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Sonographic Evaluation of Developmental Hip Dysplasia using Graf's Method

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Abstract : *The aim of the current study was to evaluate the hip joint for infants who were clinically diagnosed to have Developmental hip dysplasia (DDH) focusing mostly on the Graf's method using ultrasonography, by measuring the α and β angles and correlate the results with the anatomical findings related the hip.*
Between December 2011- December 2014 the hips of 536 newborn infants were examined by ultrasound by routines screening program for DDH at age 0day up to 4 months.
Sample including 145(27.1%) females and 391(72.9%) males .Participant's age were <30 days were 506(94.4%),31-60 days were 9(1.7%),61-90 days were 11(2.1%) ,and ages between 91-120 days were 10(1.9%).All infants were examined clinically and underwent Ultrasonography of the hip
Ultrasonographic examination was performed with a 7.5-3.5 ,5 MHZ, linear transducer (Toshiba, Philips 2010, volusum4000, Son layer SSA-270A, Japan) The sonograms were classified according to Graf's method in terms of the α and β angles.
Anatomical landmarks to be evaluated were; femoral head, hip joint capsule, acetabular labrum, acetabular hyaline cartilage, acetabular bony roof and acetabular bony rim , using the standard plane where the bony ilium in the depth of the acetabular fossa, the apparent acetabular labrum and a straight iliac wing contour were clear .
Results revealed that there is significant association between the β angle and acetabulum development, normality of the acetabuler labrum and normal presence of femoral head within the acetabuler cavity, at p =0.000,0.000,0.000 however the α angle should be considered if there is abnormal presentation of the labrum . Ischia development and acetabular bony roof , acetabular bony rim , joint capsule , acetabular hyaline cartilage and femoral head ligament normality were well correlated with the β angle at p= 0.006 and 0.000 and revealed that it was better to measure the α and β angle than to define the hip morphology and pathology alone .Application of ultrasonography using Graf's method meets the necessities for identification of the hip anatomy ,morphology and pathology .This study recommended to screen the newborn hip beside the clinical examination, because of its ability to measure the angles objectively beside the evaluation the surrounding anatomy subjectively in order to detect the dysplasia as early as possible, so that early treatment can took place.
Keywords – *Graf, Hip joint, DDH*

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I. Introduction

Developmental dysplasia of the hip (DDH) is a term explaining the situation in which the femoral head has an abnormal relationship to the acetabulum. DDH includes luxation, subluxation, instability wherein the femoral head is not localized inside the socket reflecting the inadequate formation of the acetabulum. Most of these findings may not be there at birth, and the earlier a dislocated hip is acknowledged, the more successful is the management. Despite newborn screening programs, dislocated hips continue to be diagnosed later,[1–8]

Due to the hip profound anatomical location, the physical examination becomes difficult; as well the hip joint effusions cannot be easily detected by clinical examination [[9-12]. Therefore imaging tools are necessary .Over the last decade; Ultrasonography (US) has proven to be a useful tool in the assessment of musculoskeletal anatomical structures. US has great role in the detection and differentiation between intraarticular and extraarticular pathology, as well US has good visualization of the joint cavity, quantification of soft tissue abnormalities, as well as a dynamic real-time study of multiple planes[13-27]. Many infantile hip ultrasonography methods were used to evaluate the DDH including Graf, Harcke, Terjesen and Suzuki methods.[28]

Plain radiography was the gold standard for the radiological diagnosis of (DDH) However, exposure to radiation and difficulties in studying the relationship between the cartilage femoral head and bony acetabular roofs lead to substandard its value during early infancy in DDH. On the other hand US can detect the hip problems that can be missed by clinical and radiographic examinations. [29-30]

The questions to be answered: can ultrasound has ability to detect DDH?, and to how much degree we can significantly depend upon the infantile hip ultrasonography methods in the diagnoses. Therefore the aim of the current study was to evaluate the hip joint for infants who were clinically diagnosed to have DDH focusing mostly on the Graf's method using ultrasonography, by measuring the α and β angles and correlate the results with the anatomical findings related the hip .

