3D Acquisition Strategies and Display
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3D Echocardiography Development Timeline

A-Mode 1950
Gated 3D 1970-1990
Sparse Array Matrix 1997
Fully-Sampled Matrix 2003
Real-Time Three-Dimensional Echocardiography

The Ideal Acquisition

- 1 Beat
- High Volume Rate
- High Spatial Resolution
Components of Acquisition

- Mode of Acquisition
- Beats (Single vs Multi-beat)
- Gain Settings

Modes of Acquisition

- Narrow-Angled
- Zoom
- Full-Volume
Narrow Angled Acquisition

- **Narrow-Angled**
  - Partial Volume
  - One beat acquisition
  - Steerable sector
    - Lateral
    - Elevation
Zoomed Acquisition (TTE)

- **Zoom**
  - Partial Volume
  - 1-6 beat acquisition
  - Adjustable Sector
Zoomed Acquisition

- Advantages:
  - Focus on structural pathology
  - Higher spatial and temporal resolution

- Disadvantage:
  - Loss of spatial orientation

Wide-Angled Acquisition
Wide-Angled Acquisition

Components of Acquisition

- Mode of Acquisition
  - Narrow Sector
  - Focused Sector (Zoom)
  - Wide Sector
- Beats
  - Single Beat
  - Multibeat (2, 4, 6, HVR)
- Gain Settings
1 Beat Acquisition

2 Beat Acquisition
4 Beats

Acquisition Beats

6 Beats
High Volume Rate (HVR)

- Multibeat

High Volume Rate (HVR)
# Single vs Multi-Beat

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<th>Single Beat</th>
<th>Multi Beat</th>
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<td>Overcomes rhythm and respiratory gating artifacts</td>
<td>Higher temporal resolution</td>
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<td>Poor temporal resolution</td>
<td>Requires optimal patient, provider conditions</td>
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<td>Susceptible to gating issues</td>
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## Components of Acquisition

- **Mode of Acquisition**
  - Narrow Sector
  - Focused Sector (Zoom)
  - Wide Sector
- **Beats**
  - Single Beat
  - Multibeat (2, 4, 6, HVR)
- **Gain Settings**
Optimize 2D and 3D (Gain and TGC)

Factors To Consider During Acquisition

- What is your region of interest?
  - Valve (or small structures)
  - Chamber (or large structures)
- What is important?
  - Spatial Resolution
  - Volume Rate
  - Or both
- Are there rhythm or respiratory issues?
  - No ECG available/ Atrial fibrillation/ irregular rhythms
  - Intubated patient
  - Breath holds
Region of Interest

Valvular Ds. “Small structure”

- Small Volume
- High Volume Rate
- High Spatial Resolution

Region of Interest

Valvular Ds.

- Small Volume
- High Volume Rate
- High Spatial Resolution

Chamber

- Large Volume
- Highest Volume Rate
- Good Spatial Resolution
Optimizing 3DE

- Operator
- The Patient
- Sonographer
- Machine

Acquisition Requirements
Good Quality Volume Data

- Operator
  - Well trained in TEE and 3D TEE
  - Centered Region of Interest
    - Find the right window
    - Use Ante-, Retro-, Left and Right Flexion
  - Steady Imaging
Acquisition Requirements
Good Quality Volume Data

The Patient
- Patient’s Image Quality and Anatomy
  - Presence of Air and Poor contact
  - Hiatal Hernia
  - Esophageal abnormalities
- Rhythm and Rate
  - Irregular rhythms
  - Heart rate extremes
- Sedation
  - General Anesthesia
  - Moderate or No Sedation

Operator (Sonographer)
- Well trained in 2D and 3D TTE

Optimal 2D Imaging
- “suboptimal 2D results in suboptimal 3D data sets”
- Appropriate echo window for structure of interest

Works within echo lab constraints (time, patient load, etc.)
**Acquisition Requirements**

**Good Quality Volume Data**

- The Sonographer
  - Knowledgeable about the TEE protocol in addition to 2D and 3D
  - TEE:
    - Collaboration between Echocardiographer and sonographer
    - Good communication
    - Understand 3D workflow
    - Optimizes 2D and 3DE Gain and TGC

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**Goal**

**Optimum Acquisition**

- The Machine
  - Gain
  - Sector Size
  - Depth
  - Zoom
  - Space-Time Adjustment
  - Display Pathology
**Sector Change**

- Wide
- Narrow

**Depth Change**

- Higher Depth
- Lower Depth
Optimizing Spatial and Temporal Resolution

- MV (high depth)
- MV Zoom

Space – Time Balance
Balancing

Spatial

Depth
Sector size
Zoom
Space - Time

Temporal

3D Color Acquisition

Ideal Acquisition for 3D Color Flow

1 Beat

High Temporal and Spatial Resolution

Large 3D B-mode with Steerable Color Flow
Multibeat 3D Color Imaging

- Increase Volume Rate

Single Beat Color Imaging

Wide Angled Acquisition
Large Color Sector
Volume rate 13 vps

Zoom Acquisition
Narrow Color Sector
VR = 23 vps
Goal of 3D Color Acquisition

- Visualize the origin of regurgitation
  - Useful in Paravalvular regurgitation
  - Bileaflet degenerative mitral valve disease
- Understand the severity of regurgitation or the size of the paravalvular leak

Paravalvular Leak
Steerable Color Sector
(Anterior Paravalvular Leak)

Steerable Color Sector
(Medial Paravalvular Leak)
3D Color Acquisition
(Quantitation of Volume Flow)

- Needs a high Volume Rate
  - Narrow color sector
  - Narrow 3D B-mode sector

- 3D color can include:
  - Both Mitral and Aortic flow
  - Dedicated Valvular flow

3D Display
(Types of Display)

- Volume Rendering
- Surface Rendering
- Wire-Frame
- 2D Tomographic Slices
Volume Rendered Images

- Displays Anatomy and Pathology
- Dynamic images
- Thresholding/Gain adjustments needed

Ideal Volume Rendered Display

- Display that demonstrates the pathology
- Automated Orientation depending on the specific structure
- Quick Cut planes
Wire-Framed Rendered

- Tracing ventricular or atrial chambers
- Tracing valvular structures
- No anatomic information
- Results in length, circumference, area or volumetric measurements

Surface Rendered

- Based on a wire-framed reconstruction
- Surface is applied over the wire-frame
- No anatomic detail
- Provide additional information
  - Timing of events
  - Motion
  - Displacement
Surface Rendered (Mitral Valve)

Multiplanar Reconstructions (MPR)

Single MV slice

Multiple LV slices
Segmentation or Cut Planes

- Sector
  - Narrowing the Sector
  - Zoom imaging

- Cropping
  - Box Cut Planes
    - "Auto"-crop
    - Box-crop
  - Anatomic cut plane
    - D'Art
    - Plane
    - iCrop

Segmentation
Cut-Planes

3D Volume

Auto Crop

Box Crop

YALE ECHOLAB

Cut-Planes

3D Volume

iCrop

Plane Crop

D’art / 2 click Crop

YALE ECHOLAB
Dual View
(Simultaneous Display of 2 Perspectives)

Stitch Artifact
Bovie Artifact

- Electrical Interference

Solution:
- Stop Cautery
- Probe