Original Article

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The Diagnostic Value of Combined Hip and Systemic Ultrasonography for the Early Detection of Developmental Dysplasia of the Hip and Associated Pathologies in Infants

Bebeklerde Gelişimsel Kalça Displazisi ve Eşlik Eden Patolojilerin Erken Tanısında Kombine Kalça ve Sistemik Ultrasonografinin Tanısal Değeri

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ABSTRACT

Objective: To assess the diagnostic value of combined hip and systemic ultrasonography in infants for the early detection of developmental dysplasia of the hip (DDH) and other incidental pathologies.

Methods: A retrospective chart review was conducted for infants who underwent both hip and systemic sonographic examinations. The infants were categorized into two groups: group 1 (normal) and group 2 (with DDH). Data analysis included risk factors associated with DDH, hip type, and systemic sonographic findings.

Results: Among the 496 hips scanned, 336 (67.7%) were classified as normal (group 1), and 160 (32.3%) were diagnosed with DDH (group 2). The hip types in group 2 included 2a in 75 patients (15%), 2b in 58 patients (11.7%), 2c in 18 patients (3.6%), 3 in 7 patients (1.4%), and 4 in 2 patients (0.4%). A total of 63 (25%) incidental pathologies were detected, with 35 (14%) involving the head and neck and 26 (10.5%) involving the abdomen. While most risk factors did not significantly differ between the groups, sex (p=0.004) and a family history of DDH (p<0.001) were identified as significant predictors.

ÖZ

Amaç: Kombine kalça ve sistemik ultrasonografinin, bebeklerde gelişimsel kalça displazisi (GKD) ve diğer tesadüfi patolojilerin erken tespitindeki tanısal değerini değerlendirmek.

Yöntemler: Kalça ve sistemik sonografi incelemeleri yapılan bebekler için retrospektif bir dosya taraması gerçekleştirildi. Bebekler iki gruba ayrıldı: grup 1 (normal) ve grup 2 (GKD olan). Veri analizi, GKD ile ilişkili risk faktörlerini, kalça tiplerini ve sistemik sonografi bulgularını içermektedir.

Bulgular: Taranan 496 kalçadan 336'sı (%67,7) normal (grup 1) olarak sınıflandırıldı, Hastaların 160'ı (%32,3) GKD tanısı aldı (grup 2). Grup 2'deki kalça tiplerinden 2a 75 hastada (%15), 2b 58 hastada (%11,7), 2c 18 hastada (%3,6), 3 ise 7 hastada (%1,4) ve 4, 2 hastada (%0,4) saptandı. Toplamda 63 (%25) hastada tesadüfi patoloji tespit edildi; bunlardan 35'i (%14) baş ve boyun, 26'sı (%10,5) ise karın ile ilgiliydi. Çoğu risk faktörü gruplar arasında anlamlı bir fark göstermemekle birlikte, cinsiyet (p=0,004) ve ailede GKD olması öyküsü (p<0,001) önemli belirleyiciler olarak saptanmıştır.

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ABSTRACT

Conclusion: Comprehensive ultrasonographic examination of the hips and other organ systems in infants can be valuable tools for the early detection of pathologies, including DDH, and other incidental findings.

Keywords: Developmental dysplasia of the hip, infant, ultrasonography, retrospective studies, incidental findings

ÖZ

Sonuç: Bebeklerde kalça ve diğer organ sistemlerinin kapsamlı ultrasonografik muayenesi, GKD ve diğer tesadüfi bulgular da dahil olmak üzere patolojilerin erken tespiti için değerli bir araç olabilir.

