

Ultrasound Phantoms: B-Mode, Doppler and Others

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Ultrasound Phantoms: B-Mode Doppler and Others

Overview

- Design of ultrasound phantoms
- Types of phantoms available
- Use of phantoms in a QA/QC program
- Advantages and limitations of phantoms

Ultrasound Phantoms: B-Mode Doppler and Others

What is an Ultrasound Phantom?

- A test object containing Tissue Mimicking Material (TMM) that simulates certain acoustic and physical properties of tissue
- May also contain various types of embedded objects
- Used to assess diagnostic ultrasound system performance over time

Ultrasound Phantoms: B-Mode Doppler and Others

Common TMM

- Agar
- Zerdine™
- Urethane
- TPE
- Other
 - Epoxies
 - Liquids
 - Natural materials




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Simulated Properties of TMM

- Speed of Sound
- Attenuation Coefficient
- Backscatter Coefficient or Relative Contrast
- Elasticity
- Thermal Properties
- Mechanical Properties

Ultrasound Phantoms: B-Mode Doppler and Others

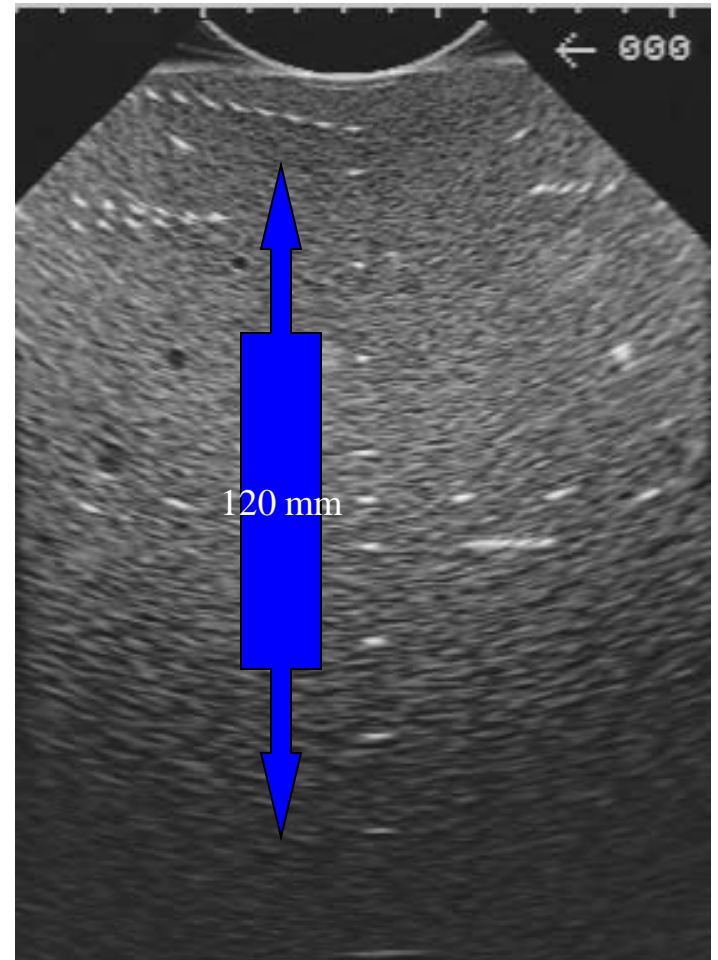
Important Properties for QA

- Speed of Sound  1540 m/s
- Attenuation Coefficient
- Backscatter Coefficient

Ultrasound Phantoms: B-Mode Doppler and Others

Speed of Sound

- Distance Measurements
- Volume Measurements
- Focusing Parameters



Ultrasound Phantoms: B-Mode Doppler and Others

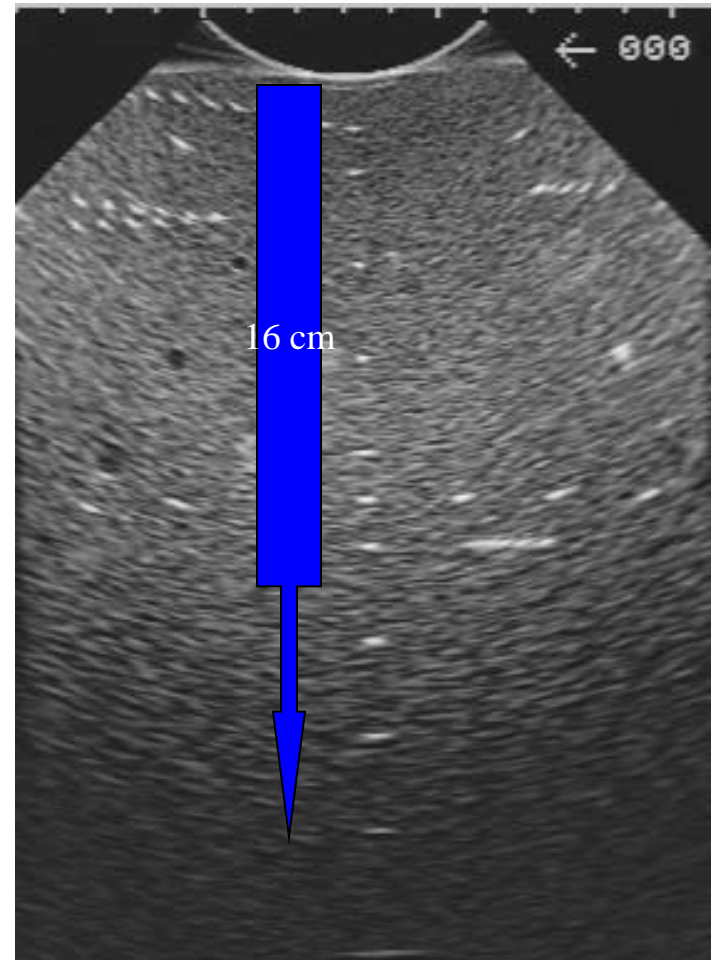
Important Properties for QA

- Speed of Sound \longrightarrow 1540 m/s
- Attenuation Coefficient \longrightarrow 0.5 dB/cm-MHz
0.7 dB/cm-MHz
- Backscatter Coefficient

Ultrasound Phantoms: B-Mode Doppler and Others

Attenuation Coefficient

- Depth of Penetration
- Resolution Parameters



Ultrasound Phantoms: B-Mode Doppler and Others

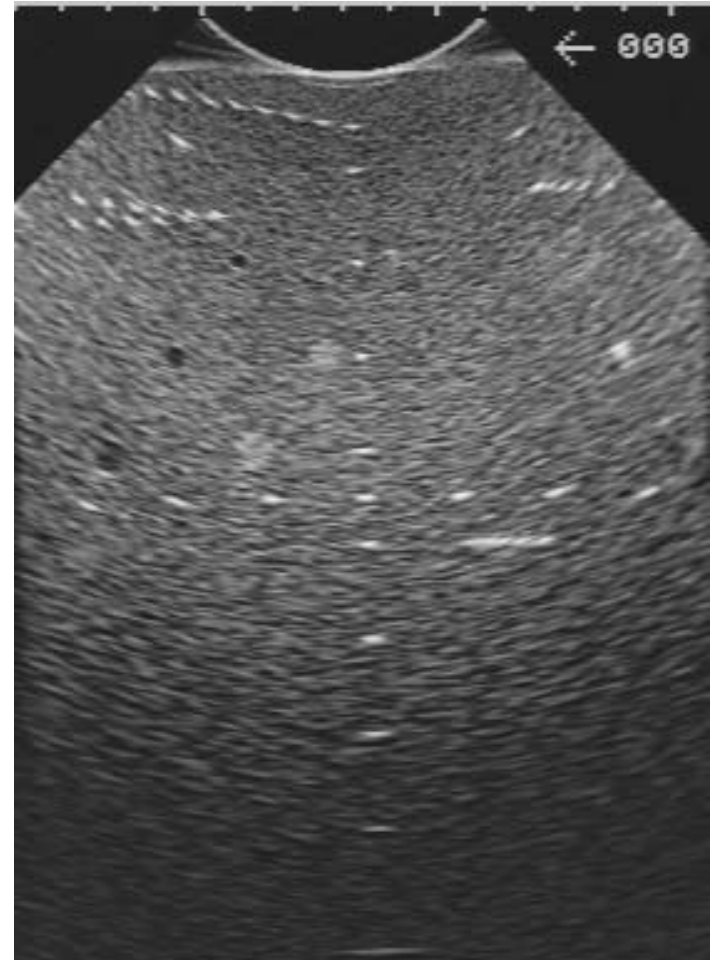
Important Properties for QA

- Speed of Sound \longrightarrow 1540 m/s
- Attenuation Coefficient \longrightarrow 0.5 dB/cm-MHz
0.7 dB/cm-MHz
- Backscatter Coefficient \longrightarrow 3×10^{-4} dB/cm-sr

