

Defining the Role of 3D/4D Ultrasonography in Assessment of Fetal Congenital anomalies; Comparative study with 2D Ultrasonography

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Abstract:

The current study compared between 2D US and 3D US in evaluation of fetal anomalies. Eighty one women with 84 fetuses were examined by 2D followed by 3D US, and 105 detected anomalies. Our results demonstrate an advantage of 3D US over 2DUS in 8.6% of cases, equal findings in 71.4%, and less information in 20% of anomalies detected.

According to our findings, 3D/4D US has shown advantage over 2DUS in demonstrating some anomalies of the face and extremities. We concluded that 2D US remains the gold standard in assessment of fetal anomalies, and 3D US, therefore, is not a screening technique but an adjunct to 2D US for those fetuses in whom malformations are already determined or suspected on the basis of standard sonography.

Key words: Ultrasound, Fetal, Anomalies, three dimensional.

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List of Figures

Fig No.	Description	Page
1	Timing of Early Human Development	4
2	Blastocyst development	5
3	Key Events during Embryogenesis	9
4	Derivatives of the Germ Layers	11
5	A mode display	23
6	B mode display	23
7	M mode display	24
8	Reverbatation artifact	25
9	shadowing Artifact	26
10	Enhancement artifacts	27
11	Mirror Artifacts	27
12	3D Scanning by a 3D probe	29
13	electrical scanning	30
14	A 2D array probe.	30
15	Three orthogonal display of a fetus.	32
16	Settings for a viewpoint and ROI for a 3D data set	33
17	Surface Rendering	33
18	3D image of fetal skeleton by maximum intensity projection.	35
19	A 3D image of a fetal megalo ureter by minimum intensity projection.	35
20	Longitudinal section of a fetus of 12 +5 weeks, showing nuchal trans-lucency as well as the amnion	38
21	The normal head by US	39-41
22	Fetal Face by US	41
23	Longitudinal section of the fetal spinal column at 22+1 weeks	42
24	Cross section of fetal thorax & 4 chamber heart views	44
25	Cross section of the fetal abdomen	45
26	2D US of Male genitalia	46
27	2D US of Female genitalia	46
28	Fetal hand	47
29	Fetal foot	47
30	Fetal face from four different views	48
31	Fetal face by 3D US	49
32	3D US of Male external genitalia	51
33	3D US of the Fetal spine using transparent mode	52
34	3D US of the Fetal spine	52
35	Fetal lower limbs by 3D US	54
36	Fetal knees by 3D US	54
37	Fetal forearm and hand by 3D US	55
38	Fetal Upper limb by 3D US	55

39	Umbilical cord cyst	57
40	Single umbilical artery	58
41	Amniotic band syndrome	59
42	Anencephaly	62
43	Sagittal section of fetal head showing a severe encephalocele	63
44	Post-natal picture of the same fetus	63
45	Spina bifida aperta	66
46	Agenesis of corpus collosum	67
47	Holoprosencephaly	69
48	Holoprosencephaly facial profile at termination of pregnancy	69
49	Hydranencephaly	70
50	Microcephaly	71
51	Microcephalic fetal head	71
52	Demonstration of the posterior fossa in Dandy Walker Syndrome	72
53	Aneurysm of the vein of Galen	73
54	Central arachnoid cyst	74
55	Hydrocephalus	75
56	Ultrasound classification of cleft lip/palate	77
57	Cleft lip and palate	78
58	Same case post partum	78
59	3D US scan showing cleft lip	79
60	A very large echo free cystic hygroma	80
61	Fetal Goiter	81
62	Congenital cystic adenomatoid malformation	83
63	2D US Extralobar sequestration	84
64	Illustration of Extralobar sequestration	85
65	Illustration of Congenital diaphragmatic hernia	85
66	Left diaphragmatic hernia	86
67	Primary Fetal hydrothorax.	87
68	Types of esophageal atresia	89
69	Esophageal atresia	89
70	Hypoplastic left heart syndrome	90
71	VSD	91
72	Complete ASD apical view of four chambers	92
73	Same case diastolic phase, using color flow mapping	92
74	Tetralogy of fallot with absent pulmonary valve	94
75	Pericardial effusion	95
76	Solitary cardiac rhabdomyoma	95
77	Ebstein anomaly	96
78	TGA	97
79	Duodenal atresia	98
80	Jejunal atresia (triple bubble sign)	99
81	Gastrochisis at 23+3 weeks.	100

