PERPUSTAKAAN KAMPUS KESIHATAN
UNIVERSITI SAINS MALAYSIA

RUJUKAN

UNIVERSITI SAINS MALAYSIA
DITERIMA
20 OCT 2005
Bahagian R & D
Pusat Pengajian Sains Perubatan

**USM SHORT TERM GRANT NO:
304/PPSP/6131273**

THE ROLE OF ULTRASOUND IN SCREENING NEWBORNS FOR DEVELOPMENTAL DYSPLASIA OF THE HIP IN HOSPITAL UNIVERSITI SAINS MALAYSIA, KELANTAN

PRINCIPLE INVESTIGATOR:
DR NOREEN NORFARAHEEN LEE
BINTI ABDULLAH
JABATAN RADIOLOGI
PUSAT PENGAJIAN SAINS
PERUBATAN

UNIVERSITI SAINS MALAYSIA

USM SHORT TERM GRANT NO: 304/PPSP/6131273

THE ROLE OF ULTRASOUND IN SCREENING NEWBORNS FOR DEVELOPMENTAL DYSPLASIA OF THE HIP IN HOSPITAL UNIVERSITI SAINS MALAYSIA, KELANTAN

PRINCIPLE INVESTIGATOR:
DR NOREEN NORFARAHEEN LEE BINTI ABDULLAH
JABATAN RADIOLOGI
PUSAT PENGAJIAN SAINS PERUBATAN

UNIVERSITI SAINS MALAYSIA

BAHAGIAN PENYELIDIKAN & PEMBANGUNAN
CANSELORI
UNIVERSITI SAINS MALAYSIA

Laporan Akhir Projek Penyelidikan Jangka Pendek

1) Nama Penyelidik: ...Dr Noreen Norfaraheen Lee binti Abdullah ....

....

Nama Penyelidik-Penyelidik
Lain (Jika berkaitan) : Dr Rofiah Ali ....

2) Pusat Pengajian/Pusat/Unit : Pusat Pengajian Sains Perubatan / Jabatan Radiologi ....

3) Tajuk Projek: The Role of Ultrasound in Screening Newborns for Developmental Dysplasia of the Hip in Hospital Universiti Sains Malaysia. ....

....

....

4) (a) Penemuan Projek/Abstrak
(Perlu disediakan makluman di antara 100 – 200 perkataan di dalam Bahasa Malaysia dan Bahasa Inggeris. Ini kemudiannya akan dimuatkan ke dalam Laporan Tahunan Bahagian Penyelidikan & Pembangunan sebagai satu cara untuk menyampaikan dapatan projek tuan/puan kepada pihak Universiti).

ABSTRAK

Tujuan kajian ini ialah megenalpasti sudut-sudut alfa dan beta sendi pinggul di kalangan bayi baru lahir yang normal. Pemeriksaan ultrasound dalam pandangan koronal semasa rehat dan semasa tekanan diberikan menggunakan transduser linear berfrekuensi tinggi (5-7.5 MHz) dilakukan kepada 49 orang bayi. Purata sudut-sudut alfa bagi sendi pinggul kanan dan kiri tanpa tekanan ialah 62.0 darjah (SD ± 6.4 darjah) dan 62.0 darjah (SD ± 5.6 darjah), manakala dengan tekanan masing-masing ialah 63.3 darjah (SD ± 7.2 darjah) dan 59.8 darjah (SD ± 8.0 darjah).

Kesimpulan nilai normal sudut-sudut alfa dan beta bayi-bayi di Hospital Universiti Sains Malaysia bersamaan dengan nilai bayi-bayi di negara barat. Terdapat perbezaan nyata nilai alfa dan beta sebelum dan selepas dikenakan pada sendi pinggul.

ABSTRACT

This study is to determine the normal values of the alpha and beta angles in normal newborns and to describe the changes of the angles during stress maneuver by ultrasound.

Coronal examinations of the hip at rest and stress were performed using a high frequency linear ultrasound probe (5-7.5 MHz) on 49 newborns at Hospital Universiti Sains Malaysia from January 2003 till March 2004. The means of the alpha angles of the right and left hips without stress were 62.0 degrees (SD ± 6.4 degrees), 62.0 degrees (SD ± 5.6 degrees) respectively and with stress were 63.3 degrees (SD ± 7.2 degrees), 59.8 degrees (SD ± 8.0 degrees). The means of the beta angles of the right and left hips without stress were 56.8 degrees (SD ± 7.4 degrees), 56.2 degrees (SD ± 7.0 degrees) respectively and with stress were 54.9 degrees (SD ± 7.1 degrees), 58.2 degrees (SD ± 8.7 degrees). The normal alpha and beta angles of the hip joints were comparable with the Caucasians. There was significant difference in the alpha and beta angle without and with stress.

(b) Senaraikan Kata Kunci yang digunakan di dalam abstrak:

Bahasa Malaysia	Bahasa Inggeris
displasia sendi pinggul	developmental dysplasia of the hip DDH
bayi baru lahir................................	newborn.............................

The Role of Ultrasound Examination in the Diagnosis of Developmental Dysplasia of the Hip

A Rofiah, M B Latifah, Y Rohaizan, N N A Lee

Department of Radiology, Hospital Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia

Summary

Purpose of Study

1. To determine the value of the alpha and beta angles of the hip joint amongst the newborns in Hospital Universiti Sains Malaysia.
2. To evaluate the changes in the alpha and beta angles in normal babies following stress maneuvers
3. To define the usefulness of ultrasound in diagnosis of DDH amongst babies with breech presentation.

Materials and Methods

In this cross-sectional study, conducted from January 2003 to March 2004, ultrasound in coronal view was done to determine the alpha and beta angles among the normal subjects. A validation study was performed to determine the reliability of the researcher technique prior the embarkation of the study. In breech subjects, the alpha angle was used to determine the hip type, which was then compared with clinical examination.

Results

Forty-nine (49) normal subjects were examined. The values of local alpha and beta angles of the newborn hips were 62.0 (SD 5.6 to 6.4) and 56.2 -56.8 (SD 6.9-7.4) degrees respectively. These values were not different from the western population and as described by Graf. There was significant difference in the values of alpha and beta angles between the right and left hips. There was also significant difference of alpha and beta angles before and after stress maneuver of the hips bilaterally. The findings were compatible with the previous school of thought that ultrasound during first 4 weeks of life often reveal the presence of minor degrees of instability and acetabular immaturity. Eleven (11) subjects with breech position were included in this study. Only one patient (1%) had abnormal clinical and sonographic findings bilaterally. All subjects in this group had compatible clinical and ultrasound findings.

Conclusion

The values of alpha and beta angles did not differ from the western population and as initially described by Graf. There was difference of the alpha and beta angles before and after stress maneuvers of the hips bilaterally and breech position was an important risk factor as an etiology for developmental dysplasia of the hip.

ACADEMY OF MEDICINE OF MALAYSIA

5TH MOH-AMM SCIENTIFIC MEETING
(incorporating 7th Scientific Meeting of the National Institutes of Health)

2nd July 2004

r Noreen
orfaraheen Lee Binti Abdullah
epartment of Radiology
PSP
niversiti Sains Malaysia
6150 Kubang Kerian
elantan

Fax: 09 766 3170

ear Dr Noreen

th MOH-AMM Scientific Meeting - Poster Presentations
5th – 28th August 2004, Sunway Lagoon Resort Hotel, Petaling Jaya, Selangor

am pleased to inform you that your abstract entitled:-

OSTER NO: PO41
HE ROLE OF ULTRASOUND EXAMINATION IN THE DIAGNOSIS OF DEVELOPMENTAL YSPLASIA OF THE HIP

as been accepted for poster presentation at the Conference.

indly note that:

Presentations in the Poster Session will be numbered as listed in the programme.
2 Posters may be mounted on the assigned board from **1400 hrs on Wednesday, 25th August 2004**.
3 The top of your poster must have a label indicating its title and author(s).
4 All illustrations should be prepared beforehand. Your illustrations should be readable from a distance of about 1 meter. Keep illustrations simple.
5 Posters <u>must not</u> be mounted on heavy board because they may be difficult to keep in position on the poster stands. The poster board area is **0.95m (width) x 1.5m (height) - portrait**. Double-sided tapes will be provided.
6 Posters must be dismounted by **1300 hrs on Saturday, 28th August 2004**. The Organising Committee will not be responsible for posters that have not been dismounted during the stipulated time.

hank you.

ours sincerely

r Safurah Jaafar
cientific Chairperson

/s **If you have not registered for the Congress, may we request you to do so before 5th August 2004 as only abstracts from registered delegates will be included in the Abstract Book. If you are an invited speaker, then please ignore this message.**

ay)

n Only)

‹ Performar (MASEPP)

›m the gove ent, private and
iinated by t national
ır country. T College of
tration fee will not cover

ak Perform ce
eem

f

Worksho

Concurrent Free Oral Paper Session

Date : 17 September 2004 (Friday) 1430-1700 hrs
AWARD SESSION
Venue : Gadila (5th Floor Function Room)
Chairperson : BJJ Abdullah

Paper Code	Time	Title (Presenter In Bold)
OA 1	1430-1442	Diffuse Tensor Imaging : Distinguishing Displaced And Destroyed White Matter In Brain Tumours **Tang PH**, Xu M, Parmar H, Golay X, Lim T SINGAPORE
OA 2	1442-1454	Is Perinephric Oedema A Good Indicator In The Assessment Of Ureteral Obstruction? **Tok CH**, Bux SI MALAYSIA
OA 3	1454-1506	Clinical Importance Of Virtual Colonoscopy In Failed Or Incomplete Colonoscopy **Cuartero CZ**, Badion MS, Co CS, Sarmiento FS THE PHILIPPINES
OA 4	1506-1518	Characterisation Of Microcalcification Properties In Digital Mammograms **Sumithra R**, Letchumanan M, Ng KH MALAYSIA
OA 5	1518-1530	Pre-operative Magnetic Resonance Staging Of Rectal Carcinoma Compared With Histopathological Examination **Hamzaini AH**, Padke P, Amran AR, Sukumar N, Siti Aishah MA, Norhafizah M, Zulfiqar MA MALAYSIA
	1530-1600	**TEA BREAK**
OA 6	1600-1612	The Value Of The Vascular Pedicle Width For Haemodynamic Assessment Of Critically Ill Cardiac Patients At A Tertiary Medical Centre **Molina MCD**, Molina JAD THE PHILIPPINES
OA 7	1612-1624	Is Ultrasound Bipolar Length A Good Predictor Of Kidney Size ? **Moorthy S**, George J, Ng KH MALAYSIA
OA 8	1624-1636	The Role Of Ultrasound In The Diagnosis Of Developmental Dysplasia Of The Hip **Rofiah A**, Lee NNA MALAYSIA

sudut alfa..........................	alpha angle..................................
sudut beta..........................	beta angle................................
....	....
....	....
....	....
....	....
....	....
....	....

5) Output Dan Faedah Projek

(a) Penerbitan (termasuk laporan/kertas seminar)
(Sila nyatakan jenis, tajuk, pengarang, tahun terbitan dan di mana telah diterbit/dibentangkan).

Pembentangan kertas

1. 12th Asian Association Radiology Conference, Muttiara Beach Resort, Pulau Piinang 16-20 September 2004
2. 5th Ministry of Health Malaysia – Academy of Medicine of Malaysia Scientific Meeting 2004 Sunway Lagoon Resort, Shah Alam, Selangor 25-28 August 2004
3. Published in Med J Malaysia Vol 59 Supplement D August 2004

....

Kertas kerja penuh

THE DETERMINATION OF THE VALUES OF ALPHA AND BETA ANGLES IN NORMAL HIPS AMONG THE NEWBORNS IN HOSPITAL UNIVERSITI SAINS MALAYSIA – A PRELIMINARY STUDY

Keywords: Developmental dysplasia hip(DDH), alpha angle, beta angle, newborn

ABSTRACT

This study is to determine the normal values of the alpha and beta angles in normal newborns and to describe the changes of the angles during stress maneuver by ultrasound. Coronal examinations of the hip at rest and stress were performed using a high frequency linear ultrasound probe (5-7.5 MHz) on 49 newborns at Hospital Universiti Sains Malaysia from January 2003 till March 2004. The means of the alpha angles of the right and left hips without stress were 62.0 degrees (SD ± 6.4 degrees), 62.0 degrees (SD ± 5.6 degrees) respectively and with stress were 63.3 degrees (SD ± 7.2 degrees), 59.8 degrees (SD ± 8.0 degrees). The means of the beta angles of the right and left hips without stress were 56.8 degrees (SD ± 7.4 degrees), 56.2 degrees (SD ± 7.0 degrees) respectively and with stress were 54.9 degrees (SD ± 7.1 degrees), 58.2 degrees (SD ± 8.7 degrees). The normal alpha and beta angles of the hip joints were comparable with the Caucasians. There was significant difference in the alpha and beta angle without and with stress.