Anahtar Kelimeler: Kalça gelişimsel displazisi, bebek, ultrasonografi, retrospektif çalışmalar, tesadüfi bulgular

Introduction

Developmental dysplasia of the hip (DDH) is a common orthopedic condition in children, and screening practices vary across regions due to differing local healthcare policies. Early diagnosis is crucial for preventing morbidity and potential sequelae in DDH (1). One of the most common anomalies associated with DDH is torticollis, with an incidence in newborns ranging between 0.017% and 1.9% (2). Ultrasonography (US) is routinely used in many centers for the diagnosis of both DDH and torticollis. Similarly, neonatal sonographic screening of various systems has become an integral part of public health screening programs in certain institutionalized populations. In recent years, prenatal and postnatal ultrasound screening for renal and urinary tract anomalies has also been widely implemented (3-5). Although its effectiveness remains controversial, postnatal US has been shown to be more reliable in diagnosing urinary system anomalies than prenatal screening is (5).

Cranial US is another imaging method increasingly used in newborns, particularly in premature infants, and has become a standard practice in neonatal intensive care units. While cranial US has traditionally been indicated for infants with neurological symptoms, recent studies highlight the potential benefits of cranial US screening in asymptomatic healthy newborns and full-term infants, which is noteworthy (6,7).

In our study, we examined additional sonographic findings and explored the necessity of routine systemic sonographic screening in healthy infants undergoing routine hip US in radiology.

Methods

We retrospectively analyzed the medical records of infants referred from different hospitals for routine hip US screening between 2012 and 2020. Infants aged 1-6 months were included in the study. Infants who did not undergo a comprehensive US examination of all systems were excluded. Detailed anamnesis was taken from each patient, including demographic data such as age, sex, birth order, type of delivery (normal/cesarean), breech presentation, foot anomalies, family history of DDH, and prenatal second-level obstetric US information. Physical examinations were performed for possible foot deformities in each infant. Patients without detailed demographic or medical information were excluded, resulting in a total of 248 infants included in the study. The fasting times of the patients prior to the examination were recorded.

US examinations were performed while the infants were asleep whenever possible. Hip US was conducted via the Graf method in the right and left lateral decubitus positions. Additional US evaluations included the neck (for torticollis, thyroid, and thymus), fontanel, abdomen, and umbilical, inguinal, and scrotal regions. Sternocleidomastoid muscle diameters were measured in the sagittal plane with the infant in the supine position, and echogenicity was assessed for signs of torticollis. The thyroid gland was scanned for nodules in both the axial and sagittal planes. The cardiac region was examined with the abdominal probe angled superiorly while the infant was in the supine position. The umbilical and inguinal regions were evaluated for hernias, whereas the ovaries in female infants and the scrotal region in male infants were examined.

The average time for each US examination was 30 minutes per infant. All US scans were performed by the same radiologist (KAG) via an Aplio XG US scanner (Toshiba Medical Systems, 2011, Japan) equipped with multifrequency transducers (a 3.5 MHz convex probe for abdominal scanning; a 5 MHz microconvex probe for transfontanel scans; and a 7.5 MHz superficial probe for the neck, hip, and scrotum).

This study was approved by the local Ethics Committee of Tekirdağ Namık Kemal University (protocol no: 2022.33.03.01, date: 29.03.2022) and was conducted in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all parents.

Statistical Analysis

Statistical analysis was performed via SPSS for Windows version 22.0 (Statistical Product and Service Solutions, Inc, Chicago, IL, USA). The descriptive data are presented as the means ± standard errors. Differences between groups were assessed via Pearson chi-square tests and independent-sample t tests. A p-value of <0.05 was considered statistically significant.

Results

A total of 248 infants, 133 girls (53.6%) and 115 boys (46.4%), participated in the study. The mean age was 97.7±40.7 days (range: 30-183 days). Among the participants, 25 infants (10%) were under 6 weeks of age, whereas 223 infants (90%) were older than 6 weeks. There were 95 infants (38.3%) aged between 6 weeks and 3 months. None of the infants had a documented history of second-level obstetric ultrasound during the prenatal period. The performance of Ortolani or Barlow tests as part of the physical examination was unknown, and no documentation

regarding these tests was available in the ultrasound request forms. The fasting times prior to ultrasound varied from 0 to 4 hours (mean: 2.0±0.9 hours).