82	illustration showing a midline abdominal wall defect with herniation of small bowel	101
83	illustration showing a midline abdominal wall defect with herniation of small bowel	101
84	Omphalocele at 16+ 4 weeks	102
85	Fetus with trisomy 18 after termination of pregnancy	102
86	Meconium peritonitis	103
87	Echogenic bowel grade 2	104
88	cyst within the wall of the small intestine	105
89	Duplication cyst in a 2 nd trimester fetus	105
90	Bilateral renal agenesis	106
91	Normal kidneys	106
92	PCKD	107
93	Longitudinal section of multicystic renal dysplasia	108
94	Uretero pelvic junction obstruction	109
95	Renal duplication with ectopic urethrocele	110
96	Urethral valve sequence	111
97	Mesoblastic nephroma coronal sonogram	111
98	Longitudinal sono-gram of the infant after delivery showing an echogenic adrenal mass	112
99	Ovarian cysts	113
100	Sacroccocygeal teratoma	114
101	Fetal profile in achondroplasia	115
102	Osteogenesis Imperfecta. Fetal femur	116
103	Osteogenesis Imperfecta: deformed skull bones	117
104	Fixed positioning of the hand in fetal arthrogryposis	118
105	Deformation of the vertebral column in fetal arthrogryposis	118
106	Club foot	119
107	Same case after termination of pregnancy	119
108	Rocker bottom foot	119
109	Post axial polydactyly	120
110	Caudal regression sequence	121
111	Case 1: CCAM Lung	141
112	Case 2: Oligodactyly	142
113	Case 3: Arthrogryposis	143, 144
114	Case 4: Autosomal Recessive Polycystic Kidneys	145
115	Case 5: Omphalocele	146
116	Case 6: hydrops	147
117	Case 7: Twin reversed arterial perfusion	148
118	Case 8: Edwards Syndrome (Trisomy 18)	149, 150
119	Case 9: Anencephaly	151
120	Case 10: Spina Bifida Aperta	152, 153
121	Case 11: Otocephaly	154,155
122	Case 12: Midline Cleft Lip (Type 4)	156

List of Tables

Table	Description	Page
1	Fate of fetuses' (abortion/delivery /IU death)	126
2	Demonstrating added value of 3DUS compared to 2D US in all types of examined anomalies.	127
3	Single and multiple system anomalies by 2D US	130
4	Single and multiple system anomalies by 3D US	130
5	CNS anomalies by 2D US compared to other groups	131
6	CNS anomalies by 3D/4D US compared to other groups	131
7	MSK anomalies by 2D US compared to other groups	132
8	MSK anomalies by 3D/4D US compared to other groups	132
9	GIT anomalies by 2D US compared to other groups	133
10	GIT anomalies by 3D/4D US compared to other groups	133
11	Face & neck anomalies by 2D US compared to other groups	134
12	Face & neck anomalies by 3D/4D US compared to other groups	134
13	Lung anomalies by 2D US compared to other groups	135
14	Lung anomalies by 3D/4D US compared to other groups	135
15	Heart anomalies by 2D US compared to other groups	136
16	Heart anomalies by 3D/4D US compared to other groups	136
17	GU anomalies by 2D US compared to other groups	137
18	GU anomalies by 3D/4D US compared to other groups	137
19	Miscellaneous anomalies by 2D US compared to other groups	138
20	Miscellaneous anomalies by 3D/4D US compared to other groups	138

List of Graphs

Graph	Description	Page
1	Number and % of anomalies according to body system	126
2	Number of fetuses with single and multiple system anomalies	128
3	% of anomalies with a score of 2 and 3 by 2D US	129
4	% of anomalies with a score of 1 , 2, and 3 by 3D US	129

List of Abbreviations:

2D	Two dimensional
3D	Three dimensional
4D	Four dimensional
AC	Abdominal circumference
ASD	Atrial Septal defect
AV	Aortic valve
BPD	Biparietal diameter
CCAM	Congenital cystic adenomatoid malformation
CNS	Central Nervous System
CRL	Crown Rump Length
EDD	Expected date of delivery
FH	Family history
GIT	Gastro intestinal
GU	Genitourinary
HC	Head circumference
IUGR	intra uterine growth retardation
Misc	Miscellaneous
MRI	Magnetic Resonance Imaging
MSK	Musculoskeletal
OEIS	omphalocele-exstrophy-imperforate anus-spinal defects
PCKD	Polycystic Kidney disease
PV	Pulmonary Valve
RVOT	Right ventricular outflow tract
STIC	spatio temporal image correlation
TD	Thanatotropic dysplasia
TGA	Transposition of great arteries
TRAP	Twin reversed arterial perfusion
TUI	tomographic ultrasound imaging
US	Ultrasound
VSD	Ventricular septal defect