INTRODUCTION

Developmental dysplasia of the hip (DDH) is a condition where the femoral head has an abnormal relationship with the acetabulum. It is a dynamic condition that occurs prenatally and postnatally. DDH includes hips that are unstable, subluxated, dislocated (luxated) and/or have malformed acetabula (Homer *et al.,* 2000). The Barlow and Ortolani tests are conventionally used clinically as screening examination to detect DDH in the neonate. The tests are not applicable when the baby is 8-12 weeks of life due to decreased capsule laxity and increased muscles tightness. There is a continuing incidence of late diagnosis despite rigorous clinical screening (Homer *et al.,* 2000).

In 1980, Graf used ultrasound (US) to examine the neonatal hip. He proposed the bony roof angle, alpha and cartilage roof angle, as parameters for assessing acetabular development (Nimityongskul *et al.,* 1995). The measurements are based on a coronal image. A reference for normal values, that is, the mean and range of the alpha angle has been established. The lower limit of normal for the alpha angle is 60 degrees (Weinthroub *et al.,* 2000). A hip is considered definitely abnormal when the alpha angle is <50 degrees and recommended treatment. A beta angle of more than 77 degrees indicates eversion of the labrum and subluxation of the hip (Weinthroub *et al.,* 2000).

In 1990, Harcke developed the dynamic study of this technique. Later, Harcke, Graf and Clarke merged their methods and proposed a Dynamic Standard Minimum Examination (DSME), which combined morphological and stability criteria. The use of ultrasound for screening of all newborns can lead to over diagnosis. Studies have shown that ultrasound is recommended for initial examination of infants with abnormal clinical signs or at risk for DDH. Ultrasound is preferably used as adjunct to clinical evaluation. The earlier DDH is detected; the treatment is simpler, more effective and less costly. There has not been any study previously done to determine the local data for the hip angles in our local population. The aims of this study are to determine the alpha and beta angles of the normal hips among babies born in Hospital Universiti Sains Malaysia (HUSM) and to define the changes of alpha and beta angles following stress maneuvers.

Materials and Methods

A cross-sectional study was conducted from January 2003 to March 2004 in Hospital Universiti Sains Malaysia (HUSM), Kubang Kerian, Kelantan. The study methodology was approved by Ethical Committee, School of Medical Science, Universiti Sains Malaysia (USM), Kubang Kerian, Kelantan. Normal full-term newborns from Maternity Unit, HUSM delivered either spontaneous vaginal delivery (SVD) or lower segment Caesarean section (LSCS) was recruited in the study. Ultrasound of the hips was done at less than 2 months of age. Excluded in this study were ill newborns that hampered proper physical and/or ultrasound examinations, newborns with neuromuscular disorder, myelodysplasia or arthrogryposis. Non-probability sampling method was used. The participants of this study were parent volunteers from the Maternity Unit HUSM. Before proceeding to the proper study, a validation study was carried out. The aim of the validation study was to validate the technique of the researcher compared to a radiologist. Once the validation study had statistically proven that the researcher's technique was compatible to the radiologist level, the proper study was then carried out.

The ultrasound examination of the hips was performed using a real time scanner Phillips (ATL) or Siemens Elegra with a broadband (5-12 MHz) linear-array transducer. The age of infant at the time of examination was less than two months. Written and informed consent was taken from the volunteer parents prior to the ultrasound examination. The infant was placed in lateral decubitus position (**Figure 1**) and the hip was in 35 degrees of flexion and 10 degrees of internal rotation (Weintroub *et al,* 2000). For static technique, the coronal image was obtained. The bony landmarks used were the iliac bone parallel to the ultrasound probe, visualisation of greater trochanter and triradiate cartilage (**Figure 3**). The morphology was assessed by angular measurement. The alpha and beta angles were measured as described above (**Figure 4 and 5**) using tool, Cobb`s angle available in digital image of Pathspeed ™ Web (General Electric).

The coronal image also obtained when the hip under stress (**Figure 1 and 2**). The stress manoeuvre that used was similar with clinical Barlow`s test. While performing the manoeuvre, the baby should be comfortable and relax. Both of the subject's hips were flexed to 90 degrees and abducted. While one hip was kept in the abducted position to stabilize the pelvis, the other hip was gently adducted and pushed posteriorly. The coronal image obtained and alpha as well as beta angles were measured again.

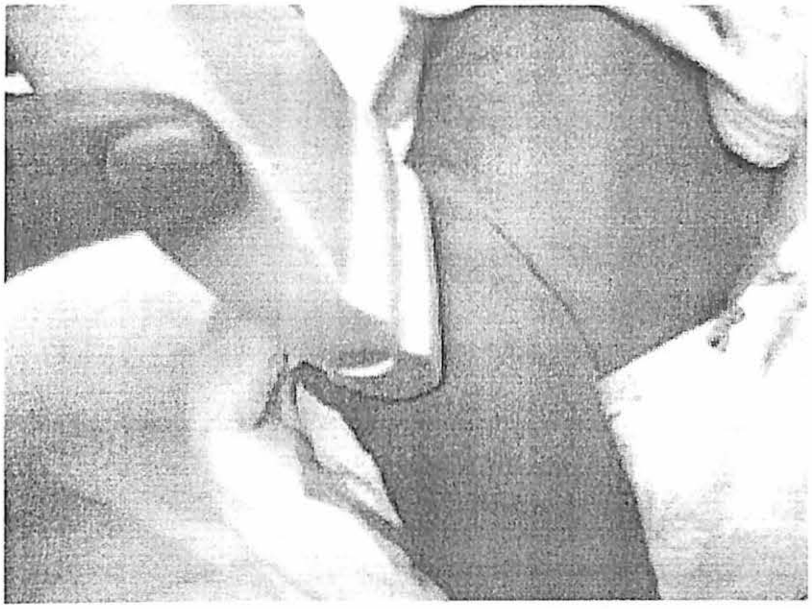


Figure 1: Coronal scan of the right hip

Figure 2: Coronal scan during Barlow stress maneuver

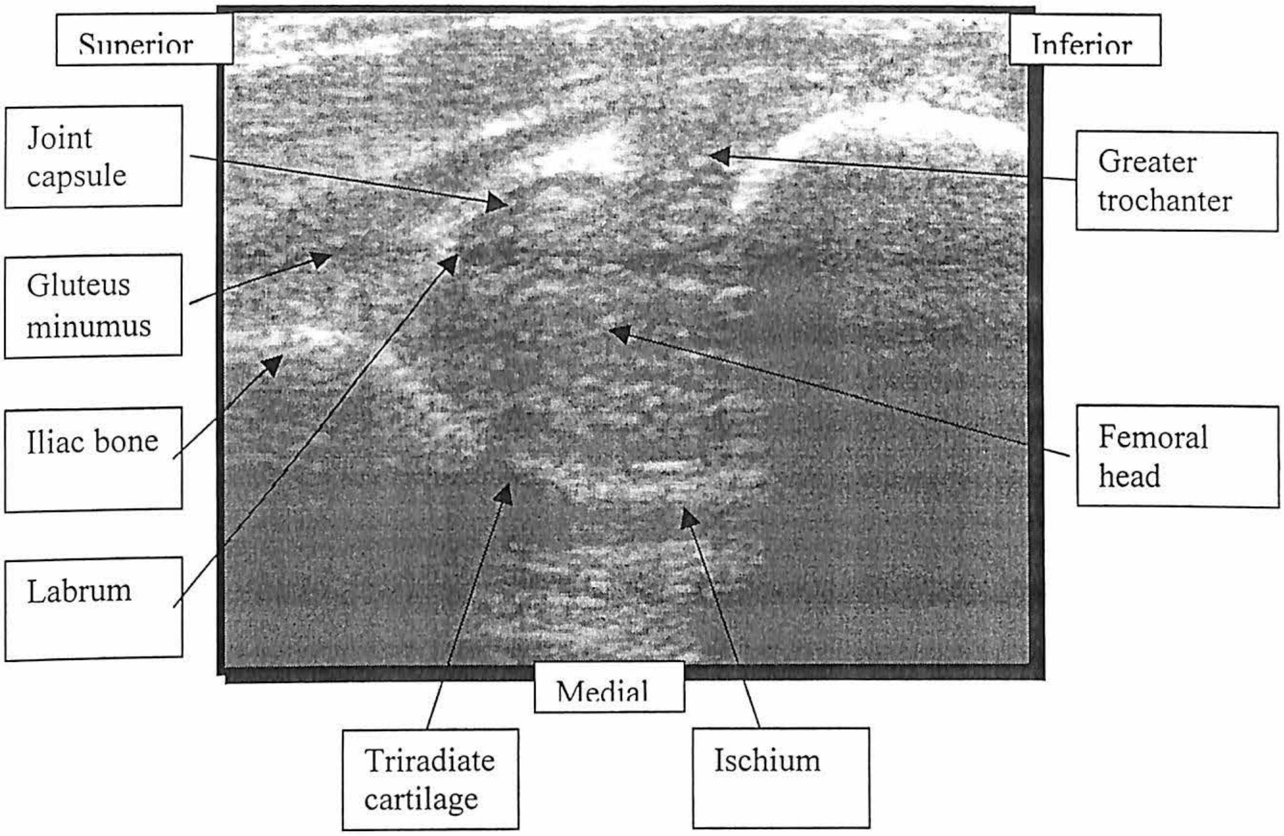


Figure 4.3: Coronal image of the hip without label (above) and with label (below).

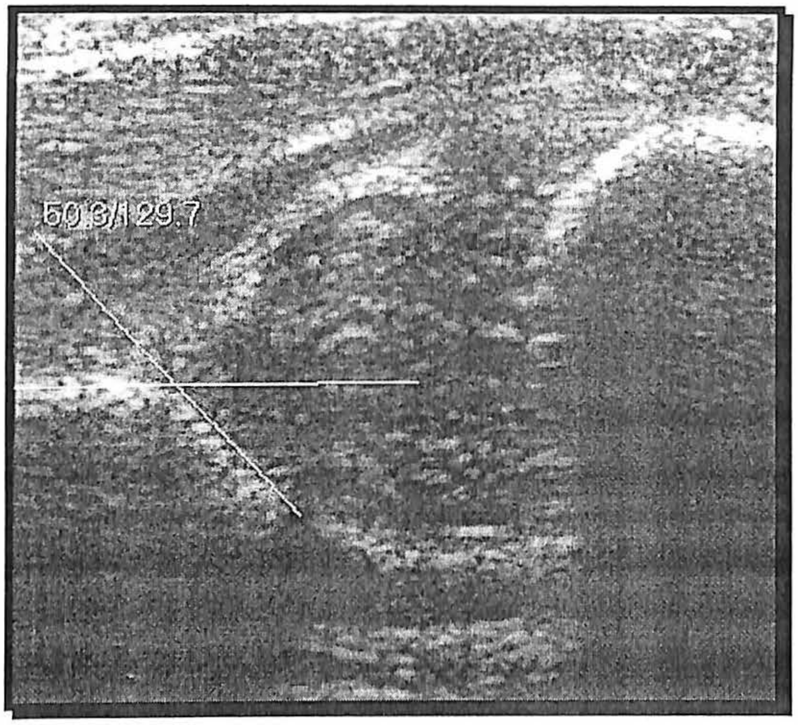


Figure 4.4: Measurement of alpha angle from coronal image

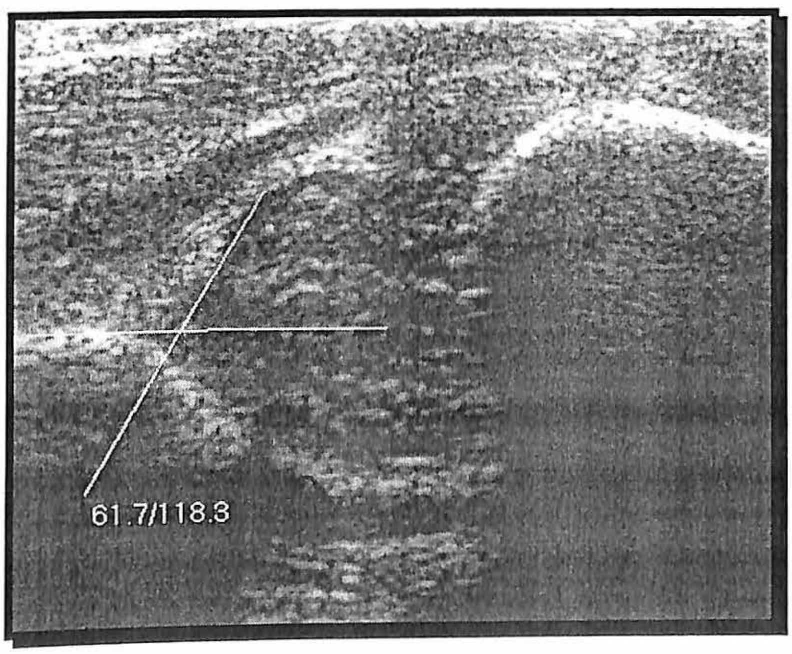


Figure 4.5: Measurement of beta angle from coronal image

RESULTS

Fourteen nine (49) subjects who fulfilled the inclusion criteria were chosen; they consisted of 32 male and 17 female. The mean and SD of the alpha angles of the right and left hips were 62.0 (SD ± 6.4) and 62.0 (SD ± 5.6) respectively. The means and SD of the beta angles of the right and left hips were 56.8 (SD ± 7.4) and 56.2 (SD ± 7.0).