The infants were categorized into two groups: the normal group (n=142; 57.3%) and the DDH group (n=106; 42.7%). Among the 106 patients in the DDH group, 53 (50%) had bilateral DDH, 48 (45%) had left-sided DDH, and 5 (5%) had right-sided DDH. Detailed demographic findings, along with clinical and sonographic data (including sex, risk factors, DDH types, and affected sides), are summarized in Table 1.

Significant differences were observed between the DDH group and the normal group in terms of sex and family history of DDH (p=0.004 and p<0.001, respectively). However, no statistically significant differences in other risk factors were detected between the two groups.

Among the 496 hips scanned, 336 (67.7%) were classified as normal (group 1), and 160 (32.3%) were classified as DDH (group 2). The hip types in group 2 included 2a in 75 patients (15%), 2b in 58 patients (11.7%), 2c in 18 patients (3.6%), type 3 in 7 patients (1.4%), and type 4 in 2 patients (0.4%) (Table 1). Isolated left-sided DDH was identified in 2 patients with right-sided torticollis and in 7 patients with left-sided torticollis. Notably, isolated right-sided DDH was not observed in any patients with torticollis. Bilateral DDH was present in 2 patients with right-sided torticollis and in 3 patients with left-sided torticollis. In 12 out of 14 patients with both torticollis and DDH, the torticollis was on the ipsilateral side.

No statistically significant differences in sonographic hip types were observed between different age groups (p=0.152).

The distribution of pathologies identified through systemic ultrasonographic analysis is summarized in Table 2. Of these, 35 pathologies (14%) were related to the head/neck, and 26 (10.5%) were related to the abdomen. A majority (34.6%) of the abdominal pathologies were associated with the kidneys. Abnormalities in the size and shape of the heart chambers were noted in 2 patients (0.8%) exhibiting growth retardation, leading to a diagnosis of congenital heart disease in these patients following consultation with a pediatric cardiologist.

The incidence of accompanying anomalies was significantly higher in patients without a family history of DDH compared to those with a positive family history, and this difference was statistically significant.

Discussion

Neonatal sonographic screening is a vital tool for detecting conditions, including DDH, that necessitate early intervention in newborns and infants (2). Numerous studies underscore its significance (1-5). Although DDH is relatively uncommon, hip ultrasound screening is widely integrated into public health programs across many countries (8,9). However, the implementation of additional neonatal sonographic screening programs remains limited.

In this study, DDH was diagnosed in 32.3% of infants undergoing routine hip US. Additionally, a substantial number of other pathologies were detected, with 63 cases (25%) identified through ultrasound examinations of various organ systems. Specifically, 35 (14%) of these pathologies involved the head and neck, while 26 (10.5%) were related to abdominal conditions.

A review of the literature identified a single study involving 769 infants, which reported a 28% incidence of incidental anomalies detected via abdominal ultrasound in infants aged 0 to 1 year (10). Furthermore, a retrospective analysis of 11,681 healthy newborns found cranial anomalies in 17.3% of cases (6). The rates of hip dislocation, renal pathology, and brain anomalies in a cohort of 3,396 healthy newborns were reported to be 17.1%, 4.4%, and 4.2%, respectively (11). In our study, the majority of detected pathologies were found in infants without DDH, and no statistically significant differences were observed between the groups.

Table 1. Patient demographic findings, possible risk factors for DDH, DDH types and sides, and additional US findings