Table of Contents

Chapter	Page
Introduction	1
Review of Literature	
Fetal Development	3
Physical principles of ultrasound	20
Development of 3D Ultrasound	28
Ultrasound of Normal Fetal Anatomy	37
Ultrasound of Fetal Anomalies	56
Patients & Methods	122
Results	126
Case Presentation	141
Discussion	157
Conclusion	174
Summary	175
References	177
Arabic Summary	192



Introduction

One of the most consistently used justifications for the use of obstetric ultrasound is that accurate diagnosis of fetal malformations before delivery can provide health care providers & parents a number of management options (Platt LD et al, 1998).

Traditional two dimensional ultrasound (2D US) provides easily visualized & accurate images of both normal fetal anatomy & pathologic findings. However, it provides only a linear (length & width) observation of fetal structures. Although resolution has increased significantly, these 2D images may be confusing & difficult to construct to some clinicians because they must be interpreted to form a 3D impression of the anatomic structures available (Platt LD et al, 1998).

With the recent development of three dimensional Ultrasonography (3D US), 3 orthogonal different planes representing longitudinal, transverse & horizontal sections can be displayed simultaneously. These 3 planes can be rotated & computer translated to obtain accurate anatomic sections needed for diagnosis & geometric measurements such as distance, area and volume. (Platt LD et al, 1998).



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 A et al, 2002)

In particular, the face, ears & fingers which are difficult to discern on 2D ultrasound images, can be seen realistically with 3D ultrasound. Abnormal severe flexion, distortion of the anatomic axis such as in clubfoot & abnormal limb curvature maybe diagnosed more easily & accurately. (Baba et al, 1999)

Four dimensional ultrasound (4D US) enables visualization of more details regarding the dynamics of small anatomical structures. Using the advantages of this technology, a physiologic pattern of embryonic or fetal motor development was made. (Kurjak et al, 2002)

Aim of Work:

To evaluate the role of 3D/4D ultrasound in assessment and detection of fetal congenital anomalies, in comparison to 2D ultrasound.



Fetal Development

In 2004, Kostovic-Knezevic L et al described Fetal Development as follows:

First week of development

Human development begins at fertilization. When an oocyte is contacted by a sperm, it completes the second meiotic division. As a result, a mature oocyte and a female pronucleus are formed. After the sperm enters the oocyte, its head separates from the tail and enlarges to become a male pronucleus. Fertilization is complete when both pronuclei unite forming the zygote. As it passes along the uterine tube towards the uterus, the zygote undergoes cleavage (a series of mitotic cell divisions) into smaller cells called blastomeres. About 3 days after fertilization, a ball of 12 or more blastomeres (the morula) enters the uterus.

The morula then develops into a blastocyst consisting of :

- The inner cell mass or embryoblast, which gives rise to the embryo and some extra embryonic tissues
- A blastocyst cavity, a fluid filled space
- The trophoblast, a thin outer layer of cells

The trophoblast encloses the inner cell mass and blastocyst cavity and later forms extraembryonic structures and the embryonic part of the placenta.

Four to five days after fertilization, the zona pellucida is shed and the trophoblast adjacent to the inner cell mass attaches to the endometrial epithelium. The trophoblast adjacent to



the embryonic pole differentiates into two layers an outer syncytiotrophoblast (a multinucleated mass without distinct cell boundaries) and an inner cytotrophoblast (a mono nucleated layer of cells). The syncytiotrophoblast invades the endometrial epithelium and underlying connective tissue. Concurrently, a cuboidal layer of hypoblast forms on the deep surface of the inner cell mass. By the end of the first week, the blastocyst is superficially implanted in the endometrium (fig 1).

