

3D/4D Ultrasound: Fetal Safety and Artifacts

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42 weeks and 31 weeks



Fetal Scanning Safety

Background:

- Approximately 250 million fetal ultrasound examinations performed per year in US
- To date no adverse effects on fetus reported
- Fetal ultrasound considered to be safe
- Ultrasound exposure can produce bioeffects at diagnostic levels in laboratory studies
- Valid experimental studies difficult to perform
- Caution advised following ALARA principle
- Do not use color or power doppler in first trimester unless necessary

Fetal Scanning Safety: Background

- FDA
 - Regulates US machines as prescription devices
 - US should be used only for medical purposes
- AIUM
 - Prudent use statement only for medical use only
 - Discourages the non-medical use of ultrasound for psychosocial or entertainment purposes
- Vendors only sell US equipment to medical providers

Fetal Scanning Safety

Reasons for Concern:

- Ultrasound is mechanical energy:
 - mechanical effects
 - thermal effects
- Energy level depends on machine setting: Try to keep the levels below 1.0
 - MI - mechanical index < 1.0
 - TI - thermal index < 1.0
- Bioeffects studies based on old limits - 94 mW/cm²
- New equipment limits much higher - 720 mW/cm²

M.I. and T.I.

- Two main bioeffects are heating and cavitation
- Mechanical index
 - Potential for US to induce inertial cavitation in tissues
- Thermal index
 - Potential for rise in temperature at the ultrasound's focal point
 - TIS - TI for soft tissue (first trimester)
 - TIB - TI for bone (2nd and 3rd trimesters)
 - TI for cranial bone (scanning in adults close to bone)

Sheiner, Freeman, Abramowicz
JUM 2005; 24:1665

Mechanical Index and Temporal Index



Motion Artifact Simulating Conjoined Face

M.I. and T.I.

- 11 first trimester, 12 second trimester, 12 third trimester patients
- Mechanical index
 - First trimester - 8.9 minutes mean time
 - Mean 0.73 (range, 0.3-1.3)
 - Second trimester - 31.8 minutes mean time
 - Mean 1.04 (range, 0.5-1.5)
 - Third trimester - 16.3 minutes mean time
 - Mean 1.06 (range, 0.2-1.5)
- Thermal index
 - First trimester
 - Mean 0.34 (range, 0.1-1.7)
 - Second trimester
 - Mean .28 (range, 0.1-2.4)
 - Third trimester
 - Mean .32 (range, 0.1-2.4)

Sheiner, Freeman, Abramowicz
JUM 2005; 24:1665

When was Temporal Index High?

- During third trimester the TI > 1.0 in 3.5% of exams for very brief periods of time
 - 2.4% were between 1.0 and 1.49
 - 1.1% were greater than 1.5
- These occurred primarily during COLOR Doppler examination

Sheiner, Freeman, Abramowicz
JUM 2005; 24:1665

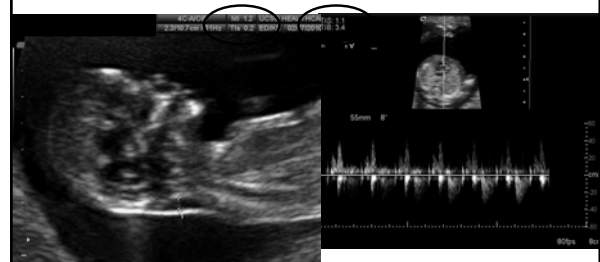
Concern over Non-Medical Provider Scanning

- Not understanding equipment limitations and operation
 - Power level limitations
 - Color Doppler limitations
- Scanning same area of fetus for prolonged time
- Identifying anomalies in a non-medical setting
- Concern that scanning by untrained personnel will lead to misinterpretation of images, particularly artifacts
- Why not license them like massage therapists, manicure specialists, automobile drivers ???