II. Materials and methods

Between December 2011- December 2014 the hips of 536 newborn infants were examined by ultrasound in our hospitals by routines screening program for DDH at age 0days up to 4 months.

Sample including 145(27.1%) females and 391(72.9%) males .Participant's age were <30 days were 506(94.4%),31-60 days were 9(1.7%),61-90 days were 11(2.1%) ,and ages between 91-120 days were (10(1.9%).All infants were examined clinically and underwent Ultrasonographic of the hip. Infants who had teratology DDH or who had been diagnosed with DDH at another center and referred to our hospital for treatment were not included in the study. Risk factors such as primperity, positive family history, swaddling use, gender, breech delivery, cesarean delivery, oligohydramnios, low birth weights and prematurity were also investigated at risk factors. Ultrasonographic was performed with a 7.5-3.5 ,5 MHZ, but most examination were performed with 3MHZscan head by available patients documents CD by numbers hip normal ,abnormal, linear transducer (Toshiba, Philips 2010, volusum4000, Son layer SSA-270A, Japan).several views of the infant hip were obtained by placing the transducer in the different position. Combination of two views was selected as being most reliable in the identification of the anatomical structures. In both views, the images are obtained by placing the transducer laterally in the region of the greater trochanter. In the view (transverse neutral, the infant is supine and the hip in the neutral position to identify the anatomical landmarks. The coronal flexion view, the ultrasound sector effectively scans a coronal section of the hip joint, the femur is in the flexed position and the transducer is rotated through 90 degree to identify anatomical landmarks. The sonograms were classified according to Graf's method in terms of the α and β angles.[31]

Table 1 Ultrasonographic hip types according to the Graf method [31]

	Bony roof/ bony roof angle α	**Superior bony rim (bony promontory)**	**Cartilaginous roof/ cartilage roof angle β**
mature hip	α ≥ 60°	angular / slightly rounded	covers the femoral head I a → β<55° (extending far distance over the femoral head) I b → β>55° (extending short distance over the femoral head)
Type II a,b	Deficient α = 50–59°	rounded	covers the femoral head
Type II c	Deficient α = 43–49°	rounded to flattened	still covers the femoral head β<77°
Type D β>77°	severely deficient α = 43–49°	rounded to flattened	displaced β<77°
Type III a,b eccentric hip α<43°	poor α<43°	flattened	pressed upwards – without structural alteration
Type IV eccentric hip α<43°	poor α<43°	flattened	pressed downwards (horizontal or mulded

III. Results

Table 2 shows the α and β angles values related to the acetabulum development, location of the femoral head and normality of acetabuler labrum

Acetabulum development					
		N	Mean	Std. Deviation	P-value
Alfa Angle	Developed	297	58.98	29.81	.474
	Undeveloped	64	56.27	10.14	
	Total	361	58.50	27.38	
Beta Angle	Developed	297	58.43	11.32	.000
	Undeveloped	64	67.66	20.39	
	Total	361	60.06	13.81	
Femoral head with in cavity					
		N	Mean	Std. Deviation	P-value
Alfa Angle	IN	305	59.46	29.37	.084
	Out	57	52.63	10.44	
	Total	362	58.39	27.38	

Beta Angle	IN	305	57.88	10.96	.000
	Out	57	73.65	19.33	
	Total	362	60.36	13.86	
Acetabuler labrum					
		N	Mean	Std. Deviation	P-value
Alfa Angle	Normal	286	59.36	30.24	.044
	Abnormal	48	50.45	10.19	
	Total	334	58.08	28.41	
Beta Angle	Normal	286	57.91	11.01	.000
	Abnormal	48	77.44	18.45	
	Total	334	60.71	14.10	

Table 3 shows the α and β angles values related to the **Ischia development**, and iliac line capsula , acetabular cartilage femoral head ligament

