, 4]. Castelein et al. reported that in 101 hips in their series, ultrasonographic findings were abnormal, and clinical examination findings were normal [3]. None were treated, and after six months DDH developed in four hips. The authors concluded that ultrasonography may be too sensitive because it also identifies clinically unimportant instability. Clarke et al. recommend the use of ultrasonography in infants who are at risk and have positive clinical examination findings [4].

Paton et al. screened 1,107 infants and concluded that risk factors alone do not have high predictive value in the identification of DDH [15]. They suggest that hip ultrasonography be used in babies who have clinically unstable hips alone or associated with 'at-risk' factors. Rosenberg et al. recommend a combined approach (clinical examination and hip ultrasonography) to screening for DDH [17].

As for the sensitivity of clinical examination in detecting DDH (97% in our series), it should also be kept in mind that many cases of DDH defined by ultrasonography can go undetected by clinical examination. The study by Castelein et al. suggests that ultrasonographic screening may lead to overtreatment of DDH [3]. However, we agree with Riboni et al. [16] that, because the treatment is benign and involves a small number of children, the risk of overtreatment associated with ultrasonographic screening is more acceptable than the risk of underdiagnosis associated with the clinical examination. To date, we have encountered no infants who were diagnosed as normal on ultrasonography but later developed DDH.

Regarding the low specificity of clinical examination for DDH, possible reasons include the need for experience and a relaxed infant. However, the clinical diagnosis of an unstable hip in a newborn can be difficult to make even in skilled

hands [21]. In conclusion, our findings suggest that clinical examination does not reliably detect ultrasonographically defined DDH in infants being screened for this disease.

References

1. Atalar H, Sayli U, Yavuz OY, Uras I, Dogruel H (2006) Indicators of successful use of the Pavlik harness in infants with developmental dysplasia of the hip. Int Orthop Apr 7
2. Barlow TG (1962) Early diagnosis and treatment of congenital dislocation of the hip. J Bone Joint Surg Br 44B:292–301
3. Castelein RM, Sauter AJ, de Vlieger M, van Linge B (1992) Natural history of ultrasound hip abnormalities in clinically normal newborns. J Pediatr Orthop 12:423–427
4. Clarke NM, Clegg J, Al-Chalabi AN (1989) Ultrasound screening of hips at risk for CDH. Failure to reduce the incidence of late cases. J Bone Joint Surg Br 71:9–12
5. Graf R (1980) The diagnosis of congenital hip-joint dislocation by the ultrasonic Combound treatment. Arch Orthop Trauma Surg 97:117–133
6. Graf R (1984) Classification of hip joint dysplasia by means of sonography. Arch Orthop Trauma Surg 102:248–255
7. Harcke HT, Kumar SJ (1991) The role of ultrasound in the diagnosis and management of congenital dislocation and dysplasia of the hip. J Bone Joint Surg Am 73:622–628
8. Jomha NM, McIvor J, Sterling G (1995) Ultrasonography in developmental hip dysplasia. J Pediatr Orthop 15:101–104
9. Krismer M, Klestil T, Morscher M, Eggl H (1996) The effect of ultrasonographic screening on the incidence of developmental dislocation of the hip. Int Orthop 20:80–82
10. Kutlu A, Memik R, Mutlu M, Kutlu R, Arslan A (1992) Congenital dislocation of the hip and its relation to swaddling used in Turkey. J Pediatr Orthop 12:598–602
11. Marks DS, Clegg J, al-Chalabi AN (1994) Routine ultrasound screening for neonatal hip instability. Can it abolish late-presenting congenital dislocation of the hip? J Bone Joint Surg Br 76:534–538
12. Omeroglu H, Koparal S (2001) The role of clinical examination and risk factors in the diagnosis of developmental dysplasia of the hip: a prospective study in 188 referred young infants. Arch Orthop Trauma Surg 121:7–11
13. Ortolani M (1976) Congenital hip dysplasia in the light of early and very early diagnosis. Clin Orthop Relat Res 119:6–10
14. Palmen K (1984) Prevention of congenital dislocation of the hip. The Swedish experience of neonatal treatment of hip joint instability. Acta Orthop Scand Suppl 208:1–107
15. Paton RW, Srinivasan MS, Shah B, Hollis S (1999) Ultrasound screening for hips at risk in developmental dysplasia. Is it worth it? J Bone Joint Surg Br 81:255–258
16. Riboni G, Bellini A, Serantoni S, Rognoni E, Bisanti L (2003) Ultrasound screening for developmental dysplasia of the hip. Pediatr Radiol 33:475–481
17. Rosenberg N, Bialik V, Norman D, Blazer S (1998) The importance of combined clinical and sonographic examination of instability of the neonatal hip. Int Orthop 22:185–188
18. Smaill GB (1968) Congenital dislocation of the hip in the newborn. J Bone Joint Surg Br 50:525–536
19. Schuler P, Feltes E, Kienapfel H, Griss P (1990) Ultrasound examination for the early determination of dysplasia and congenital dislocation of neonatal hips. Clin Orthop Relat Res 258:18–26
20. Sucato DJ, Johnston CE 2nd, Birch JG, Herring JA, Mack P (1999) Outcome of ultrasonographic hip abnormalities in clinically stable hips. J Pediatr Orthop 19:754–759
21. Tonnis D, Storch K, Ulbrich H (1990) Results of newborn screening for CDH with and without sonography and correlation of risk factors. J Pediatr Orthop 10:145–152
22. Ucar DH, Isiklar ZU, Kandemir U, Tumer Y (2004) Treatment of developmental dysplasia of the hip with Pavlik harness: prospective study in Graf type IIc or more severe hips. J Pediatr Orthop B 13:70–74
23. Wientroub S, Grill F (2000) Ultrasonography in developmental dysplasia of the hip. J Bone Joint Surg Am 82:1004–1018
24. Wirth T, Stratmann L, Hinrichs F (2004) Evolution of late presenting developmental dysplasia of the hip and associated surgical procedures after 14 years of neonatal ultrasound screening. J Bone Joint Surg Br 86:585–589