The mean, standard deviation and p values of the alpha and beta angles of both hips, before and after stress test were summarized **Table 5.1.** Distribution of alpha and beta values, before and after stress maneuver showed normal distribution for all variables with mild skewed of the distribution to the right and left.

To determine the significant difference of the alpha and beta angles before and after the stress maneuver paired sample T-test was used. There was significant difference of the alpha and beta angles of the hips bilaterally, before and after stress maneuver. The p values of the right and left hips alpha angle were 0.03 and 0.001 respectively. The p values of the right and left hips beta angles were <0.001 and 0.001 respectively. The result summary was listed in **Table 5.1.**

Table 5.1: Results of the alpha and beta angles, before and after stress maneuver

		Before stress maneouver		After stress maneouver		P value CI 95%
		Mean	SD	Mean	SD	
Alpha	RT	62.0	6.4	63.3	7.2	0.03
	LT	62.0	5.6	59.8	8.0	0.001

Beta	RT	56.8	7.4	54.9	7.1	0.000
	LT	56.2	7.0	58.2	8.7	0.001

To determine the significant difference of the alpha and beta angle means between the right and left hips, the paired sample T-test was used. There was significant different of the alpha and beta angle means between the right and left hips, at 95% confidence interval (p alpha = 0.028, and p beta = 0.01).

DISCUSSION

Real-time ultrasonography has been established as an accurate method for hip imaging during the first few months of life. With ultrasound, the cartilage can be visualized and the hip viewed while assessing the stability of the hip and the morphologic features of the acetabulum. In some clinical settings, ultrasound could provide information comparable to arthrography, without the need for sedation, invasion, contrast medium, or ionizing radiation (Homer, 2000).

Although the availability of equipment for ultrasound is widespread, accurate results in hip sonography require training and experience. Even though expertise in pediatric hip ultrasound is increasing, this examination may not always be available or obtained conveniently (Homer, 2000). Not all communities have such services and some orthopaedic surgeons find themselves without access to this technique. In many communities in the United States, there are three systems: radiology-based, radiology and orthopaedic-based, and orthopaedic-office based for providing ultrasonography for DDH. The orthopaedic-office based system was the most convenient, cost-effective, and efficient, for patients, families, and treating physicians (Wientroub and Grill, 2000).

From 1996 to 2000, only 50 cases of congenital dislocation of the hip or DDH were recorded in HUSM. The age ranges from two days to 19 years old, with similar distribution for male and females (Unit Rekod Perubatan, HUSM).

In HUSM, breech deliveries occured about 1- 2.8% (Unit Rekod Perubatan, HUSM), delivered either vaginally or by Caeserean Section (LSCS). There was no definite protocol in referring for ultrasound (in Radiology Department HUSM) of the infant with risk factors (including breech delivery) or those with abnormal physical findings for DDH. The diagnosis was mainly made by physical examination and pelvic radiograph. The referrals for ultrasound were made to selected cases only. Less than 50 cases referred to radiology for ultrasound of the hip. So, the practice of using ultrasound in diagnosis of DDH was not widespread in HUSM.

The coronal image of the hip ultrasound is not difficult to produce; however, there have been controversies as to the reproducibility and reliability of alpha and beta angles in assessing the acetabular anatomy. With both static and dynamic techniques, there was considerable inter-observer variability, especially during the first 3 weeks of life (Homer, 2000).

In this study, the mean and standard deviation (SD) for alpha angles of right and left hips were 62.0 (SD 6.4) and 62.0 (SD 5.6) degrees respectively. The measurement of alpha angles ranged from 48.8 to 75.9 degree. The beta values were 56.8 (SD 7.4) and 56.2 (SD 7.0) degrees for right and left hip respectively. The reading range was between

38.2 to 76.8 degrees. Only few studies published discussed the means for alpha and beta. No local study was previously done to determine the local data for the angles. The results of this study were comparable with other studies performed elsewhere.

Nimityongskul (1995) observed that the alpha measurement for normal Type 1a and 1b (normal) was between 54.5 to 57 degrees, with standard deviation of 3.6 to 5.5. The beta reading for the same group was 46.4- 50.8 degrees with standard deviation of 3.8 – 8.3 degrees. Rosendahl (1994) gave alpha value of 59.0 degrees with SD of 5.5 for normal patients in neutral position. The corresponding beta value was 61.4 degrees and the standard deviation was 5.8 degrees.

As initially described by Graf, the alpha angle of more than 60 degree and beta angle more than 55 degrees were used to classify the hip into Type 1 and 11a (< 3 months). In this group of subjects who have normal hips clinically, the mean of alpha and beta angles followed the same trend. These results signified the local values of alpha and beta angles were not different from the western population. However, the number of subjects of this study was small, in which the result cannot be applied to the whole population.

There was significant difference of the mean of alpha and beta angles between right and left hips (p= 0.028 and p= 0.01 respectively at 95% confidence interval). Differences between the right and left hips were only noted in the beta angles in study by Cheng *et al.*(1994). The observation most likely contributed by the right hand as the dominant hand of the researcher. It was easier to hold the transducer with right hand and get the image while doing left hip ultrasound examination.

For the result of alpha and beta angles before and after stress maneuver, this study showed difference of the measurement before and after stress maneuver of the hips bilaterally. For the alpha angle, the p value was significant, with the values of 0.03 and 0.001 for right and left hip respectively. The p value of the right and left hips for beta angle were <0.001 and 0.001 respectively. The findings were not conflicting or compatible with the previous school of thoughts that ultrasound during first 4 weeks of life often revealed the presence of minor degrees of instability and acetabular immaturity (Homer, 2000). However, this study only stressed the difference of angles and no other morphological parameters were taken into account or tested. Again, the study was limited to a small number of samples, and may not be applicable to the population. In this study, no follow-up or re-examination of the infants hips after age of four (4) weeks. The reason was due to short duration of the study.

Engesaeter *et al.* (1990) concluded in their study that alpha and beta angles could not be used as indices for treatment of DDH because they bore no relation to the final outcome. However, these authors believed that the dynamic ultrasound study was meaningful. They also found no significant correlation between clinical and ultrasound examination by dynamic technique observed for the right hip when compared to the left hip. Their opinion was a right-handed observer was less accurate in detecting minor hip instability when the non-dominant hand performed the examination. Their study also concluded that the dynamic component of the ultrasound examination of both hips showed a strong predictive value when compared with the outcome. Stable hips had a significantly better outcome than unstable hips ($p<0.001$).

The technique of dynamic hip ultrasonography incorporate motion and stress maneuvers which based on accepted clinical examination techniques. Vendantam (1995) found the dynamic ultrasound technique to be valuable not only in the early detection of CDH but also in monitoring the effectiveness of splintage in the treatment of CDH. In this technique, an attempt was made to visualize the Barlow and Ortolani maneuvers on the ultrasound screen. The technique was dependent on ligamentous or capsular laxity, and, as with the physical examination, the study quality relied on the operator performing the stress test (Homer, 2000) and also required experience. The test should be performed when the baby is relax and not in distress. As the physical examination, the tests cannot be performed when the baby reached 8-12 weeks of age due to decreased capsule laxity and increased muscle tightness. At this age, however, the morphological technique can still be used to detect DDH and for follow-up of the cases.

There was still conflicting issue either to do ultrasound to `high-risk` groups or to do screening to the whole population of the newborns. Paton *et al.* (1999) study concluded that routine ultrasound screening of the `at-risk` groups on their own is of little value in significantly reducing the rate of `late` dislocation, but screening clinically unstable hips alone or associated with `at-risk` factors has a high rate of detection.

Lewis *et. al.* (1999) in their study had come to the conclusion that simple static ultrasound was an effective screening test for DDH but that it should be applied to the whole population and not simply to the `at-risk` group. Holen *et al.* (2002) concluded that if the neonatal clinical screening of the hip was of high quality as in their study, universal ultrasound screening is not needed. A selective screening policy for neonates with abnormal or suspicious clinical findings and those with risk factors for DDH should be recommended.

Eastwood (2003) found that screening babies with risk factors alone would miss between 30-40% of clinically unstable hips. Therefore, where selective screening has been used, all babies with clinical instability and those with defined risk factors were screened once and this prevented late diagnosis. However, early diagnosis did not reduce the incidence of surgery (defined as a procedure requiring a general anesthesia). They suggested that increased clinical effectiveness during a study period was also an important factor when evaluating selective screening program.

This issue was emphasized earlier by Paton *et al.* (2002), which summarized that targeted ultrasound screening did not reduce the overall rate of surgery compared with the best conventional clinical screening programs. The development of a national targeted ultrasound-screening program for `at-risk` hips could not be justified on a cost or result basis.

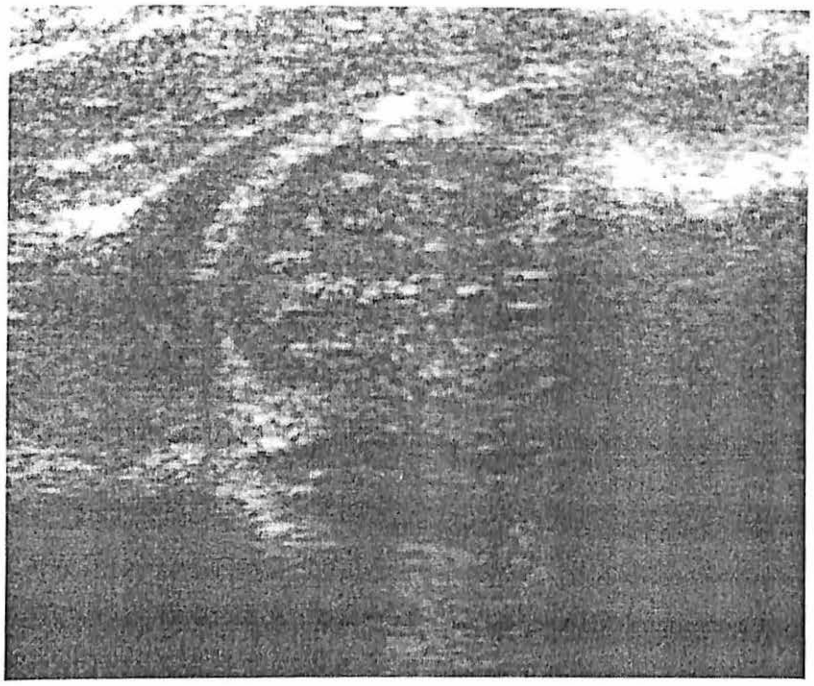


Figure 6.1: Coronal image of right hip at rest showed dislocation of the right hip joint. The labrum was inverted. The alpha and beta angles were 53.2 and 122.8 degrees respectively.