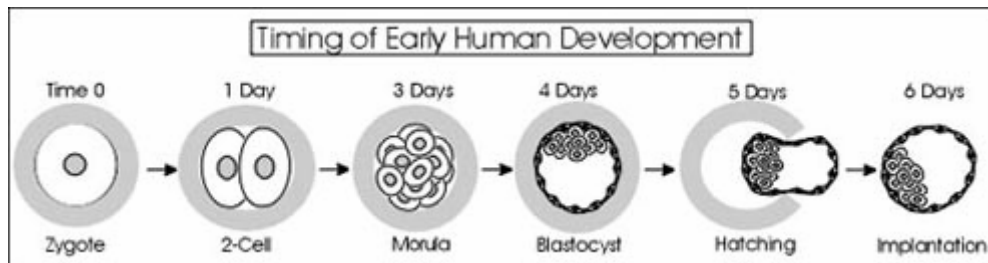


Fig 1: Timing of Early Human Development (O'Day D. 2009)

Second week of development

Rapid proliferation and differentiation of the trophoblast are important features of the second week. These processes occur as the blastocyst completes its implantation in the endometrium (fig 2). The various endometrial changes resulting from adaptation of these tissues to implantation are known as the decidual reaction. Concurrently the primary yolk sac forms and extra embryonic mesoderm arises from the endoderm of the yolk sac as well as from the primitive streak. The extra embryonic coelom forms from cavities that develop in the extra embryonic mesoderm, and later



becomes the chorionic cavity. The primary yolk sac disappears as the secondary one develops. As these changes occur:

- the amniotic cavity appears as a space between the cytotrophoblast and the inner cell mass or the embryoblast
- the inner cell mass differentiates into a bilaminar embryonic disc, consisting of an epiblast, related to the amniotic cavity and a hypoblast adjacent to the blastocyst cavity
- The prechordal plate develops as a localized thickening of the hypoblast, which indicates the future cranial region of the embryo, and is an important organizer of the head region.

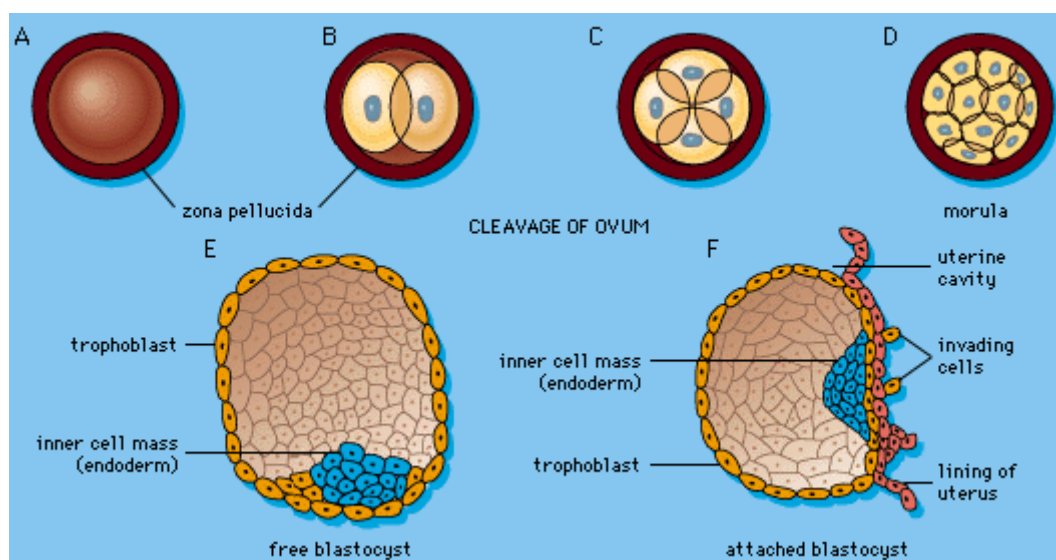


Fig 2: Blastocyst development (Arey LB et al 2009)



Third week of development

Major changes occur in the embryo as the bilaminar embryonic disc is converted into a trilaminar disc during gastrulation (fig 3). These changes begin with the appearance of the primitive streak.

Primitive streak:

It begins at the beginning of the third week as a localized thickening of the epiblast at the caudal end of the embryonic disc. As soon as the primitive streak begins to produce mesenchymal cells, the epiblast layer becomes known as the embryonic ectoderm. Some cells of the epiblast displace the hypoblast and form the embryonic endoderm. Mesenchymal cells produced by the primitive streak soon organize into a third germ layer, the intra embryonic mesoderm. By the end of the 3rd week, mesoderm exists between the ectoderm and the endoderm everywhere except at the oropharyngeal membrane, in the median plane occupied by the notochord and the cloacal membrane.

Notochord formation:

Early in the third week, mesenchymal cells arising from the primitive node of the primitive streak form the notochordal process, which extends cranially from the primitive node as a rod of cells between the embryonic ecto and endoderm. The primitive pit extends into the notochordal process and forms notochordal canal. When fully developed, the