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Backscatter Coefficient

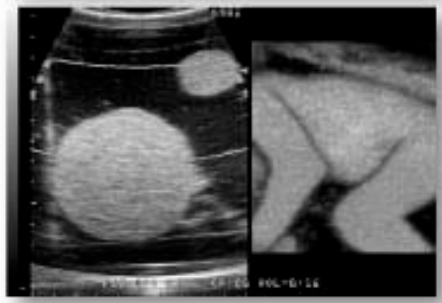
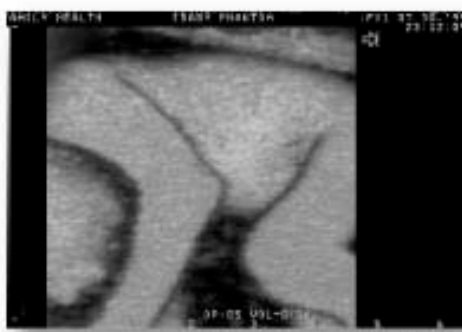
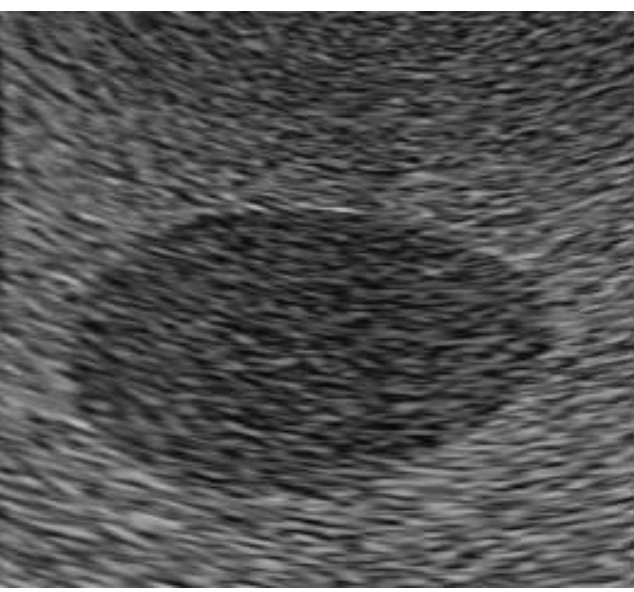
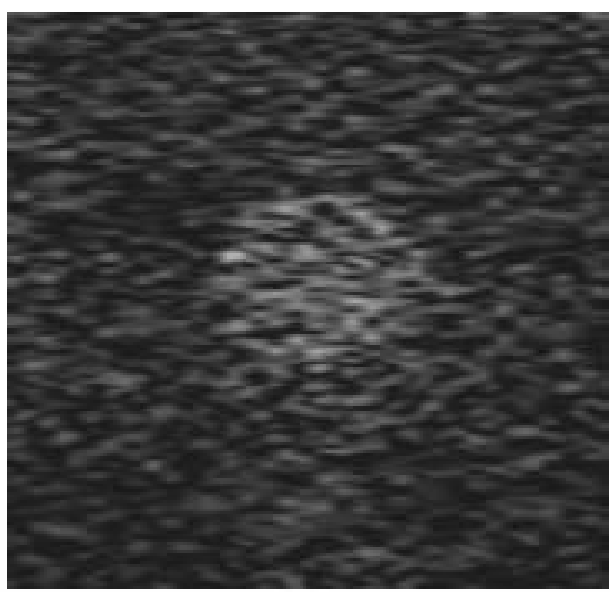
- Depth of Penetration
- Resolution Parameters
- Lesion Detectability



Ultrasound Phantoms: B-Mode Doppler and Others

Types of QC Phantom Targets

- Wires
 - Properties
 - 0.1mm - 0.3mm diameter
 - nylon monofilament
 - stainless steel
- Cylindrical & Spherical Anthropomorphic Objects
 - Properties
 - >1mm diameter
 - varying contrast relative to background
 - varying stiffness relative to background material
- Channels
 - Properties
 - >3mm diameter
 - Walled or wall-less
 - Can be attached to various pumping systems



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Phantom Quality



- Target Position Verification
 - CMM Machining
 - Ultrasonic Techniques
- Acoustic Property Verification
 - Testing on samples from individual batches or completed phantoms
- Visual Inspections

Ultrasound Phantoms: B-Mode Doppler and Others

Types of Phantoms

- General Purpose QA Phantoms
 - Typically used for general B-Mode imaging
- System Specific QA Phantoms
 - Prostate Brachytherapy
 - Breast Ultrasound
 - 3D Systems
 - Radiotherapy Systems
 - Doppler Systems
 - Elasticity Systems
- Training & Demonstration Phantoms
 - Developing eye-hand coordination
 - Learning general scan techniques
 - System Demonstrations
 - Task Trainers

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Use of phantoms in Ultrasound QC/QA

- Equipment Selection
- Acceptance Testing/Commissioning
- Consistency Checks
 - Is my system performing the same today as it did yesterday?
- Accreditation Programs
 - ACR
 - AIUM
 - ICAVL

Ultrasound Phantoms: B-Mode Doppler and Others

Phantom QA/QC Measurements

- B-Mode Parameters
 - Image Uniformity
 - Depth of Penetration
 - Axial, Lateral and Elevational Resolution
 - Near Field/Dead Zone
 - Lesion Detectability
 - high contrast (anechoic objects)
 - low contrast (gray scale objects)
- 3-D Parameters
 - Volume
 - Reconstruction Accuracy
- Doppler Parameters
 - Flow Rate
 - System Sensitivity
 - Directional Discrimination
 - Location of Flow
 - Maximum Penetration

Ultrasound Phantoms: B-Mode Doppler and Others

Advantages of Ultrasound Phantoms

- Known characteristics
 - Acoustic properties
 - Size of embedded targets
 - Location of embedded targets
- Stability over time
- Readily available

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Limitations of Ultrasound Phantoms

- Difficult to determine specific mode of failure
- Qualitative vs Quantitative
- Stability over time

Ultrasound Phantoms: B-Mode Doppler and Others

Ultrasound Phantom Manufacturers

- ATS Laboratories
 - www.atslabs.com
- Blue Phantom
 - www.bluephantom.com
- CIRS
 - www.cirsinc.com
- Gammex
 - www.gammex.com
- Kyoto Kagaku
 - www.kyotokagaku.com