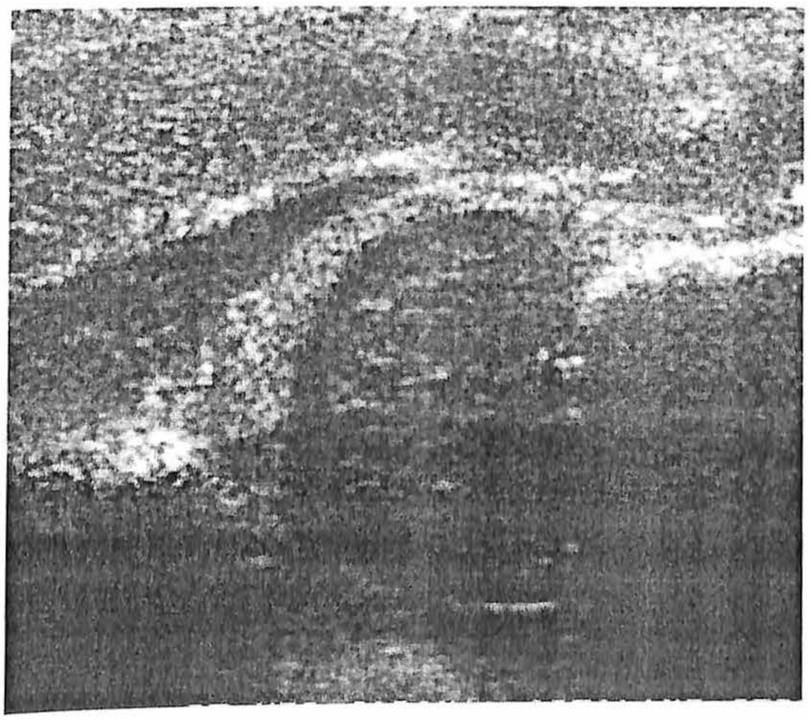


Figure 6.2: Coronal image of right hip following Ortolani stress maneuver. The femoral head was reduced. The alpha and beta angles were 61.3 and 82.3degrees respectively.

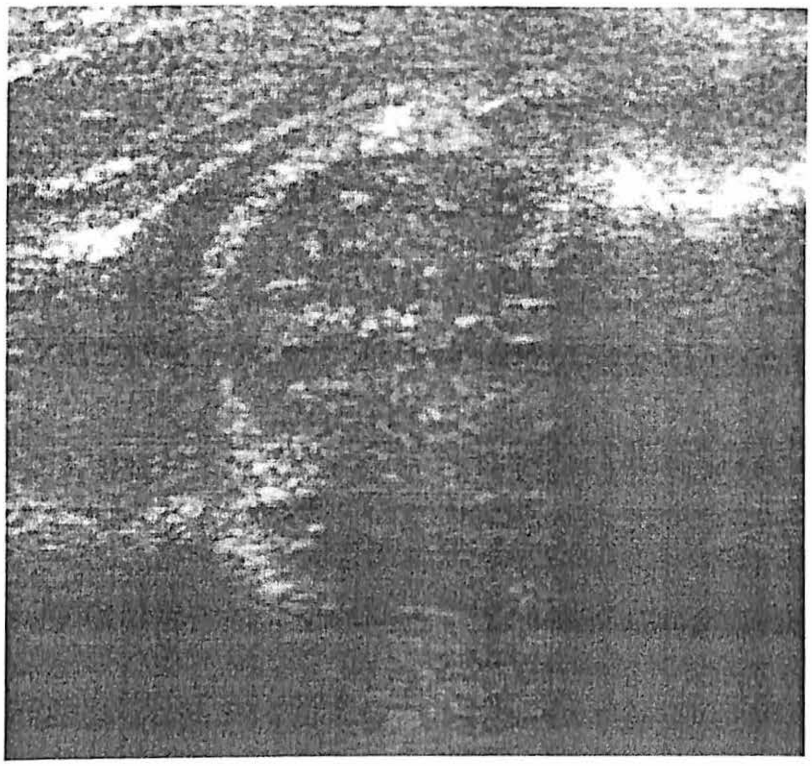


Figure 6.3: Coronal image of left hip at rest showed dislocation of the right hip joint. The labrum was inverted. The alpha and beta angles were 51.6 and 110.5 degrees respectively.

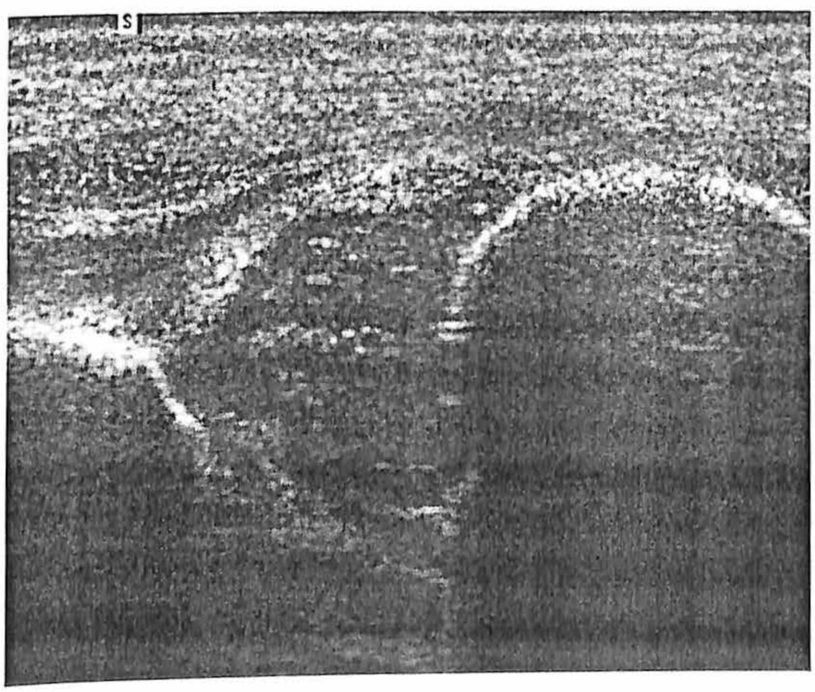


Figure 6.2: Coronal image of left hip with Ortolani stress maneuver. The femoral head reduced. The alpha and beta angles were 58.4 and 56.6 degrees respectively.

REFERENCES

Aoki, K., Mitani, S., Asaumi, K., Akazawa, H., Inoue, H. (1999). Utility of MRI in detecting obstacles to reduction in developmental dysplasia of the hip: comparison with two-directional arthrography and correlation with intraoperative findings, *J Orthopaedic Science,* **4,** 255-263.

Aronsson, D.D., Goldberg, M.J., Kling, T.F. Jr, Roy, D.R. (1994). Developmental dysplasia of the hip, *Pediatrics,* **94** (2), 201-8.

Avisse, C., Gomes, H., Delvinquiere, V., Ouedraogo, T., Lallemand, A., Delattre, J.F., Flament, J.B. (1997). Anatomic study of the pre- and neonatal hip. Physiopathologic considerations on dysplasia and congenital dislocation of the hip, *Surg Radiol Anat.*, **19** (3), 155-9 (abstract only).

Bache, C.E., Clegg, J., Herron, M. (2002). Risk factors for developmental dysplasia of the hip: ultrasonographic findings in the neonatal period, *J Pediatr Orthop Br.*, **11** (3), 212-8 (abstract only).

Bialik, V., Bialik, G.M., Wiener, F. (1998). Prevention of over treatment of neonatal hip dysplasia by the use of ultrasonography, *J Pediatr Orthop Br.*, 7(1), 39-42 (abstract only).

Bialik, V., Bialik, G.M., Blazer, S., Sujov, P., Wiener, F., Berant, M. (1999). Developmental Dysplasia of the Hip: A New Approach to Incidence, *Pediatrics*, **103** (1), 93 -99.

Castelein, R.Mm, Sauter, A.J. (1988). Ultrasound screening for congenital dysplasia of the hip in newborns: its value, *J Pediatr Orthop.*, **8** (6), 666-70.

Castelein, R.M., Sauter, A.J., de Vlieger, M., van Linge, B. (1992). Natural history of the ultrasound hip abnormalities in clinically normal newborns, *J Pediatr Orthop.*, **12** (4), 423-7 (abstract only).

Cheng, J.C., Chan, Y.L., Hui, P.W., Shen, W.Y., Metreweli, C. (1994). Ultrasonographic hip morphometry in infants, *J Pediatr Orthop.*, **14** (1), 24-8 (abstract only).

Clegg, J., Bache, C.E., Raut, V.V.(1999). Financial justification for ultrasound screening of the neonatal hip, *Journal of Bone and Joint Surgery Br.*, **81** (5), 852-7.

Cunningham, K.T., Moulton, A., Beningfield, S.A., Maddock, C.R. (1984). A clicking hip in a newborn baby should never be ignored, *The Lancet,* **24**, (8378), 668-70 (abstract only).

Dahlstrom, H., Oberg, L., Friberg, S. (1986). Sonography in congenital dislocation of the hip, *Acta Orthop Scand.*, **57** (5), 402-6 (abstract only).

Dahlstrom, H., Friberg, S., Oberg, L. (1990). Stabilisation and development of the hip after closed reduction of late CDH, *J Bone Joint Surg Br.*, **72** (2), 186-9 (abstract only).

De Pellegrin, M. (1991). Ultrasound screening for congenital dislocation of the hip. Results and correlations between clinical and ultrasound findings, *Ital J Orthop Traumatol.*, **17** (4), 547-53 (abstract only).

Dezateux, C., Elbourne, D., Arthur, R., Clarke, N.M.P., Gray, A., King, A., Quinn, A., Gardner, F., Russell, G. (2002). Ultrasonography in the diagnosis and management of developmental hip dysplasia (UK Hip Trial): clinical and economic results of a multicentre randomised controlled trial, *The Lancet*, **360** (9350), 2009-2017.

Dias, J.J., Thomas, I.H., Lamont, A.C., Mody, B.S., Thompson, J.R. (1993). The reliability of ultrasonographic assessment of neonatal hips, *J Bone Joint Surg Br.*, **75** (3): 479-82 (abstract only).

Donaldson, J.S. & Feinstein, K.A. (1997). Imaging of Developmental Dysplasia of the Hip, *Pediatric Clinics of North America*, **44** (3), 591-614.

Duppe, H. & Danielsson, L.G. (2002). Screening of neonatal instability and of development dislocation of the hip: A survey of 132 601 living newborn infants between 1956 and 1999, *Journal of Bone and Joint Surgery Br*, **84**(6), 878-884.

Duffy, C., Taylor, FN., Coleman, L., Graham, H. (2002). Magnetic resonance imaging in evaluation of surgical management in developmental dysplasia of the hip in childhhod, *Journal of Pediatric Orthopaedics*, **22**(1), 92-100.

Eastwood DM. (2003). Neonatal hip screening, *The Lancet*, **361** (9357), 595-598.

Eidelman, M., Chezar, A., Bialik, V. (2002). Developmental dysplasia of the hip incidence in Ethiopian Jews revisited: 7-year prospective study, *J Pediatr Orthop Br.*, **11**(4), 290-2.

Engesaeter, L.B., Wilson, D.J., Nag, D., Benson, M.K.D. (1990). Ultrasound and congenital dislocation of the hip. The important of dynamic assessment, *Journal of Bone Joint Surgery Br*, **72-B** (2), 197-201.

Exner, G.U. (1988) Ultrasound screening for hip dysplasia in neonates, *J Pediatr Orthop.*, **8** (6), 656-60 (abstract only).

Falliner, A., Hahne, H.J., Hassenpflug, J. (1999). Sonographic hip screening and early management of developmental dysplasia of the hip, *J Pediatr Orthop Br.*, **8** (2), 112-7 (abstract only).

Gomes, H., Ouedraogo, T., Avisse, C., Lallemand, A., Bakhache, P. (1998). Neonatal hip: from anatomy to cost-effective sonography, *Eur Radiol.*, **8** (6), 1030-9 (abstract only).

Hansson, G., Nachemson, A, Palmen., K. (1983). Screening of children with congenital dislocation of the hip joint on the maternity wards in Sweden, *J Pediatr Orthop.*, **3** (3), 271-9 (abstract only).

Harcke, H.T & Grissom, L.E. (1990). Performing Dynamic Sonography of the infant hip, *American Journal of Roentgenology*, **155**, 837-844.

Hennrikus, W.L. (1999). Developmental dysplasia of the hip: Diagnosis and treatment in children younger than 6 months, *Pediatric Annals*,. **28** (2), 740- 745.

Hernandez R.J., Cornell, R.G., Hensinger, R.N. (1994). Ultrasound diagnosis of neonatal congenital dislocation of the hip. A decision analysis assessment, *J Bone Joint Surg Br.* **76** (4), 539-43 (abstract only).

