

ROLE OF 3D ULTRASONOGRAPHY IN ASSESSMENT OF FETAL SKELETAL ANOMALIES

Essay

*Submitted for Partial Fulfillment of Masters Degree
in Radiodiagnosis*

Presented By

Ibrahim Hamdy Mohamed Hamza

Under Supervision Of

Prof. Dr. Salwa Taha Ismail

*Professor of Radiodiagnosis
Faculty of Medicine - Ain Shams University*

Prof. Dr. Hanan Eissa Ahmed

*Prof of Radiodiagnosis
Faculty of Medicine - Ain Shams University*

**Faculty of Medicine
Ain Shams University
2012**

دور الموجات فوق الصوتية ثلاثية الأبعاد في تشخيص العيوب الخلقية بالهيكل العظمى للجنين

رسالة

توطئة للحصول على درجة الماجستير
في الأشعة التشخيصية

مقدمة من

الطبيب / إبراهيم حمدي محمد حمزة

تحت إشراف

أ.د. سلوى طه إسماعيل

أستاذ الأشعة التشخيصية
كلية الطب - جامعة عين شمس

أ.د. حنان عيسى أحمد

أستاذ الأشعة التشخيصية
كلية الطب - جامعة عين شمس

كلية الطب
جامعة عين شمس

٢٠١٢

SUMMARY AND CONCLUSION

The majority of fetal anomalies can be diagnosed in the late first/early second trimester anomaly scanning of pregnancy. However, the gestational ages at which the different skeletal dysplasias are seen vary; therefore, the diagnosis of an abnormality should not be excluded if it is not visualized during a single in utero examination. Often, serial examinations are necessary.

Prenatal sonographic evaluation of short-limbed dwarfism is initiated when a significantly shortened femur is found or by referral of a patient with a family history of skeletal dysplasia. If a short femur is demonstrated (length less than the 95% confidence limit), all the long bones are measured and evaluated for bowing, fractures, and mineralization. The bone dysplasia is categorized according to whether it is mesomelic, rhizomelic, or micromelic and whether bowing or fractures are present. The fetal spine, head, thorax, hands, and feet are carefully evaluated to differentiate the type of bone dysplasia and to determine whether it is lethal or not. The differentiation between the lethal and the nonlethal variety is very important in terms of antenatal care and the prediction of fetal outcome.

Thus, any apparently trivial finding of prenatal sonography suggesting musculoskeletal anomaly should be overlooked because it may be a part of wider chromosomal abnormality. So a detailed search for associated abnormalities should always ensue.

List of Contents

<i>Title</i>	<i>Page No.</i>
Introduction	1
Aim of the work	
• Chapter (1): Physics of Three Dimensional Ultrasound	4
• Chapter (2): Technique of the 3D and 4D Fetal Scanning.....	21
• Chapter (3): Fetal Development.....	27
• Chapter (4): Normal Fetal Skeleton 3D ultrasound findings	38
• Chapter (5): Fetal Skeletal Anomalies Pathology and Conventional 2D Sonographic Findings.....	51
• Chapter (6): Fetal skeletal anomalies 3D Ultrasound Manifestations.....	112
• Chapter (7): Role of Other Imaging Modalities in Diagnosis of Fetal Skeletal Anomalies (X-RAY, CT and MRI).....	131
• Chapter (8): Demonstrative Cases	151
Summary and Conclusion.....	157
References	162
Arabic Summary	---

List of Figures

<i>Figure No.</i>	<i>Title</i>	<i>Page No.</i>
Figure (1):		5
Figure (2):		5
Figure (3):		6
Figure (4):		7
Figure (5):		8
Figure (6):		9
Figure (7):		10
Figure (8):		11
Figure (9):		12
Figure (10):		13
Figure (11):		13
Figure (12):		15
Figure (13):		19
Figure (14):		27
Figure (15):		28
Figure (16):		29
Figure (17):		32
Figure (18):		35
Figure (19):		37
Figure (20):		39
Figure (21):		41
Figure (22):		42
Figure (23):		43
Figure (24):		44
Figure (25):		45
Figure (26):		47
Figure (27):		48
Figure (28):		49
Figure (29):		50
Figure (30):		50
Figure (31):		53
Figure (32):		55
Figure (33):		56
Figure (34):		57

List of Figures (Cont...)