Ischia development					
		N	Mean	Std. Deviation	P-value
Alfa Angle	Developed	303	58.87	29.5	.437
	Undeveloped	231	57.32	8.1	
	Total	534	58.20	22.8	
Beta Angle	Developed	303	58.94	11.9	.006
	Undeveloped	231	62.12	14.8	
	Total	534	60.32	13.3	
Development acetabular bony roof and acetabular bony rim , joint capsule , acetabular hyaline cartilage and femoral head ligament					
		N	Mean	Std. Deviation	P-value
Alfa Angle	Developed	292	59.22	29.9	.089
	Undeveloped	53	52.12	10.2	
	Total	345	58.13	27.9	
Beta Angle	Developed	292	58.21	11.3	.000
	Undeveloped	53	72.89	19.2	
	Total	345	60.47	13.8	

IV. Discussion

According to the Graf ultrasonographic hip classification system, the α and β angles are the quantitative indicators of the bony and cartilage acetabular roofs, respectively .The α angle mainly determines the hip type and the other parameters, such as the age of the patient, β angle value, β angle value under stress, course of the perichondrium of the cartilage acetabular roof and structural changes in the cartilage roof, give particular differentiations [31]

In the current study, 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.

In the current study US provided detailed imaging of the hip. The current study applies the guidance mentioned by the American Institute of Ultrasound in Medicine and the American College of Radiology published guideline for the standardized performance of the infantile hip ultrasonographic examination. [32]

Results showed that the static ultrasonography demonstrated coverage of the femoral head by the cartilaginous acetabulum (α angle).Alfa angle showed significant difference in the measurement done when the acetabuler labrum is developed or not .

The Graf method was performed in the lateral decubitus position as mentioned by Graf [31] Before starting to classify the hip joint, anatomical landmarks were identified to be evaluated ; femoral head, hip joint capsule, acetabular labrum, acetabular hyaline cartilage, acetabular bony roof and acetabular bony rim , when the sonogram contains the bony ilium in the depth of the acetabular fossa, as well as an apparent acetabular labrum and a straight iliac wing contour,this means that it has a standard plane .

Ultrasound detected some instable, sublaxed and dislocated hips which were not diagnosed at birth by clinical examination. Those cases present late with the prospect of lasting disability. This applied ultrasound of neonatal hips makes it possible to late-presenting DDH.

There is significant association between the β angle and acetabulum development,normality of the acetabuler labrum and normal presence of femoral head within the acetabuler cavity, at p =0.000,0.000,0.000 however the α angle should be considered if there is abnormal presentation of the labrum (table2) . Ischia development and acetabular bony roof , acetabular bony rim , joint capsule , acetabular hyaline cartilage and femoral head ligament normality were well correlated with the β angle at p= 0.006 and 0.000 (table3).The

results of the current study revealed that it was better to measure the α and β angle than to define the hip morphology and pathology alone ,this was consistent with other previous studies [33,34,35]

Our experience that Graf class as deficient bony roof/bony roof angle α and worse hips can be detected by clinical examination in experienced hands, but the risk of missing the diagnoses is considerably high by performing clinical examination alone as mentioned previously by (Omerog˘lu H and Koparal S ;2001) [36]. The results of another study revealed that there was still no strong evidence for the diagnostic accuracy of hip ultrasonography as a screening tool [37]. However our judgment that ultrasonographic hip screening is better than clinical hip screening alone, even if the clinical examination is performed by an experienced physician because of its ability to measure the angles objectively and evaluation the surrounding bony anatomy subjectively.

V. Conclusion

Clinical examination still has diagnostic value in newborn as it is the first tract for referring the pediatrics for hip screening, but it needs highly experienced hands, hip ultrasonography is found to be accurate diagnostic tool in developmental DDH as we measured the α and β angles .It is better to perform the ultrasonographic hip screening within the early years. An effective hip ultrasonography method should include accurate, quantitative and consistent definitions for α and β angles for obtaining accurate diagnosis and managing the hip dysplasia in a proper way. Application of ultrasonography using Graf method meets the necessities for identification of the hip anatomy ,morphology and pathology .Our study recommended to screen the newborn hip beside the clinical examination, in order to detect the dysplasia as early as possible, so that early treatment can took place.

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