Hinderaker, T., Daltveit, A.K., Irgens, L.M., Uden, A., Reikeras, O. (1994). The impact of intra-uterine factors on neonatal hip instability. An analysis of 1,059,479 children in Norway, *Acta Orthop Scand.*, **65**(3), 239-42.

Holen, K.J., Tegnander, A., Eik-Nes, S.H., Terjesen, T. (1999). The use of ultrasound in determining the initiation of treatment in instability of the hip in neonates, *Journal of Bone and Joint Surgery Br.*, **81** (5), 846-852.

Holen, K.J., Tegnander, A., Bredland, T., Johansen, O.J. (2002). Universal or selective screening of the neonatal hip using ultrasound? A prospective randomized trial of 15, 529 newborn infants, *Journal of Bone and Joint Surgery Br*, **84** (6), 886-891.

Homer, C.J., Baltz, R.D., Hickson, G.B., Miles, P.V., Newman, T.B., Shook, J.E., Zurhellen, W.M. (2000). Committee on Quality Improvement and Subcommittee on Developmental Dysplasia of the Hip. Clinical Practice Guideline: Early Detection of Developmental Dysplasia of the Hip, *Pediatrics,* **105** (4), 896- 905.

Jomha, N.M., McIvor, J., Sterling, J. (1995). Ultrasound in Developmetal Hip Dysplasia, *Journal of Pediatric Orthopaedics*, **5** (1),101-104.

Kim, HT., Wenger DR. (1997). The morphology of residual acetabular deficiency in childhood hip dysplasia: three-dimension computed tomographic analysis, *J Pediatric Orthop.,* **17**(5), 637-47.

Lewis, K., Jones, D.A., Powell, N. (1999). Ultrasound and Neonatal Hip Screening: The Five-Year Results of a Prospective Study in High-Risk Babies, *Journal of Pediatric Orthopaedics*, **19** (6), 760-762.

Marks, D.S., Clegg, J., al-Chalabi, A.N. (1994). Routine ultrasound screening for neonatal hip instability. Can it abolish late-presenting congenital dislocation of the hip? *J Bone Joint Surg Br.,* **76** (4), 534-8.

Nimityongskul, P., Hudgens, R.A., Anderson, L.D., Melhem, R.E., Green, A.E., Saleeb, S.F. (1995). Ultrasonography in management of developmental dysplasia of the hip, *Journal of Pediatric Orthopaedics*, **15** (6), 741-746.

Palmen, K. (1984). Prevention of congenital dislocation of the hip. The Swedish experience of neonatal treatment of hip joint instability, *Acta Orthop Scand* **208**, 1-107 (abstract only).

Paton, R.W., Jan, S., Srinivasan. (2002). Unilateral limitation of abduction of the hip: A valuable clinical sign for DDH? *Journal of Bone and Joint Surgery Br*, **84** (1),104-108.

Paton, R.W., Hossain, S., Eccles, K. (2002). Eight-year prospective targeted ultrasound screening program for instability and at-risk hip joints in developmental dysplasia of the hip, Journal of *Paediatric Orthopaedics*, **22** (3), 338-341.

Reikeras, O., Kristiansen, L.P., Gunderson, R. (2002). Ultrasonography of the hip: The significance of provokable instability with normal morphology, *Orthopedics*, **25**(8), 833-836.

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** (3), 185-8 (abstract only).

Rosenberg, N., Bialik, V. (2002) The effectiveness of combined clinical-sonographic screening in the treatment of neonatal hip instability, *European Journal of Ultrasound,* **15** (1-2), 55-60 (abstract only).

Rosendahl, K., Aslaken, A., Markestad, T., Lie, R.T. (1994). Reliability of ultrasound in the early diagnosis of developmental dysplasia of the hip, *Pediatric Radiology*, **25**, 219-225.

Rosendahl, K., Markestad, T., Lie, R.T. (1996). Developmental dysplasia of the hip. A population-base comparison of ultrasound and clinical findings, *Acta Paediatric*, **85**, 64- 69.

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.*, **258**, 18-26 (abstract only).

Smith, BG., Millis MB., Hey LA., Jaramillo D., Kasser JR. (1997). Postreduction computed tomography in developmental dislocation of the hip: part 11: predictive value for outcome, *J Pediatric Orthop.*, **17**(5), 631-636 (abstract only).

Stoffelen, D., Urlus, M., Molenaers, G., Fabry, G. (1995). Ultrasound, radiographs, and clinical symptoms in developmental dislocation of the hip: a study of 170 patients. J *Pediatr Orthop Br.*, **4** (2), 194-9 (abstract only).

Tennant S., Kinmont C., Lamb G., Gedroyc W., Hunt DM. (1999). The use of dynamic interventional MRI in developmental dysplasia of the hip, *J Bone Joint Surgery Br.*, **81**(3), 392-7 (abstract only).

Teo, H.J. (2002). Clinics in Diagnostic Imaging, *Singapore Medical Journal*, **43** (1), 49-52.

Tonnis, D., Storch, K., Ulbrich, H. (1990). Results of newborn screening for CDH with and without sonography and correlation of risk factors. *J Pediatr Orthopaedics*, **10** (2), 145-52 (abstract only).

Unit Rekod Perubatan, Hospital Universiti Sains Malaysia (HUSM), 2001.

Van Holsbeeck, M.T. & Introcaso, J.H. (2001). Musculoskeletal Ultrasound. Second Edition, Missouri: Mosby, p277-292.

Vedantam, R. & Bell, M.J. (1995). Dynamic Ultrasound Assessment for monitoring of treatment of Congenital Dislocation of the Hip. *J Pediatr Orthopaedics*, **15** (6), 725-728.

Wientroub, S. & Grill, F. (2000). Current Concepts Review. Ultrasonography in Developmental Dysplasia of the Hip. *The Journal of Bone and Joint Surgery*, **82-** A(7), 1004-1018.

Zieger, M. & Hilpert, S. (1987). Ultrasonography of the infant hip. Part IV: Normal development in the newborn and preterm neonate. *Pediatr Radiol.*, 17(6), 470-3 (abstract only).

....

....

....

....

....

....

....

....

(b) Faedah-Faedah Lain Seperti Perkembangan Produk, Prospek Komersialisasi Dan Pendaftaran Paten.

(Jika ada dan jika perlu, sila guna kertas berasingan)

Tiada

(c) Latihan Gunatenaga Manusia

i) Pelajar Siswazah: Dr Rofiah Ali

ii) Pelajar Prasiswazah: ...Tiada

iii) Lain-Lain : Tiada

6. Peralatan Yang Telah Dibeli:

....................Tiada....................

UNTUK KEGUNAAN JAWATANKUASA PENYELIDIKAN UNIVERSITI

Laporan menepati kegiatan penyelidikan

T/TANGAN PENGERUSI
J/K PENYELIDIKAN
PUSAT PENGAJIAN

PROFESSOR ABDUL AZIZ BABA
Chairman of Research & Ethics Committee
School of Medical Sciences
Health Campus
Universiti Sains Malaysia
16150 Kubang Kerian, Kelantan.

20/11/08

MANUSKRIP

THE ROLE OF ULTRASOUND IN SCREENING NEWBORNS FOR DEVELOPMENTAL DYSPLASIA OF THE HIP IN HOSPITAL UNIVERSITI SAINS MALAYSIA, KELANTAN

CONTENTS

LIST OF FIGURES AND TABLES

Figures

Tables

No. of Tables **Page**

LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviations

CDH	Congenital dislocation of the hip
CI	Confidence interval
CT	Computed tomography
DDH	Developmental dysplasia of the hip
DF	Degree of freedom
HUSM	Hospital Universiti Sains Malaysia
ICC	Intraclass correlation
LSCS	Lower segment Caeserian section
LT	Left
MHz	Megahertz
MRI	Magnetic resonance imaging
RT	Right
SD	Standard deviation
SVD	spontaneous vaginal delivery
US	Ultrasound

Symbols

σ	Standard deviation
Δ	Precision
n	Sample size
p	p value
$<$	Less than
$=$	Equal

ABSTRACT

ABSTRACT

English

Topic: Alpha and beta angles of the hip joints in normal newborns.

Objective: To determine the alpha and beta angles in normal newborns and to define the changes of the angles following stress maneuver.

Methodology: Coronal examinations at rest and stress were done using high frequency linear probe (5-7.5 MHz) ultrasound on 49 patients.

Results: The means of the alpha angles means of the right and left hips without stress were 62.0 degrees (SD +/- 6.4 degrees) and 62.0 degrees (SD +/- 5.6 degrees) respectively and with stress were 63.3 degrees (SD +/- 7.2 degrees) and 59.8 degrees (SD +/- 8.0 degrees). The means of the beta angles of the right and left hips without stress were 56.8 degrees (SD +/- 7.4 degrees) and 56.2 degrees (SD +/- 7.0 degrees) respectively and with stress were 54.9 degrees (SD +/- 7.1 degrees) and 58.2 degrees (SD +/- 8.7 degrees).

Conclusion: The normal alpha and beta angles of the hip joints were comparable with Western values. There was significant difference in the alpha and beta angle without and with stress.

ABSTRAK

Bahasa Melayu

Tajuk: Sudut-sudut alfa dan beta sendi pinggul di kalangan bayi baru lahir normal.

Objektif: Untuk menentukan sudut-sudut alfa dan beta sendi pinggul di kalangan bayi baru lahir normal.

Metodologi: Pemeriksaan ultrasound dalam pandangan koronal semasa rehat dan semasa tekanan diberikan menggunakan transduser linear berfrekuensi tinggi (5-7.5 MHz) dilakukan kepada 49 subjek.

Keputusan: Purata sudut-sudut alfa bagi sendi pinggul kanan dan kiri tanpa tekanan adalah masing-masing 62.0 darjah (SD +/- 6.4 darjah) dan 62.0 darjah (SD +/- 5.6 darjah), manakala dengan tekanan adalah masing-masing 63.3 darjah (SD +/- 7.2 darjah) and 59.8 darjah (SD +/- 8.0 darjah). Purata sudut-sudut beta kanan dan kiri tanpa tekanan adalah masing-masing 56.8 darjah (SD 7.4 +/- darjah) dan 56.2 darjah (SD +/- 7.0) darjah, manakala dengan tekanan adalah masing-masing 63.3 darjah (SD +/- 7.2) dan 59.8 darjah (SD +/- 8.0 darjah).

Kesimpulan: Nilai normal sudut-sudut alfa dan beta adalah sebanding dengan nilai pada populasi kanak-kanak barat. Terdapat perbezaan nyata nilai alfa dan beta sebelum dan selepas tekanan diberikan.

CHAPTER ONE:

INTRODUCTION

1.0 INTRODUCTION

Developmental dysplasia of the hip (DDH) is a term to describe the condition where the femoral head has an abnormal relationship with the acetabulum (Homer *et al.*, 2000). The condition was previously termed congenital dislocation of the hip (CDH). DDH is presently the preferred term since the acetabulum continues to develop postnatally. Furthermore, not all dysplasia present at birth. It is a dynamic condition that can occur prenatally and postnatally. The acronym DDH includes hips that are unstable, subluxated, dislocated (luxated) and/or have malformed acetabula (Homer *et al.*, 2000). DDH is an evolving process, and the physical findings change on clinical examination.

The clinical tests of Barlow and Ortolani are conventionally used as screening examination to detect DDH in the neonate. The tests cannot be used when the baby is 8-12 weeks of life due to decreased capsule laxity and increased muscles tightness. Despite early optimism of the tests, specificity and sensitivity have come under scrutiny. There is a continuing incidence of late diagnosis despite rigorous clinical screening (Homer *et al.*, 2000).

The use of ultrasound (US) to examine the neonatal hip was introduced by Graf in 1980 (static technique). Graf, proposed the bony roof angle, alpha and cartilage roof angle, beta as parameters for assessing acetabular development (Nimityongskul *et al.*, 1995). The measurements are based on a coronal image. Classification of hip dysplasia is based on morphology aspects and angle measurements (alpha and beta angles) which can be divided into 4 major types. The classification then has been subdivided (Engesaetar *et al.*, 1990).

A reference for normal values, that is, the mean and range of the alpha angle has been established. The lower limit of normal for the alpha angle is 60 degrees (Weinthroub *et al.,* 2000). A hip is considered definitely abnormal when the alpha angle is <50 degrees and treatment is strongly recommended. A beta angle of more than 77 degrees indicates eversion of the labrum and subluxation of the hip (Weinthroub *et al.,* 2000).