Parameters		Groups		p-value
		Normal	DDH	
Gender, n (%)	Female	65 (45.8%)	68 (64.2%)	**0.004***
	Male	77 (54.2%)	38 (35.8%)	
Birth order, n (%)	1st	79 (55.6%)	68 (64.2%)	0.177
	>1st	63 (44.4%)	38 (35.8%)	
DDH history, n (%)	Yes	3 (2.1%)	15 (14.2%)	**0.001***
	No	139 (97.9%)	91 (85.8%)	
Type of birth, n (%)	Normal	75 (52.8%)	53 (50%)	0.661
	Cesarean	67 (47.2%)	53 (50%)	
Birth presentation, n (%)	Head	74 (98.7%)	52 (98.1%)	1.000
	Breech	1 (1.3%)	1 (1.9%)	
Foot anomaly, n (%)	Yes	2 (1.4%)	0 (0)	0.509
	No	140 (98.6%)	106 (100%)	
Torticollis, n (%)	Yes	9 (6.3%)	14 (13.2%)	0.065
	No	133 (93.7%)	92 (86.8%)	
Torticollis side, n (%)	Right	4 (44.4%)	4 (28.6%)	0.657
	Left	5 (55.6%)	10 (71.4%)	
DDH type, n (%)	1	336 (67.7%)		
	2a		75 (15.1%)	
	2b		58 (11.7%)	
	2c		18 (3.6%)	
	3		7 (1.4%)	
	4		2 (0.4%)	
DDH side, n (%)	Right		59 (36.9%)	
	Left		101 (63.1%)	
Additional US pathology, n (%)	Yes	30 (21.1)	10 (9.4)	0.091
	No	112 (78.9)	96 (90.6)	

*: Chi-square test, DDH: Developmental dysplasia of the hip, US: Ultrasonography

Among the 24 patients presenting with accompanying anomalies, 8 demonstrated type 2a morphology, 8 exhibited type 2b, and 8 showed type 2c morphology.

DDH is influenced by a combination of genetic, environmental, and biomechanical factors. Key risk factors include a positive family history of the condition, breech presentation, female sex, firstborn status, and associated conditions such as torticollis. Furthermore, factors like ligamentous laxity, prenatal positioning, and swaddling practices may also contribute to the development of DDH (12-15).

In our study, there were no statistically significant differences in risk factors between the groups, except for sex and family history of DDH. The higher prevalence of DDH in girls aligns with the literature (12,16).

Table 2. Additional systemic pathologies detected via ultrasonography

Ultrasonographic pathologies	Groups		
	Normal (n=142)	DDH (n=106)	Total (n=248)
Torticollis, n (%)	9 (6.3%)	14 (13.2%)	23 (9.3%)
Kidney stone, n (%)	2 (1.4%)	1 (0.9%)	3 (1.2%)
Hydronephrosis, n (%)	4 (2.8%)		4 (1.6%)
Ectopic kidney, n (%)	1 (0.7%)	1 (0.9%)	2 (0.8%)
Umbilical hernia, n (%)	4 (2.8%)	2 (1.9%)	6 (2.4%)
Inguinal hernia, n (%)	3 (2.1%)		3 (1.2%)
Hepatosplenomegaly, n (%)	2 (1.4%)		2 (0.8%)
Ovarian cyst, n (%)		3 (2.8%)	3 (1.2%)
Epididymis cyst, n (%)		1 (0.9%)	1 (0.4%)
Undescended testis, n (%)		1 (0.9%)	1 (0.4%)
Situs inversus, n (%)		1 (0.9%)	1 (0.4%)
Congenital heart disease, n (%)	2 (1.4%)		2 (0.8%)
Hydrocephalus, n (%)	4 (2.8%)		4 (1.6%)
Septum pellucidum et vergae variation, n (%)	2 (1.4%)		2 (0.8%)
Thyroid nodule, n (%)	5 (3.5%)		5 (2%)
Thyroid hypoplasia, n (%)	1 (0.7%)		1 (0.4%)
Total, n (%)	39 (27.3%)	24 (22.6%)	63 (25%)

DDH: Developmental dysplasia of the hip

The most commonly recognized congenital anomalies associated with DDH are foot deformities, such as pes equinovarus and pes calcaneovalgus (2,14,15). Additionally, rare congenital anomalies have been documented, with congenital hypothyroidism being the most common (17).