<i>Figure No.</i>	<i>Title</i>	<i>Page No.</i>
Figure (35):		60
Figure (36):		61
Figure (37):		62
Figure (38):		62
Figure (39):		63
Figure (40):		64
Figure (41):		65
Figure (42):		65
Figure (43):		66
Figure (44):		67
Figure (45):		68
Figure (46):		69
Figure (47):		71
Figure (48):		72
Figure (49):		73
Figure (50):		73
Figure (51):		75
Figure (52):		75
Figure (53):		76
Figure (54):		78
Figure (55):		79
Figure (56):		80
Figure (57):		81
Figure (58):		82
Figure (59):		83
Figure (60):		84
Figure (61):		85
Figure (62):		86
Figure (63):		87
Figure (64):		88
Figure (65):		88
Figure (66):		89
Figure (67):		90
Figure (68):		91

List of Figures (Cont...)

<i>Figure No.</i>	<i>Title</i>	<i>Page No.</i>
Figure (69):		91
Figure (70):		92
Figure (71):		93
Figure (72):		94
Figure (73):		94
Figure (74):		95
Figure (75):		96
Figure (76):		97
Figure (77):		97
Figure (78):		100
Figure (79):		101
Figure (80):		103
Figure (81):		103
Figure (82):		104
Figure (83):		105
Figure(84):		105
Figure(85):		105
Figure (86):		106
Figure (87):		107
Figure (88):		108
Figure (89):		109
Figure (90):		109
Figure (91):		111
Figure (92):		114
Figure (93):		115
Figure (94):		116
Figure (95):		117
Figure (96):		118
Figure (97):		118
Figure (98):		119
Figure (99):		120
Figure (100):		121
Figure (101):		122
Figure (102):		123

List of Figures (Cont...)

<i>Figure No.</i>	<i>Title</i>	<i>Page No.</i>
Figure (103):		123
Figure (104):		124
Figure (105):		125
Figure (106):		126
Figure (107):		126
Figure (108):		127
Figure (109):		128
Figure (110):		129
Figure (111):		130
Figure (112):		132
Figure (113):		132
Figure (114):		133
Figure (115):		133
Figure (116):		135
Figure (117):		136
Figure (118):		139
Figure (119):		140
Figure (120):		142
Figure (121):		142
Figure(122):		142
Figure (123):		143
Figure (124):		144
Figure (125):		144
Figure (126):		146
Figure (127):		147
Figure (128):		148
Figure (129):		149
Figure (130):		150
Case (1):		151
Case (2):		152
Case (3):		153
Case (4):		153
Case (5):		154
Case (6):		154
Case (7):		155
Case (8):		156



*First and foremost I feel always indebted to **ALLAH**, the most kind and the most merciful.*

*I would like to express my sincere thanks and deep gratitude to **Prof Dr. Salwa Taha Ismail**, Professor of Radiodiagnosis, Faculty of Medicine, Ain Shams University, for her enormous efforts and keen supervision to produce this work in a respectable form, in addition to her continuous encouragement and support.*

*No words can do justice to the great efforts of **Prof Dr. Hanan Eissa Ahmed**, Professor of Radiodiagnosis, Faculty of Medicine, Ain Shams University, for her unlimited support, patience and continuous guidance.*

I must also express my gratitude and thanks to my family members for their continuous great help and encouragement.

*✍ **Ibrahim Hamdy Mohamed Hamza***

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿وَأَنْزَلَ اللَّهُ عَلَيْكَ الْكِتَابَ وَالْحِكْمَةَ وَعَلَّمَكَ مَا لَمْ
تَكُن تَعْلَمُ وَكَانَ فَضْلُ اللَّهِ عَلَيْكَ عَظِيمًا﴾

سورة النساء آية (١١٣)

صدق الله العظيم

INTRODUCTION

Development of human embryo is a complex and evolutive process that requires accurate evaluation to detect any fetal malformation that may result in lethal or morbid outcome of pregnancy. Early and accurate antenatal diagnosis of fetal musculoskeletal malformations and differentiation between a lethal and a non-lethal variety has important implications for the management of a pregnancy and prediction of fetal outcome (*Lee et al., 2002*).

Real-time three-dimensional ultrasound is tridimensional and intuitionistic, which produces more sufficient information for diagnosis of fetal surface malformations and is superior to two-dimensional ultrasound and a reliable technique in prenatal diagnosis (*Chen et al., 2010*).

The 3D/4D ultrasound does not only enable the physician to precisely demonstrate isolated defects to the parents, but the technology can also provide more convincing evidence of a normal fetus than 2D sonograms in cases with increased recurrence risk (*Merz et al., 2009*).

When skeletal dysplasia is suspected antenatally, the use of 3D ultrasound in the examination of the fetal general appearance and bony structures provides additional information and facilitates antenatal diagnosis and management of the condition (*Wong et al., 2008*).