Later on dynamic study of this technique was developed by Harcke in 1990. In 1993, Harcke, Graf and Clarke merged their methods and proposed a Dynamic Standard Minimum Examination (DSME), which combined morphological and stability criteria. The use of ultrasound for screening of all newborns can lead to over diagnosis. Moreover, the exercise is expensive. Studies have shown that ultrasound is recommended for initial examination of infants with abnormal clinical signs or at risk for DDH. Ultrasound is preferably used as adjunct to clinical evaluation. The earlier DDH is detected; the treatment is simpler, more effective and less costly.

Only few studies published discussed the means for alpha and beta. No local study was previously done to determine the local data for the angles.

The aims of this study are to determine the alpha and beta angles of the normal hips among babies born in Hospital Universiti Sains Malaysia (HUSM) and to define the changes of alpha and beta angles following stress maneuvers. This study hopefully will initiate the usage of ultrasound as an adjunct in diagnosis and management of the babies with abnormal finding and those with risk factors to develop DDH in HUSM.

CHAPTER TWO:

LITERATURE REVIEW

2.0 LITERATURE REVIEW

2.1 Terminology

DDH was formerly called `congenital dislocation of the hip` (CDH) as it used to be thought that infants were born with this problem. Though true in some instances, most infants developed hip dysplasia after birth (Teo, 2002). Therefore the preferred description is now developmental dysplasia of the hip (DDH), reflecting that not all dysplasias present at birth (Donaldson *et al.*, 1997). In recent years various medical organisations have suggested this change in nomenclature to more accurately describe the pathogenesis of hip dysplasia. This change in terminology helped to eliminate the blame placed on pediatricians/neonatologists who performed the initial neonatal hip examination of a child and later found to have DDH (Donaldson *et al.*, 1997). DDH indicates a dynamic condition, occurring prenatally or postnatally and potentially capable of getting better or worse. DDH is the term used to describe an abnormal relationship between the femoral head and the acetabulum. The term is used to describe dislocation, subluxation and instability when it is possible to dislocate and locate the femoral head into the acetabulum, and a whole array of abnormalities that expressed inadequate acetabular development (Wientroub *et al.*, 2000).

2.2 Embryology and etiology

Understanding the development nature of the DDH and subsequent spectrum of hip abnormalities requires knowledge of the growth and development of the hip joint (Arronson *et al.,* 1994). Embryologically, the femoral head and acetabulum developed from the same block of primitive mesenchymal cells. A cleft developed to separate them at 7-8 weeks` gestational period. By 11 weeks` of gestation, the hip development was complete (Homer *et al.,* 2000). The shape of acetabulum varied during gestational development and affected by genetic and hereditary factors (Donaldson *et al.*, 1997). The femoral head grew disproportionately faster than the surrounding cartilage, so at birth the femoral head was less than 50% covered. Therefore, during late gestation and the first few months after birth, the femoral head has the least structural support from the acetabulum. The hip was at highest risk to subluxate or dislocate during this period (Donaldson *et al.,* 1997). Within a few weeks after birth, the acetabular cartilage developed more rapidly than the femoral head, resulting in progressive increased coverage. At birth, the femoral head and the acetabulum were primarily cartilaginous rim (the labrum) that surrounded the bony acetabulum and caused the socket to deepen. Development of the femoral head and acetabulum were intimately related, and normal adult hip joints depended on further growth of these structures. Hip dysplasia may occur in utero, perinatally, during infancy or childhood (Homer *et al.,* 2000). There were four periods the hip was most at risk of dislocation:

1) The 12th gestational week

2) The 18th gestational week

3) The final 4 weeks of gestation, and

4) The postnatal period.

During the 12th gestational week, the hip was at risk as the fetal lower limb rotates medially. All elements of the hip joint will develop abnormally. The hip muscles development begins around the 18th gestational week. Neuromuscular problems at this time, such as myelodysplasia and arthrogryposis, will lead to teratologic dislocations. During the final 4 weeks of pregnancy, mechanical forces have a role. Conditions such as oligohydramnios or breech position predispose to DDH (Hinderaker *et al.,* 1994). Postnatally, infant positioning such as swaddling, combined with laxity of the ligament, also has a role (Homer *et al.*, 2000). Ligament laxity was related to hormonal as well as genetic factors. It caused abnormal motion between the femoral head and the acetabulum, causing deterioration of both the cartilaginous and osseous structures. The abnormal motion prevented normal ossification of the acetabulum and contributed to dysplasia (Donaldson *et al.,* 1997). DDH was more likely to occur in infants who have a sibling or parent with DDH (van Holsbeeck *et al.,* 2001).

Causative factors behind congenital hip dislocation have been disputed in the past. The pathophysiology remained very debatable and several concepts were propounded. For a better pathophysiologic understanding, Gomes *et al.* (1998) had carried out a study of the morphology and development of 22 prenatal and neonatal hips. At first, the acetabulum was cartilaginous and distorted by the moving femoral head; this acetabulum was histologically affected by the femoral pressure. The pathologic hip was characterized by defective posterior bony coverage of the femoral head by the acetabulum. The acetabulum was ossified during the 3 months following birth, forming a cup-like cavity under the pressure of the femoral head (Gomes *et al.,* 1998). It remains unclear whether the pathogenesis was primarily caused by dysplasia or whether dysplasia was secondary to abnormal joint laxity (Reikeras *et al.,* 2002).

The etiology of DDH was complex and multifactorial, with factors affecting both acetabular morphology and hip stability. If a shallow cartilaginous acetabulum provided poor structural support to the femoral head, the head was allowed to move, and stretching of the ligamentous support was lax, excess motion will cause deterioration of the acetabulum and progress to dysplasia. These two mechanisms were closely related (Donaldson *et al.,* 1997). The factors involved in the etiology of DDH included the small intrauterine space of the primipara, breech presentation, oligohydramnios, congenital dislocation of the knee, congenital muscular torticollis, and metatarsus adductus (Henrikus *et al.,* 1999). Breech position occurred in about 3% of births, and DDH occurred more frequently in breech presentations, reported as many as 23%. The frank breech position of hip flexion and knee extension placed a newborn or infant at the highest risk.

Postnatally, infant positioning such as swaddling, combined with ligamentus laxity also has a role (Donaldson *et al.,* 1997 and Homer *et. al.,* 2000). In addition, in Native Americans, the postnatal practice of strapping a child's hip in extension contributed to DDH. Physiologic factors included ligament laxity in female infants. This laxity stemmed from the influence of the maternal hormones estrogen and relaxin and explained why DDH was six times commonner in females. A genetic influence on DDH was supported by studies of family history, siblings, and twins (Hennrikus *et al.,* 1999). Wynne-Davies reported an increased risk with positive family history that was 6% for healthy parents and an affected child, 12% with affected parents, and 36% with an affected parent and one affected child. Apart from that, children with neonatal hip instability and a family history of DDH seemed to represent a subgroup with an increased failure risk of primary treatment and may need prolonged abduction treatment (Hansson *et al.*, 1983).

2.3 Incidence and prevalence

The prevalence of DDH ranged from 1 in 10 to 1 in 100. The inclusion and exclusion of neonates with hip clicks or laxed hips that spontaneously become stable in the first week of life is the main reason for this wide variation of reported prevalence (Nimityongskul *et al.*, 1995). The true incidence of DDH can only be presumed. There is no `gold standard` for diagnosis during the newborn period. Physical examination, plain radiography, and US all are fraught with false-positive and false-negative results. Arthrography and magnetic resonance imaging, although accurate for determining the precise hip anatomy, are inappropriate methods for screening the newborn and infant (Homer *et al.*, 2000). The reported incidence of DDH ranges considerably (Reikeras *et al.*, 2002) and was very much influenced by genetic and racial factors, diagnostic criteria, the experience and training of the examiner, and the age of the child at the time of examination (Homer *et al.*, 2000).

Palmen in 1961 reported that 20 in 1000 newborns had unstable hips when stressed (Donaldson *et al.*, 1997). Barlow in 1962, found that 58% of neonatal instability spontaneously resolved by 7 days and 80% by 2 months (Donaldson *et al.*, 1997). Although the numbers vary, the prevalence of dislocation is approximately 1.3 in 1000, and that of dislocatable hips requiring treatment is about 1.2 in 1000 newborns in North America and Western Europe. Barlow and Dunn reported about 2% of newborns are found to have some degree of hip instability, but only 0.2% will probably progress to dislocation if left untreated. Majority of these were detectable by the Ortolani and Barlow clinical examinations (Donaldson *et al.,* 1997). Some newborn screening surveys suggested an incidence as high as 1 in 100 newborns with evidence of instability (Homer *et al.,* 2000). The incidence was higher in girls due to reason mentioned above. The left hip was involved 3 times as commonly as the right hip, perhaps related to the left occiput anterior positioning of most non-breech newborns. In this position, the left hip resided posteriorly against the mother's spine, potentially limiting abduction (Homer *et al.,* 2000). Bialik (1999) reported sonographic DDH incidence of 55.1 per 1000. However, follow-up of those cases had given the true incidence of 5 per 1000 hips. It was suggested their approach for better founded the definition of DDH and for an appropriate determination of its incidence.

Early detection of hip dysplasia has been a topic of interest since the mid-1900s. Roser (Donaldson et al, 1997) first described that `` flail`` hips could be dislocated by adduction of the leg and then reduced again by abduction. Ortolani, however, deserved the credit for his 1939 description of the abduction ``scatto`` or snapping of dislocated hip. Through his educational efforts, this test bore his name and now part of the widespread clinical screening for DDH. Barlow, Palmen and others contributed significantly to implementation of clinical screening in newborns (Donaldson et al, 1997). Screening guidelines for CDH (not DDH) were introduced 30 years ago and updated in 1983 (Eastwood, 2003). The rationale was that early detection of these cases would allow prompt management. Prompt treatment of DDH was vital for optimum results, and reduced the need for surgical intervention. Therefore, neonatal screening programs using physical examination were highly recommended. This program has been widely practiced in an effort to reduce the morbidity of DDH. However, diagnosis remained difficult: neither clinical examination nor plain radiographs of the pelvis were reliable indicators of DDH (Zieger *et al.*, 1986, 1987).

2.4 Diagnosis

DDH is an evolving process, and its physical findings on clinical examination change (De Pellegrin *et al.*, 1991 Arronson *et al.*, 1994, and Stoffelen *et al.*, 1995). The newborn must be relaxed, warm, and comfortable, with diaper removed and preferably examined on a firm surfaced. A crying child will contract hip and leg muscles, which may disguise hip instability (Hennrikus *et al.*, 1999). Patience and skills are required. There were no pathognomonic signs for a dislocated hip. The examiner must look for asymmetry. Indeed, bilateral dislocations are more difficult to diagnose than unilateral dislocation as symmetry is retained. Asymmetry of thigh or gluteal folds is better observed when the child is prone. Apparent limb length discrepancy, restricted motion especially abduction are significant, but not pathognomonic signs. With the infant supine and the pelvis stabilized, abduction to 75 degrees and adduction to 30 degrees should occur readily under normal circumstances (Homer *et al.*, 2000). Other features that will arouse suspicion include asymmetry of the thigh folds, a positive Allis or Galeazzi sign (relative shortness of the femur with the hips and knees flexed), and leg length discrepancy.

From birth to approximately 2 months of age, the Barlow test and Ortolani sign (Hennrikus, 1999) are helpful in diagnosing hip instability. These tests were first described by Le Damany in 1908 (Clegg *et al.,* 1999). Both tests are no longer positive by 8 to 12 weeks of life due to decreased capsule laxity and increase muscles tightness. The maneuvers are performed one hip at a time. The Barlow (dislocation) test is provocative, and attempts to dislocate unstable hip. Both of the patient's hips are flexed to 90 degree and abducted. While one hip is kept in the abducted position to stabilize the pelvis, the other hip is gently adducted and pushed posteriorly. The unstable hip will be felt to dislocated or `clunk` (not `click`) as the hip moves out of the acetabulum. A positive result on the Barlow test identifies a dislocated hip (Hennrikus, 1999).

The significance of clicks has been a subject of controversy. Some authors believe that hip clicks are benign and have no pathological significance (Nimityongskul *et al.,* 1995). Other authors, however, reported that clicking hip in a newborn baby is not always benign and should not be ignored (Nimityongskul *et al.,* 1995). In Clinical Practice Guidelines by American Academy of Pediatrics, the decision that positive examination for Barlow and Ortolani will produce `clunk` sound of dislocation or reduction (Homer *et al.,* 2000). `Click` findings are related to soft tissue clicking from the ligamentum teres, iliopsoas tendon, labrum, or tensor fascia (Hennrikus, 1999).