Fetal Foto : 18 weeks



Doppler in First Trimester



A Warning

- Concerns have been raised in the past related to
 - Autism
 - Abnormal hearing, vision or language development
 - Intrauterine growth retardation
 - Childhood cancer
 - Increase in non-right handedness

Abramowicz J, UOG 29:363, 2007

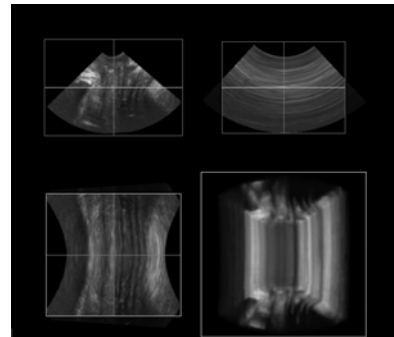
A Warning re US Biohazard

- Ang ESBC, Gluncic V, Duque A, Schafer ME, Rakic P, Prenatal exposure to ultrasound waves impacts neuronal migration in mice, *Proceedings of the National Acad of Sci*, August 2006; 103: 12903-12910. Links
- 335 mice
- Ultrasound for 30 - 420 min
- A small number of neurons failed to acquire their proper position
- They remain scattered within inappropriate cortical layers
- Consequences such as epilepsy, schizophrenia and autism

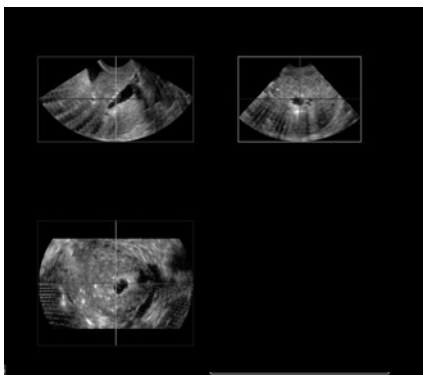
3DUS Artifacts - Key Concepts

- Acquire volumes with 3D probe
- Identification of artifacts is essential
- Artifacts may mimic
 - Abnormal development
 - Masses
 - Missing structures
- Confirm findings identified on rendered images with 2DUS and/or multiplanar images
- Examining multiplanar images, particularly in acquisition plane can be helpful

3D Acquisition with a 2D Probe



Electrical Artifact in O.R.



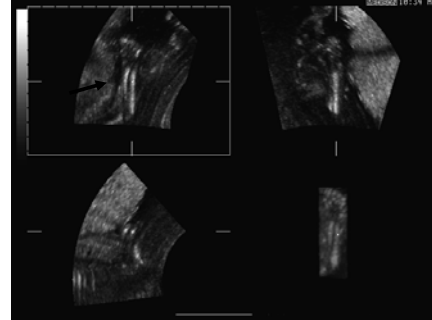
Sources of 3DUS Artifacts

- B-model Artifacts
 - Resolution
 - Propagation
- Attenuation
 - Color/Power Doppler Artifacts
 - Aliasing
 - Gain
- 3DUS Specific Artifacts
 - Acquisition
 - Rendering
 - Editing

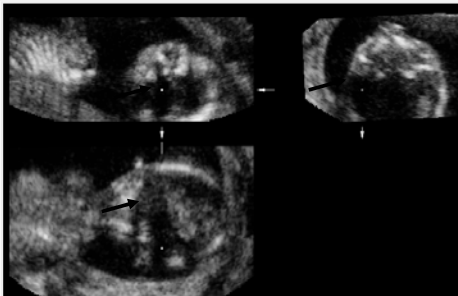
Sources of 3DUS Artifacts

- B mode artifacts
 - Propagation
 - Reverberation - added objects
 - Refraction - location, shape
 - Multi-path - location
 - Mirror image - added objects
 - Side/grading lobe - location