In our study, two patients presented with foot anomalies, two with congenital heart defects, and one with thyroid hypoplasia; all of these cases were categorized within the normal hip morphology group. A 30-day-old female infant with situs inversus exhibited bilateral type 2a hip morphology, which was most likely attributable to her early age. Nonetheless, DDH may also be associated with conditions such as cerebral palsy-affecting in utero extremity positioning due to muscular weakness-and Joubert syndrome, which is characterized by congenital cerebellar ataxia, hypotonia, oculomotor apraxia, cystic kidney disease, and hepatic fibrosis (18,19).

Delayed diagnosis of DDH can lead to serious complications, including delays in walking, asymmetrical leg length, chronic pain, avascular necrosis, and osteoarthritis, which may ultimately necessitate total hip replacement (1). During the neonatal period, DDH can be identified through Ortolani and Barlow tests during physical examinations; however, limited abduction is considered the most reliable physical finding in this age group (12). In our cases, none of these tests or findings were recorded. Given the lack of significant correlations between pathological physical examination findings and DDH, routine sonographic screening is recommended for DDH even in the presence of normal physical examination results (12).

Ultrasound is recognized as the most sensitive method for diagnosing DDH (1,2). According to the literature, the incidence of DDH identified via ultrasound ranges from 0.8 % to 30% (12,14,19-22). The incidence of DDH in our study was found to be relatively high at 32.3% compared to rates reported in the literature. This elevated rate may be attributed to the limited sample size, which can amplify the influence of outliers on prevalence estimates, as well as selection bias arising from the inclusion of some infants who underwent systemic US due to clinical suspicion, potentially leading to an overestimation of DDH prevalence.

Although opinions vary regarding the optimal timing for hip ultrasound, the sixth week is often cited as a period when minor temporary abnormalities resolve and more permanent anomalies can be identified (12). A study reported that clinical stabilization of the hip occurred without treatment by 4-6 weeks of age in 19 out of 30 infants (63%) (23). In our cohort, 23 hips (46%) among the 25 patients under 6 weeks of age were classified as type 2a, whereas 3 hips (6%) were classified as type 2c. Our total number of type 2a hips was 52 (27.4%) in infants aged 6 weeks to 3 months; however, we did not find a statistically significant difference in hip type between the two age groups.

The most prevalent pathology identified in the head and neck region was torticollis, whereas cranial anomalies were the least common. The co-occurrence of torticollis and DDH has been

reported to range from 0% to 29% (2,24-26). Some authors argue that the history and physical examination findings are sufficient for diagnosing DDH in infants with torticollis, rendering routine hip ultrasound unnecessary (2). Typically, torticollis is detected on the same side as DDH (2,14,25). In our study, there were no statistically significant differences in torticollis incidence between the groups; however, ipsilateral torticollis was observed in 12 of the 14 patients with both torticollis and DDH in our DDH group. Ultrasound is an important diagnostic tool for torticollis, just as it is for DDH (27).

US plays a crucial role in the early detection of intracranial anomalies in healthy newborns (7,28). In a study of 11,681 healthy full-term newborns, the incidence of intracranial anomalies was found to be 17.3%, with approximately 5.7% of these infants developing neurodevelopmental disorders at follow-up (6). Notably, we did not observe any significant cranial pathology aside from hydrocephalus.

For newborn infants, abdominal US examination is recommended as a screening tool, particularly for the urinary system, in conjunction with hip assessments (3,5,11). Renal tract malformations are a leading cause of childhood end-stage renal disease, and chronic kidney disease can lead to both kidney failure and an increased risk of cardiovascular disease (4).

The prevalence of congenital kidney and urinary tract anomalies detected via antenatal US is approximately 0.1%, increasing to 1% with postnatal US (4). In a screening study involving 17,783 healthy infants, congenital urinary tract anomalies were identified in 171 patients, 42 of whom underwent surgical intervention. Additionally, several serious extrarenal intra-abdominal pathologies have been detected (5). The most common finding in abdominal US scans is hydronephrosis, with ureteropelvic obstruction being the most frequent congenital anomaly associated with it (4). Hydronephrosis presenting with a renal pelvis diameter of 5-20 mm or a grade 1-2 ratio during the fetal or neonatal period may undergo spontaneous resolution (3,29). In this study, the predominant abdominal pathologies related to the kidneys included hydronephrosis, renal calculi, and ectopic kidneys. A correlation between nephrolithiasis detected in the first year of life and metabolic abnormalities has been reported (30). Urolithiasis in newborns and infants may resolve spontaneously within the first year, whereas hydronephrosis may resolve by the second year (31). However, spontaneous resolution did not occur in the follow-up of our three patients with renal calculi. Ovarian cysts are more prevalent than expected during the neonatal period, with an incidence of 30% (3). Cysts exceeding 4 cm are considered pathological; in our cases, none exceeded this size.