The Ortolani (relocation) maneuver attempts to relocate a dislocated a hip that rests posterior to the acetabulum. Again, one hip is held at 90 degree of flexion and in abduction to stabilize the pelvis. The hip to be examined is flexed to 90 degree and the examiner`s long finger is placed posteriorly on the greater trochanter while moving the hip into abduction. If a palpable `clunk` (not `click`) is felt, the result of the Ortolani maneuver is positive and the dislocated hip has been returned to the acetabulum (Hennrikus, 1999).

Both Ortolani and Barlow tests are legal requirement in every UK newborn baby (Eastwood, 2003). The specificity is high, essentially 100%, but the sensitivity is low with false-positive results leading to over-treatment and false negative results associated with a high late presentation rate. Sensitivity is improved significantly with the use of experience examiners (paediatricians, orthopaedic surgeons or physiotherapists) but it is not a legal requirement that the tests are performed by such people; nor in these days of clinical governance is necessary that the examiner has been trained to do them (Eastwood, 2003).

Radiographs of the pelvis and hips have historically been used to assess an infant with suspected DDH. During the first few months of life when the femoral heads are composed entirely of cartilage, radiographs have a limited value. Displacement and instability may be undetectable, and evaluation of acetabular development is influenced by the infant's position at the time the radiograph is performed. Lefaure et al described that radiographic screening approach in France failed to improve early detection of DDH (Donaldson *et al.,* 1997). By 4-6 months of age, radiographs become more reliable, particularly when the ossification centre developed in the femoral head. Radiographs are readily available and relatively low in cost (Homer *et al.,* 2000). In setting where reliable ultrasound is not available, a radiograph after 3 months of age is indicated if DDH is suspected (Donaldson *et al.,* 1997). Various lines (Hilgenreiner, Shenton, Perkin) have been used to help assess the position of the femoral head and degree of dysplasia in infants. These lines are of limited help because they represent indirect ways of assessing the hip. Generally the AP and frog-leg are adequate for evaluating this progressive type of hip dysplasia (Donaldson *et al.,* 1997).

Computed tomography (CT) scan is used sometimes for children with DDH under special circumstances. If a child is placed in a spica cast, the ultrasound window is too small to adequately image the hips and much less to document reduction. Ten measurements were made on CT-scans including acetabular indices and anteversion, hip abduction angle, lateral and posterior displacement of the femur from the acetabulum, and femoral displacement from a modified Shenton's line drawn from the pubic rami (Smith *et al.,* 1997). CT is performed in children with severely dysplastic hips as a preoperative study to help the orthopedic surgeon plan for the proper corrective procedures. The 3DCT method used produced a `topographic-map' that replicates the contact relation between the acetabulum and the femoral head. Analyzing the femoral head-acetabular contact relation and the type of acetabular deficiency allows the surgeon to plan better surgical correction of the hip dysplasia in children.

Magnetic resonance imaging (MRI) is reserved for severely dysplastic hips, often if therapy has been unsuccessful in restoring concentric reduction. Generally T1 and gradient-echo sequences are all that is necessary to image both cartilaginous and osseous structures of the hip joint. Multiplanar capability is not possible with CT. MRI is helpful in assessing obstructions to reduction. The intracapsular obstructions consist of inverted limbus, interposition in the acetabulum, including thickened ligamentum teres and large pulvinar tissue, deformities of the femoral head, and contracted transverse ligaments. Extracapsular obstacles include formation of an isthmus by the iliopsoas muscle, thight iliopsoas tendon, shortening of the short external rotators and adhesion of the capsule to the ilium(Donaldson *et al.*, 1997, Kiyoshi et al., 1999). MRI also can be utilised in assessment of the adequacy of reduction of dislocated hip. It has the advantage of showing the immature femoral head so that its center can be adequately determined regardless of the presence of the ossific nucleus. The immature cartilaginous anlage of the acetabulum is also clearly visualised on MRI, allowing assessment of the morphology of the whole hip (Duffy et al., 2002). For assessment of stability, MRI also allows dynamic imaging while giving stress to the hips (Tennant *et al.,* 1999).

2.5 Ultrasound diagnosis

The use of ultrasound to examine neonatal hip was first report in 1980. Since then, there have been many publications on this subject. The most extensive study was done by Graf, who proposed the bony roof angle, alpha and cartilage roof angle, beta as parameters for assessing acetabular development (Nimityongskul *et al.,* 1995). The evaluation was based on a coronal image (equivalent to anteroposterior[AP] radiograph of the hip) obtained through a lateral approach when the infant is in lateral decubitus position (**Figure 2.1 and 2.2**) and the hip in 35 degrees of flexion and 10 degrees of internal rotation (Weintroub *et al.,* 2002). Stressing morphological characteristics, his method emphasized measurements of angle to quantitate femoral head coverage on the basis of acetabular landmarks, in addition to the position of hip position (**Table 2.1**). Graf, an orthopedic surgeon, implemented widespread US screening performed in conjunction with clinical screening in Austria. Eighteen years later, he claimed that they no longer see late diagnosis of DDH in the Steirmach region of Austria (Donaldson *et al.*, 1997).

Critics of Graf's morphological technique reported limitations with regards to its accuracy as well as inter-observer and intra-observer variations that influenced the analysis (Cheng *et al.,* 1994, Dias *et al.*, 1993 and Engesaeter *et al.*, 1990). Advocates of Graf's method believed that, when performed properly, the variability in measurement is not an important factor and standardization is easier to establish (Nimityongskul *et al.*, 1995, Weinthroub *et al.*, 2000).

Real-time linear array transducers are preferred for the assessment of the hips in newborns and infants. Highly reproducible images can be generated, allowing seriel static quantitative assessment of hip development and maturation. The use of sector or curved-faced transducers should be limited to qualitative evaluation (Wientroub *et al.*, 2000).

Graf classification (1986) of hip dysplasia based on morphology aspects and angle measurements (alpha and beta angles) can be divided into 4 major types (**Table 2.1**) which have since been subdivided (Engesaetar *et al.*, 1990). Graf proposed a 60 degree alpha as the cut-off point for normal hips. However, a hip is considered definitely abnormal when the alpha angle is <50 degrees and treatment is strongly recommended. An alpha between 50-60 degrees is considered physiologically immature (younger than 3 months of age), and observation is recommended (Nimityongskul *et al.*, 1995). Exner (1988) studied the validity of Graf alpha and beta angles and found inter-observer difference of 5 degree for alpha and 7 degree for beta angles. He also noted that the image can be false positive. The alpha angle is more reliable because the bony roof is distinct and line drawing is more reproducible. However, variations in measurement ranging from 4.0 to 6.5 degrees were reported. The labral measurement (beta angle) had a high degree of variation (van Holsbeeck *et al.,* 2001).

The alpha and beta angles are obtained in a coronal image (**Figure 2.2**) with the construction of three lines which are:1) a vertical line drawn parallel to the ossified lateral wall of the ilium; 2) a line drawn along the roof of the cartilaginous acetabulum, from the lateral osseous edge of the acetabulum to the labrum; 3)a line drawn from the inferior edge of the osseous acetabulum (the inferior iliac margin) at the roof of the triradiate cartilage to the most lateral point on the ilium (the superior osseous rim). The angles are calculated. The alpha angle is formed by the intersection of the line parallel to the lateral wall of the ilium and the line parallel to the osseous acetabulum **(Figure 2.3).**

A reference for normal values, that is, the mean and range of the alpha angle has been established. The lower limit of normal for the alpha angle is 60 degrees. A maturation curve of spontaneous development has been established to characterize the measurement of the natural progression of acetabular growth in the normal hip joint. Since the alpha angle reflects osseous coverage of the femoral head by the acetabulum, the smaller the angle, the greater the degree of dislocation(Weinthroub *et al.,* 2000).

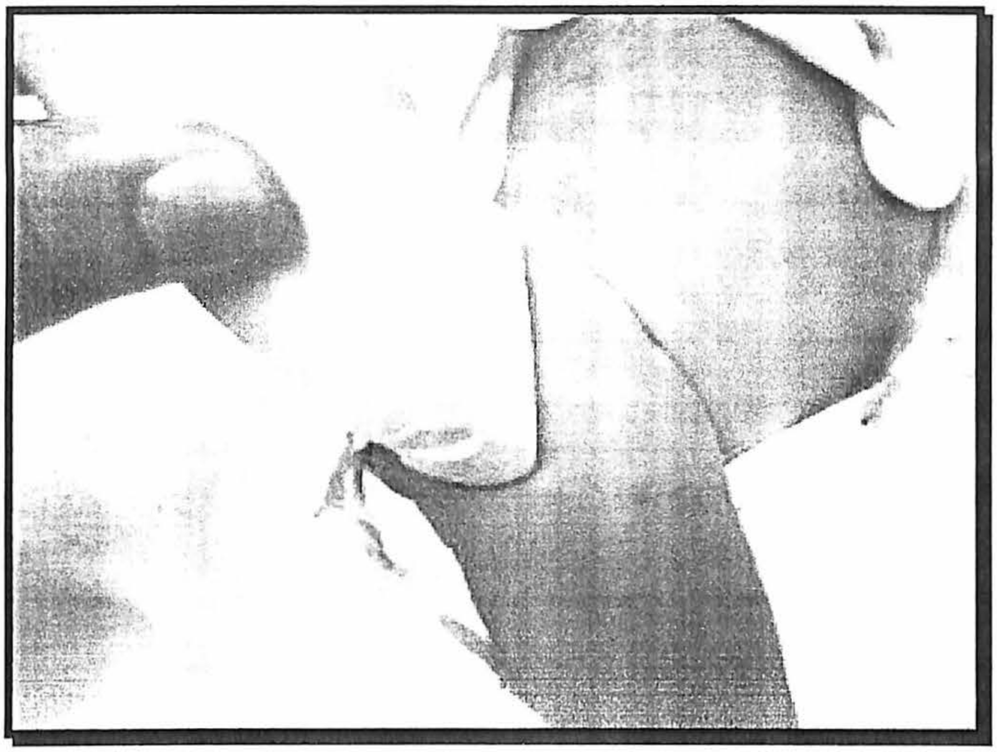
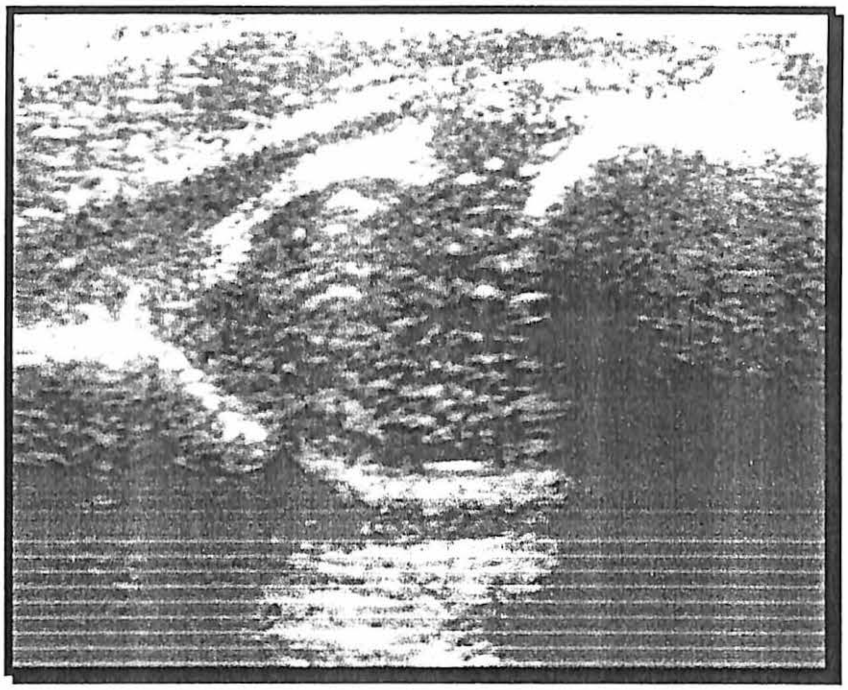