Attenuation - Shadowing Partial Absence of the Radius

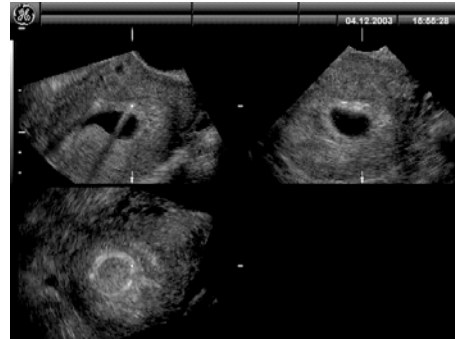


Attenuation - Shadowing

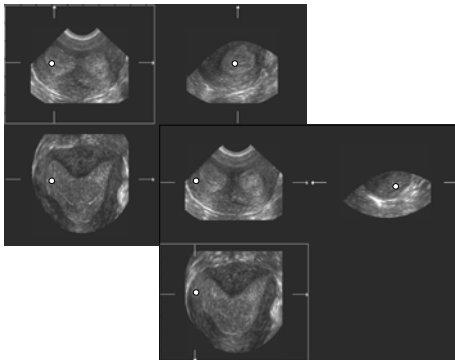


Courtesy of Dr. Gindes

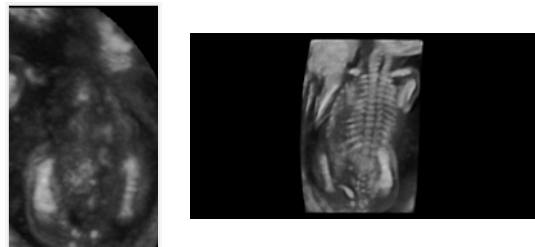
Shadowing Artifact of IUD



Septate Uterus with Endometrial Enhancement

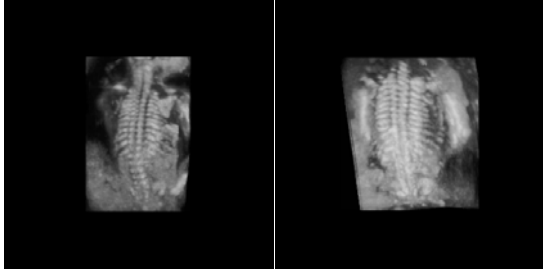


B-mode - Beam Path Normal Femurs Appearing Different



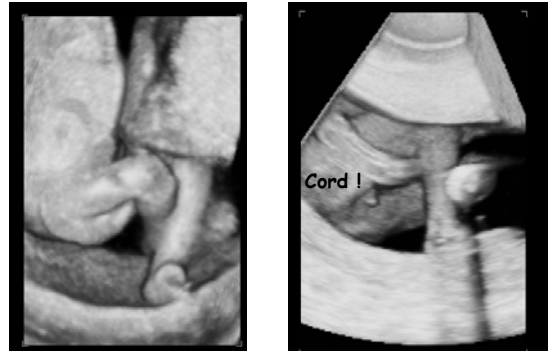
Courtesy of Dr. Gindes

Missed Information Absence of Scapula



Courtesy of Dr. Gindes

Three Legs ???



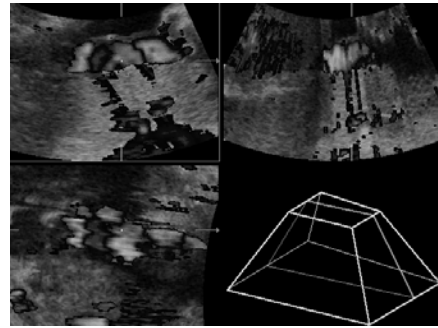
Courtesy of Dr. Gindes

Sources of 3DUS Artifacts

- Color/Power Doppler artifacts
 - Aliasing - directional confusion
 - Motion - flash
 - Flow where there is none - added objects
 - Noise
 - Bleeding
 - No flow where there is some
 - Signal voids

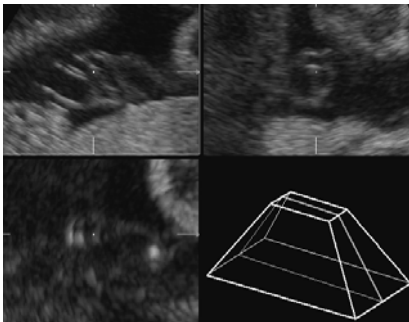
Color/power Doppler - Blooming

Pseudo 2 Vessel Cord: 29 weeks

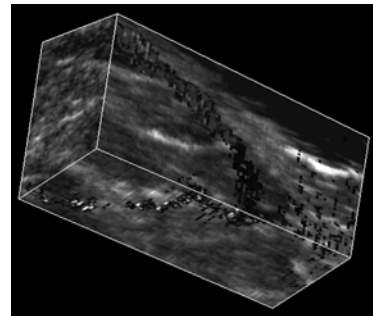


Color/Power Doppler - Gain - Blooming

Normal 3 Vessel Cord: 29 weeks



Color/Power Doppler Directional Confusion



Breast blood flow - color change

Sources of 3DUS Artifacts

- 3DUS Specific Artifacts
 - Acquisition
 - Patient motion
 - Respiration
 - Fetal motion
 - Organ motion
 - Vessel pulsations
 - Cardiac motion
 - Peristalsis