Major congenital anomalies affect 2.3% to 4.1% of live births, making it essential to thoroughly investigate for additional anomalies when any congenital anomaly is detected in a newborn (32). A large study on the prevalence of congenital renal anomalies found that screening policies significantly influence outcomes, with the lowest detection rates in countries without routine ultrasound screening (33).

In our study, sonographic anomalies were detected in 63 out of 248 infants who were referred for screening and considered healthy. This corresponds to a rate of approximately 25%, and the majority of these pathologies are of a clinically significant nature.

In our country, routine hip examinations during the neonatal period are recommended to identify high-risk and clinically suspicious groups, facilitating early and appropriate treatment (34). However, aside from hip ultrasound scans, there are currently no studies or recommendations for routine systemic sonographic screening of specific organ systems during infancy. As this study highlights, not all infants undergo prenatal ultrasound screening, and even when performed, the effectiveness of this screening as a second-level review is limited by high costs and a shortage of qualified professionals.

Study Limitations

This study has several limitations. First, it had a retrospective design, and the data were obtained from cases in which both hip US and systemic US were performed during the same session. Systemic US was conducted in some patients as part of routine clinical protocols, at the discretion of the physician, or for the evaluation of additional anomalies. However, due to the retrospective nature of the study, the specific indications for performing systemic US could not be consistently documented. This should be taken into account when interpreting the results.

Second, the relatively small sample size might limit the generalizability of the findings. Performing a comprehensive ultrasonographic examination-including hip, cranial, cervical, abdominal, and scrotal imaging-in a single session is both time-consuming and labor-intensive. To our knowledge, no previous studies in the literature have routinely performed systemic US alongside hip US as done in this study. This lack of standardization hinders the comparison of physical examination findings with ultrasonographic results and limits the ability to uniformly assess the indications for systemic imaging.

Conclusion

This study underscores the critical role of US as an effective screening tool for the early detection of systemic pathologies in infants. The findings reveal a significant prevalence of intracranial anomalies and renal tract malformations in otherwise healthy newborns, emphasizing the necessity of routine abdominal and cranial US examinations in conjunction with hip assessments. Given its non-invasive nature, accessibility, and cost-effectiveness -particularly its avoidance of X-ray exposure- there is a compelling justification for the broader application of US in the early identification of potentially preventable conditions. Although statistical significance was not achieved in all cases, the evidence suggests that comprehensive screening encompassing multiple organ systems during routine evaluations may substantially enhance the timely identification and management of potential health issues in infants, ultimately improving long-term health outcomes. The opportunity to rapidly screen other systems in all infants undergoing hip ultrasound-regardless of the primary

reason for referral-is considered highly valuable, especially given the challenging conditions in our outpatient clinics.

Ethics

Ethics Committee Approval: This study was approved by the local Ethics Committee of Tekirdağ Namık Kemal University (protocol no: 2022.33.03.01, date: 29.03.2022) and was conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent: Informed consent was obtained from all parents.

Footnotes

Authorship Contributions

Surgical and Medical Practices: K.A.G., Concept: K.A.G., Ö.M.B., Design: K.A.G., Ö.M.B., Data Collection or Processing: K.A.G., Analysis or Interpretation: K.A.G., N.C.K., Ö.M.B., Literature Search: K.A.G., N.C.K., Ö.M.B., Writing: K.A.G., N.C.K., Ö.M.B.

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