Figure 2.1: Coronal scan of the right hip



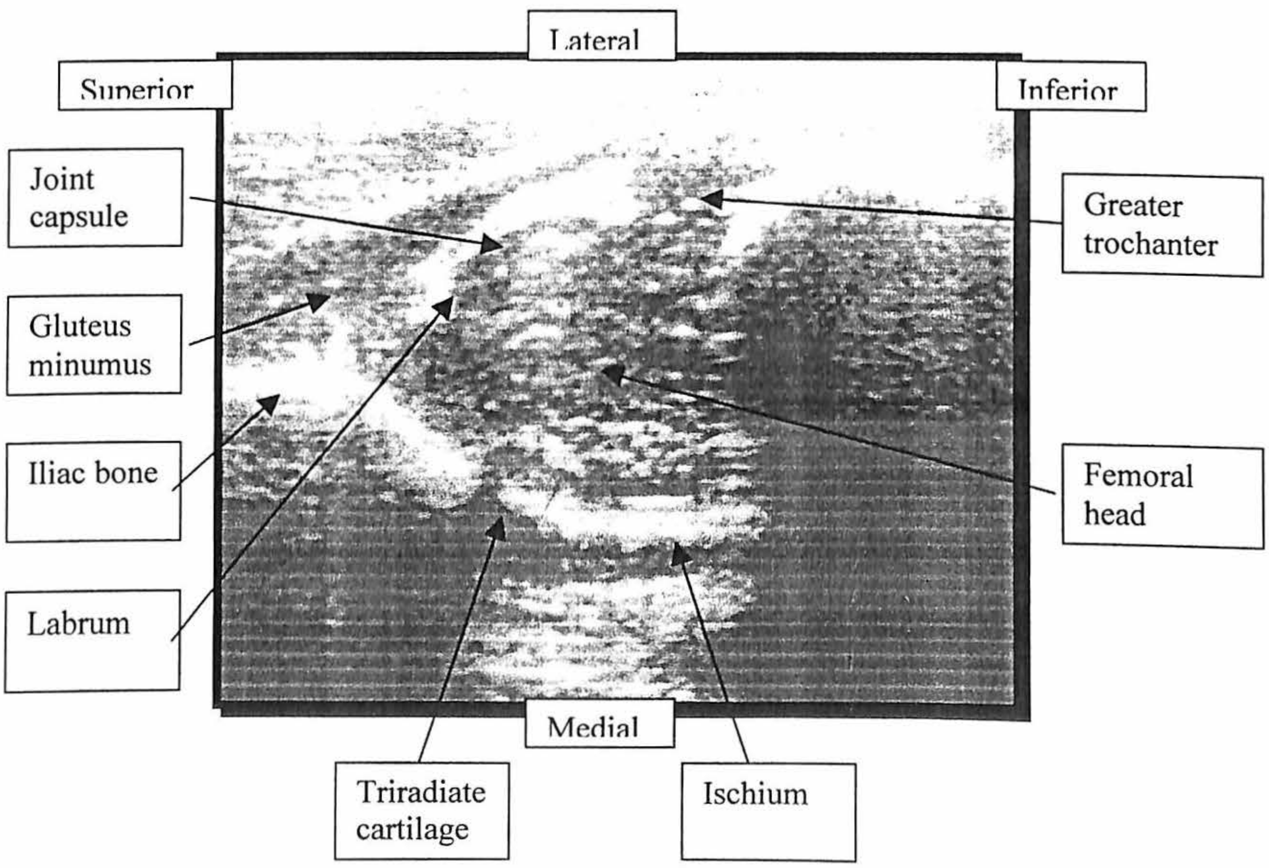


Figure 2.2: Coronal image of the hip without label (above) and with label (below).

Table 2.1: Sonography Hip Types According to Graf (Bialik *et al.*, 1999)

Type	Bony roof	Bony rim	Cartilaginous Roof	Angle alpha (degree)	Angle beta (degree)
I Mature hip joint	Good	Angular/blunt	Narrow, covering	>60	>55
II [<3 months] Physiologically immature IIa + [appropriate for age] IIa - [maturity deficit]	 Sufficient Deficient	 Round Round	 Wide, covering	 50-59	 >55
IIb [>3 months] Delay of ossification	Deficient	Round	Wide, covering	50-59	>55
IIc [any age] critical range	Severely deficient	Round to flat	Wide, but still covering	43-49	<77
D [any age] decentering hip	Severely deficient	Round to flat	Displaced	43-49	>77
III Eccentric [decentered]hip IIIa	 Poor	 Flat	 Displaced cranially, without structural alterations [hypoechoic]	<43	>77
IIIb	Poor	Flat	Displaced cranially, with structural alteration [echogenic]	<43	>77
IV Eccentric[decentered]hip	Poor	Flat	Displaced inferomedially	<43	>77

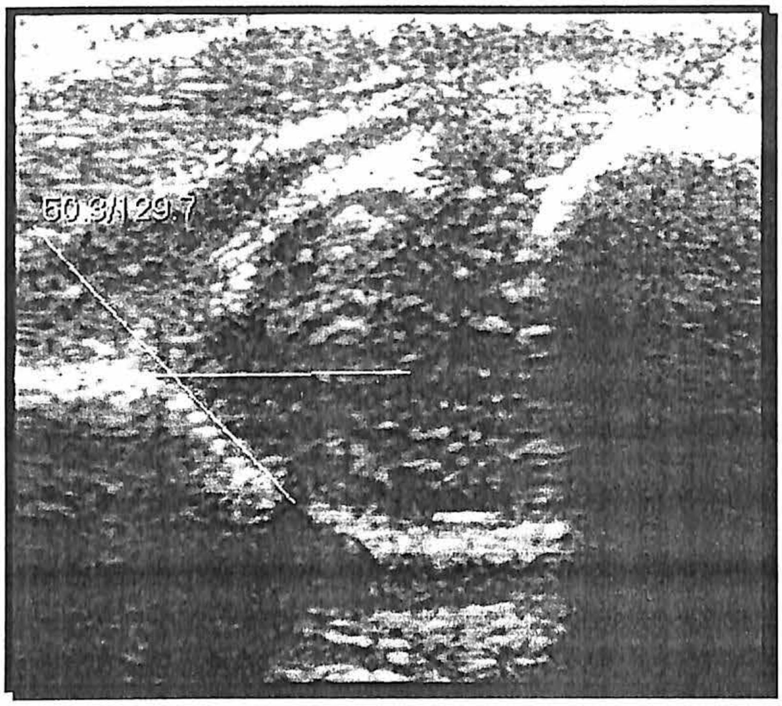


Figure 2.3: Measurement of alpha angle from coronal image

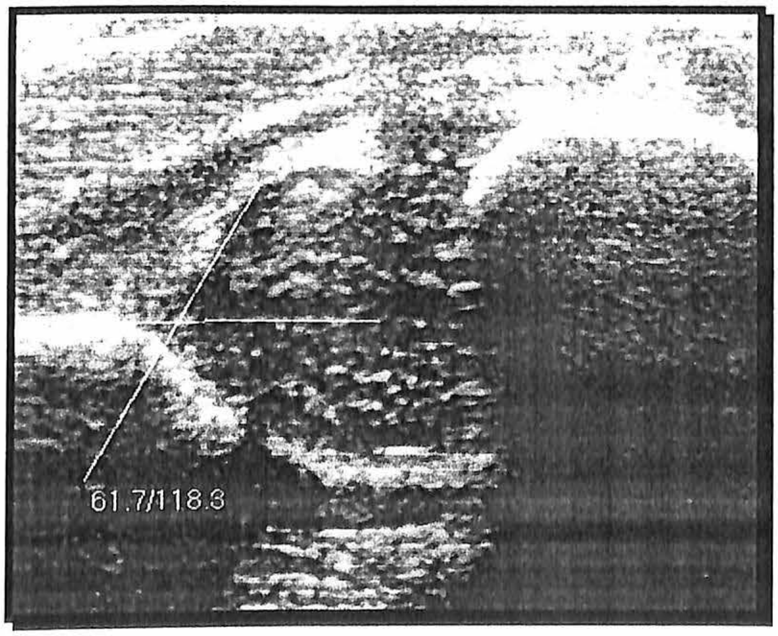


Figure 2.4: Measurement of beta angle from coronal image

The beta angle (**Figure 2.4**) is formed by the intersection of the line parallel to the lateral wall of the ilium and the line parallel to the roof of the cartilaginous acetabulum. A beta angle of more than 77 degrees indicates eversion of the labrum and subluxation of the hip (Weinthroub *et al.,* 2000).

In contrast to the single-view approach of Graf's technique, Harcke *et al.,* (1984, 1990 and1994) developed a technique based on a dynamic multiplanar examination that assess the hip in positions produced by Ortolani and Barlow maneuvers. The dynamic approach can also be used to assess acetabular development; however, it placed the greatest emphasis on the position and stability of the femoral head (Wientroub *et al.,* 2000). The technique is dependent on ligamentous or capsular laxity, and as with the physical examination, the study quality depends on the operator performing the stress test. Using these maneuvers, each hip was classified as stable, borderline unstable (subluxation), dislocatable or dislocated (**Table 2.2**) (Rosendahl *et al.,* 1992). When the femoral head is completely dislocated, fibrofatty tissue with increased echogenic properties fills the space between the head and the acetabulum (Weintroub *et al.,* 2000).

Study by Engesaeter (1990) with a hundred infants showed only dynamic assessment of stability that had a significant relation with the outcome. The study concurred with the findings of Saeis, Foster and Lequensne in 1988. Reikeras (2002) concluded that sonographically, provoked instability in morphologically normal or immature hips has no clinical significance. In this study, infants with normal hips morphologically but with bilateral or unilateral instability, were divided into a group that received treatment with abduction splint and another group was left untreated.

Assessment by repeat ultrasound and measurement of acetabular index by radiographs at 16 weeks revealed normal hip development with no differences between the two groups.

Table 2.2: Classification of hip stability by ultrasound (Rosendahl et al., 1996)

Stability	Comment
1. Stable hip	
2. Borderline unstable hip	A gap can be visualized between the femoral head and acetabulum
3. Dislocatable hip	The femoral head can be dislocated lateral to baseline, followed by a concentric reduction into the acetabulum
4. Dislocated	The femoral head is seen constantly lateral to the baseline

Critics of the dynamic technique maintained that it was more prone to subjectivity on the part of the examiner and that standardization was difficult to establish. Advocates of dynamic ultrasound had pointed out that traditional clinical examinations were based on criteria of stability in addition to morphological characteristics (Weintroub *et al.*, 2000).

In 1993, Harcke, Graf and Clarke merged their methods and proposed a Dynamic Standard Minimum Examination (DSME), which combined morphological and stability criteria. The principle of this examination mandate that the hip be examined both at rest and when stressed. The essential elements of the DSME were assessment in the coronal plane with the hip at rest and assessment in the transverse plane with the hip under stress. With regards to the specifics of these elements, some options were left to the preference of the examiner (Weintroub *et al.*, 2000).

Ultrasound during the first 4 weeks of life often reveals the presence of minor degrees of instability and acetabular immaturity. Studies (Castelein *et al.*, 1992, Homer et al, 2000 and Marks *et al.*, 1994) indicate that nearly all these mild early findings, which will not be apparent on physical examination, resolved spontaneously without treatment. Avisse suggested neonatal screening tests such as sonography must take place in the first weeks of life since the acetabulum ossified during the 3 months following birth (Avisse *et al.*, 1997).

2.6 Neonatal screening sonographically

Barlow and Ortolani tests were conventionally used in screening of DDH. Despite early optimism about the effectiveness of these procedures, their specificity and sensitivity have been questioned (Weintroub *et al.*, 2000). An important issue was whether ultrasound screening of newborns for DDH was justified on the basis of the degree of sensitivity, specificity and cost-effectiveness. Newborn screening with ultrasound has required a high frequency of repeated examination and resulted in a large number of hips being unnecessarily treated. One study (Rosendahl *et al.*, 1994) demonstrated that a screening process with higher false-positive results yielded increased prevention of late cases. Study by Marks showed that routine ultrasound screening has detected cases which would otherwise have presented late (Marks *et al.*, 1994).

In many centers `high-risk` babies were offered ultrasound screening. Selective screening program may appear similar but, again, there is problem with terminology. What constituted risk factors varied from group to group and the relevance of such factors had recently been questioned (Eastwood, 2003). Screening babies with risk factors alone would miss between 30-40% of clinically unstable hips (Eastwood, 2003). The study by Bache (2002) found that majority of babies requiring intervention would not have been identified utilizing present criteria for selective ultrasound screening.

Bialik (1999) recommended that ultrasound examination to be performed for all newborns. Study by Rosenberg (1998) had evidence that combined clinical and ultrasonographic examination significantly improved the detection rate of dysplastic hips in newborns. Some European centres screened all newborns (Wientroub *et al.*, 2000).