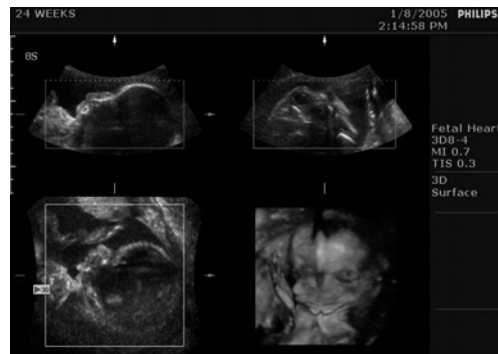


Artificial defect caused by fetal movement during scanning

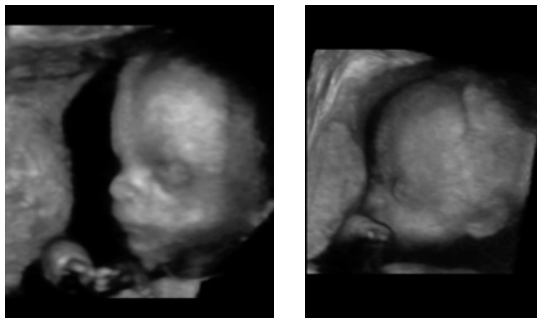
Motion Artifact Simulating Cleft Lip: 32 weeks



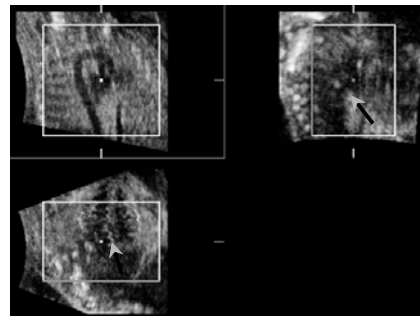
Motion Simulating Conjoined Face



It's Really Normal! 24 weeks



3DUS - Acquisition - Organ Motion



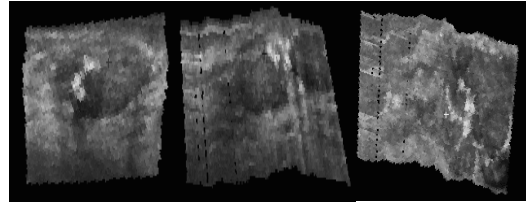
Non-gated Fetal Heart Study Motion Artifacts

Sources of 3DUS Artifacts

- 3DUS Specific Artifacts
 - Acquisition
 - Position sensing errors
 - Metallic distortion
 - Improper calibration
 - Improper operation
 - No position sensing
 - Improper geometry assumptions

3DUS - Acquisition - Position Sensing

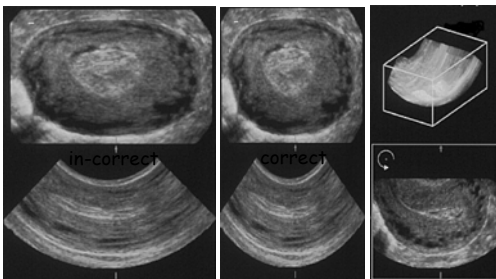
Sensor Inaccuracy



Fibroadenoma of the breast

3DUS - Free-hand Without Position Sensing

Aspect Ratio Error



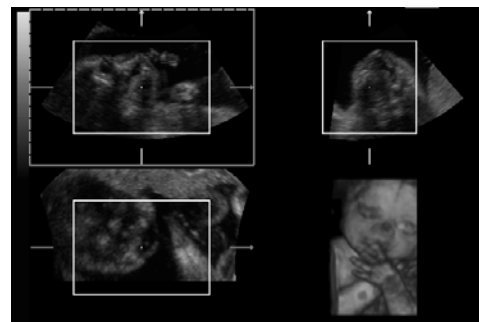
Sources of 3DUS Artifacts

- 3DUS Specific Artifacts
 - Rendering
 - Thresholding
 - Region of interest boundaries
 - Editing
 - Deletion of volume data

Over Thresholding: Black Eyes Artifact



Rendering Artifact: Black Nose



27 weeks