The 3D ultrasound proves not only a useful tool in appreciating the severity of a fetal defect, but also provides more convincing evidence of a normal fetus than conventional two-dimensional sonograms in cases with increased risk of a recurrent surface malformation (*Merz & Welter, 2005*).

Three Dimensional Ultrasonography has become the new standard in prenatal diagnosis. This technique enables detailed examination of the fetal anatomy and higher quality depiction of congenital anomalies (*Kurjak et al., 2002*).

Three-dimensional ultrasound can provide an intuitive and life like fetal surface structure of images which enriches the diagnostic information and enhances diagnostic confidence. It is complementarily of the two-dimensional ultrasound and the two in combination can increase the detection rate of the surface malformations (*Zhang et al., 2010*).

The 3D imaging had advantages over the 2D imaging when it came to evaluation of facial dysmorphism, relative proportion of the appendicular skeletal elements and the hands and feet. Most importantly, the patient and referring physician appreciated the 3D images of the abnormal findings more readily which aided in counseling and management of the pregnancy (*Krakow et al., 2003*).

AIM OF THE WORK

To prove significance in using three-dimensional (3D) ultrasonography compared to using two-dimensional (2D) ultrasonography in detecting fetal skeletal abnormalities.

PHYSICS OF THREE DIMENSIONAL ULTRASOUND

Development of 3D Ultrasound:

Szilard developed a mechanical three-dimensional (3D) display system to see a fetus three-dimensionally in 1974 (*Szilard, 1974*). Brinkley and colleagues developed a 3D position sensor for a probe. They acquired many tomographic images of a stillbirth-baby under water, traced its outline manually and showed its wire-framed 3D image in 1982. (*Brinkely et al., 1982*).

A modern 3D ultrasound system was first developed by Baba and colleagues in 1986 and a live fetus in utero was depicted three dimensionally. The system was comprised of an ultrasound scanner, position sensor and a computer. An imaging technology named surface rendering was used for 3D image construction. (*Baba and Satoh, 1986*).

A 3D probe and an ultrasound scanner, that displayed three orthogonal planes on a screen, were developed and became commercially available. In the early 1990's, clinical applications of the 3-orthogonal-plane display in obstetrics were reported (*Kuo et al., 1992*). Sohn reported translucent display by using volume rendering in 1991. (*Sohn et al., 1991*). Since then, the number of reports on a 3D image of the fetus increased rapidly because a 3D ultrasound scanner, that could construct and display 3D image as well as 3 orthogonal planes, and became commercially available. (*Baba, 2004*).

Technical Aspects of 3D Ultrasound:

The three-dimensional data are usually acquired as a large number of consecutive tomographic images through movements of an ultrasound transducer array (conventional 2D ultrasound probe) and the 3D data are obtained automatically (Figure 1 & 2) (*Smith et al.,1992*).

The 3D probe has a built-in transducer array (2D ultrasound probe) which tilts in the 3D probe, and 3D data are obtained automatically. Each tomographic image should be acquired with its positional information for the following process, construction of a 3D data set. Accurate positional information can be obtained through an electromagnetic position sensor or an electric gyro attached to the probe. (*Smith et al.,1992*).

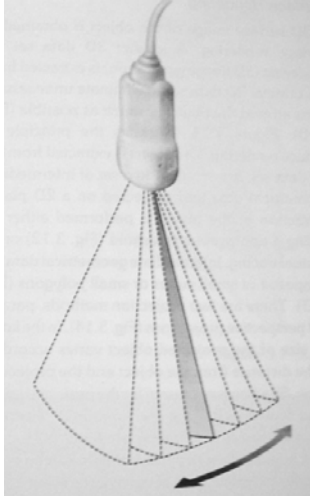


Figure (1): 3D Scanning by a 3D probe (*Quoted from Baba et al.,2001*).

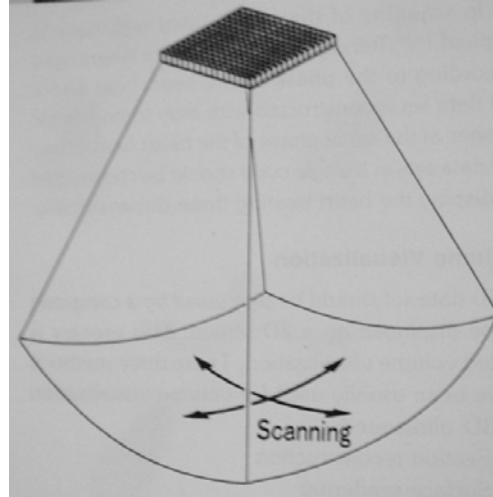


Figure (2): 2D array probe. Transducers are arranged two dimensionally and 3D scanning is performed electrically (*Quoted from Baba et al.,1997*)