Real-Time 3-Dimensional Echocardiography (RT3DE) in Clinical Practice
M- mode to 2- D Echo
2- Dimensional Echocardiography (2DE) looks wonderful enough!
Modalities of Echocardiography

- Contrast Echo
- M-mode
- Tissue Doppler
- Color Doppler
- Echocardiography
- Spectral Doppler (PW, CW)
- 2-Dimensional
- TEE
- Stress Echo
Limitation of 2DE

- Geometric assumption

Everything about the heart is 3-dimensional !!!

- Mental conceptualization
Advantages in 3DE

- Quantification without geometric assumption
  - Mass, volume and EF
- Improved visualization of spatial relations
  - Complex congenital heart disease
- Unique view of valve structures
  - En face views
Advance in 3DE

Top view of Matrix (~3000 elements)
## Matrix Array Transducer

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element</td>
<td>~3000</td>
</tr>
<tr>
<td>Frequency</td>
<td>1.6- 4.0 MHz</td>
</tr>
<tr>
<td>Sector size</td>
<td>30<em>30 to 93</em>84</td>
</tr>
<tr>
<td>2D imaging</td>
<td>Biplane imaging</td>
</tr>
<tr>
<td>Harmonic imaging</td>
<td>Available</td>
</tr>
<tr>
<td>3D rendering</td>
<td>On-line</td>
</tr>
</tbody>
</table>
xSTREAM 3D Architecture

Conventional 2D Echo Processing

Amount of data processed

xSTREAM Live 3D Architecture

Amount of data processed

Powerful supercomputer architecture instantaneously processes an extraordinary amount of information vs. conventional ultrasound

Proprietary components in the xSTREAM 3D architecture enable it to accommodate massive amounts of 3D data streaming in real time

From PHILIPS
narrow-angled scan  zoom mode  wide-angled acquisition
RT3DE
Image Acquisition and Crop
3D Data Analysis

- **Qualitative**
  - Observe the rendered images of the endocardial and valvular surfaces

- **Quantitative**
  - Manually
  - Semiautomatically
Qualitative Analysis
Better visualization of (complex) anatomic features

- Congenital heart disease
  - Location, size, and phasic changes of defect
  - Identify spatial inter-relationship in complex form
  - Surgical or en face view
  - Tailored surgery
- Vegetation, tumor and thrombus
- Hypertrophic cardiomyopathy
Atrial Septal Defect
Ventricular Septal Defect
HCM
Apical HCM
Vegetation
Tumor
Better quantitation of size, volume, mass and function

- Volume and Mass of LV and RV
- Regional/global function
- Diastolic function
- Size of dysfunctional myocardium
- Size and volume of intracardiac mass
- Defect size: ASD, VSD etc.
Valve Area and Mass Volume
Mitral valve annulus
LV Analysis

Regional/global function, Diastolic function
(Using TomTec software)
LV Volume

and dysfunctional myocardium
Size of Defect
Better assessment of valves

- Valve morphology
- Stenotic valve orifice
- Regurgitant volume and orifice area
- Mitral valve prolapse
  - Identify prolapsing scallop
  - Measure extent of defect
- Geometric assessment of mitral apparatus
- Differentiate valvular from perivalvular regurgitation
Mitral Stenosis
RT3DE for rheumatic mitral valve stenosis evaluation: an accurate and novel approach

- 80 pts (76 women, 50 ± 13.9 years)
- MVA
  - by conventional echo-Doppler method, RT3DE and invasive Gorlin’s formula
  - RT3DE: best agreement with invasive one
- Valvular score evaluation: better interobserver agreement with 3DE
- Feasible, accurate and highly reproducible technique for assessing MVA

Mitral Valve Prolapse
Usefulness of RT3DE in the assessment of degenerative mitral valve insufficiency before surgical repair: preliminary data and clinical applications

- 22 patients (age: 60 ± 3)
- Clinically useful images in all pts
- Improved in 3DE
  - Mitral scallops involved in the prolapse and ruptured chordae in flails
  - Characterization of the "texture" (myxomatous disease vs fibroelastic deficiency)
  - Identification of functional "interscallop" clefts, paracommissural lesions and annular shape with a better localization of small mitral annular calcification
- Promising in the clinical setting of repair surgery

A. Grimaldi, et al. (2003) Milan, Italy ESC
Usefulness of 3DE for evaluation of MVP

- 25 consecutive pts (15 men, 55 ± 17 years)
- Reconstructed in surgeon’s view
- Compared with 2DE
- Sensitivity 75~100 %, Specificity 100%

Valve Prosthesis
Cleft Mitral Valve
Tricuspid Valve
Aortic Valve
Usefulness of RT3DE in aortic valve stenosis evaluation

- 11 pts
- AV orifice area: correlated well with intraoperative 3DTEE ($r=0.85$)
- 4 pts with moderate AS by 2DTTE: confirmed at surgery as severe AS
- Useful complement to the existing modalities due to complete noninvasiveness and 3 dimensional views

Bicuspic Aortic Valve
Color 3DE

- Stenotic, regurgitant, or shunt flows
  - Location, phase, direction, length, width, area, course and severity
- Enhance quantification
- Coronary artery circulation
Regurgitations
MR, AR, TR
Tricuspid Regurgitation
LVOT Flow and MR
Shunt Flow
Better catheter guidance in 3D space

- Pericardiocentesis
- Biopsy
  - transplanted heart, tumor, native heart
- PMV (percutaneous mitral balloon valvuloplasty)
- Non-invasive therapeutic procedures
  - ASD device closure
  - PLAATO (percutaneous LAA transcatheter occlusion)
- EP lab
  - Where catheter is
  - Calculate distances
3D Stress Echocardiography

- One volume rendered image
- Time saving
- Any cut-plane
3D Contrast Echocardiography
Limitations

- Lack of need
- Still off-line quantification
- Hemodynamic assessment
- Artifacts
- Big probe
Comparison of RT3DE with conventional 2DE in the assessment of structural heart disease

- 106 pts
- Diagnosis on the basis of 2D findings
- Graded as
  - A, new finding; 7%
  - B, useful anatomic perspective; 18%
  - C, equivalent; 61%
  - D, missed; 14%
- Useful anatomic insight in MV disease and CHD

RT3DE as the Primary Mode of Echocardiographic Imaging in Routine Daily Clinical Practice: Experience in 500 Patients

- Adult and pediatric pts
- Both physicians and sonographers
- Visualize all major pathology
  - Stenotic valves, prolapsing and flail MV, Ebsteins anomaly, ASD and VSD, Fallot’s tetralogy, HCM and DCM, ventricular aneurysm, clot and tumor, pericardial effusions, etc.
- Novel on-line cut-planes
- Time added to examination was less 10 min
- Easy performance and navigation

KS Hong, N. Pandian, N. Nanda ASE 2004
Future directions

- Larger volume rendered image
- Rapid and easy quantitation
  - Automatic border detection technique
- Stress and Contrast 3DE
- Interventional fields
- Real-time 3D TEE
Conclusions

- Important breakthrough in the field of ultrasonic medicine
- Complementary to 2DE
- More useful in the diagnosis and assessment of wide range of cardiovascular disease
Real-time Multidimensional Echocardiography

- Morphology
- Function
- Flow dynamics
- Perfusion
- Mechanics
- Multimodality
Thank You !