**Advanced Heart Failure**

The complete picture an echocardiographic perspective

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I have no disclosures regarding this presentation
I will not be discussing off label use of products

**Background on Heart Failure**

<table>
<thead>
<tr>
<th>Population Group</th>
<th>Prevalence</th>
<th>Incidence</th>
<th>Mortality</th>
<th>Hospital Discharges</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population</td>
<td>5,700,000</td>
<td>670,000</td>
<td>50% within 5.5 years</td>
<td>1,100,000</td>
<td>$37 billion</td>
</tr>
</tbody>
</table>

- Over 1 million patients hospitalized this year;
- 12 million outpatient office visits
- HF hospitalizations one of largest expenses for CMS
- Mortality rates remain very high
- One of the few major cardiovascular diseases increasing in incidence

**Pathophysiology (Downhill Cascade)**

- Myocardial Insult
- Myocardial Dysfunction
- Reduced System Perfusion
- Inflammation
- Reduced Gene Expression / Apoptosis / Remodeling

**Un-Natural History of Heart Failure**

- Annual Survival Rate
- Hospitalizations / year
- Deceased

Adapted from Bristow, MR Management of Heart Failure, Heart Disease: A Textbook of Cardiovascular Medicine, 6th edition, ed. Braunwald et al.

**General Considerations for Imaging Heart Failure**

- Structure
  - Remodeling
- Function
  - Sympathetic
  - Diastolic
- Hemodynamics
  - Stroke Volume
  - Doppler
- Prognostics Variables
  - 5 Rules

Challenges with diagnostic imaging

- Clinical
  - Accuracy
  - Expertise
  - Radiation
  - Contrast (renal)
- Technical
  - Geometric assumptions
  - Foreshortening
  - Acoustic
  - Baffle
  - Temporal resolution
- Special considerations
  - Probes
  - The right ventricle
  - Clinical trials
  - Therapeutics
Prognostic importance of systolic function (EF)

RULE 1
- LVEF < 25% (high risk)
  - 50% symptomatic CHF
  - 40% risk hospitalization
  - 10% risk death
- Decline in ejection fraction (5%)
  - 20% risk of death

RULE 2a. LV size
- Correlate with NYHA
- Correlates with PVC and VT
- <6 cm = 9% mort
  - Sth + PWth < 1.5 cm = 30%
- >7.5 cm = 35% mort
- Improvements in LVEF, NYHA, Survival can occurs if LVEDD<6.5cm

RULE 2b: LA Size
- Normal LA size
- Volume>Area>dimension
- >32 ml/m2 increased risk for cardiovascular
- Correlate with degree of diastolic dysfunction
- >60 ml/m2 high risk of death
- Like the hemoglobin A1c of heart failure

Long-term prognostic significance of three dimensional echocardiographic parameters of the left ventricle and left atrium

Stefano Caselli, Emanuele Canali, Maria Laura Foschi, Daria Santini, Emanuele Di Angelantonio, Natesa G. Pandian, Stefano De Castro
Eur J Cardiol 2009
Less intra and inter-observer variability (better reproducibility).
Minimal LAV (3D) is a marker of survival and correlates with E/Em.

Accuracy and Reproducibility of Quantitation of Left Ventricular Function by Real-Time Three-Dimensional Echocardiography Versus Cardiac Magnetic Resonance:
Osama I.I. Soliman MD PhD, Sharon W. Kirschbaum MD, Bas M. van Dalen MD, Heleen B. van der Zwaan MD, Babak Mahdavian Delavary MSc, Wim B. Vletter MSc, Robert-Jan M. van Geuns MD PhD, Folkert J. Ten Cate MD PhD, and Marcel L. Geleijnse MD PhD.

$\text{n=17 SHF (10 ICM, 7 NICM) 7 control}$

Who is higher risk???

Value of the RV
- Fractional area change
  - n=141, 2.6 years
  - FAC<32% = 69% mort
  - 1% FAC = 16%

- Tricuspid Annular Plane
  - n=166, 1.5 years
  - TAPSE < 1.4cm = 2X death or transplant

- RV shortening
  - n=166, 1.5 years
  - RV short < 1.2cm = 60% mort

Excellent correlation with MRI measures of ventricular volume and function.

Who is higher risk???
RULE 3

- RV dysfunction high risk marker
  - FAC<32%
  - TAPSE<1.5 cm
  - RV short < 1.2 cm
  - RV annular TDI < 10.8 cm/sec
- Mortality 40% (1.5 years)
- Transplant or Death 65% (1 year)

Classic Observations

Measures of systolic function correlate poorly with functional capacity

Hemodynamic Impact of Diastolic Dysfunction

Important Concepts
- Prolong relaxation
- Higher Pressure
- Diastole ~ Systole
- Increased Stiffness

Echocardiographic Measures of Diastolic Function (Depressed EF)

MORBIDITY & MORTALITY

Preload

Relaxation

Compliance

Up Left Atrial Pressure

Symptoms

Thohan V. Curr Op Cardiol 2004

Larrie-Dacs: JACC 1999
**RULE 4**

- Transmitral flow pattern:
  - Diastolic parameters (RFP/E/A>2 and DT<140)
  - Morbidity (exercise capacity, NYHA, hosp.)
  - Mortality
    - RFP=30-40% annual
    - NRFP=5% annual
  - Reversal of the RFP with meds and/or device improves morbidity and mortality (5-6% annual)

**Rule 5: 3D is the future of heart failure imaging**

**Life Saving Therapies**

- **Stage A**
  - ACE Inhibition (ARB, valsartan, candesartan)
  - Beta Blocker (Carvedilol)
  - Aldosterone antagonist (Eplerenone post MI)
  - CRT + ICD

- **Stage B**
  - Hydralazine Nitrates

- **Stage C**
  - Heart Failure Management Program

- **Stage D**
  - Heart Transplant

**Measurement of cardiac output by real-time 3D echocardiography in patients undergoing assessment for cardiac transplantation**

- Stephen P. Hoole, James Boyd, Vlassis Ntanos, Jayan Parameshwar, and Rosemary A. Rusk
- Eur J Card 2008

- n=40 (24 men, 24 ICM, 10 DCM)
  - 4 excluded (large LV, poor qual)

- Technical
  - RT3D: Philips, single breath hold
  - Online analysis (3 min) 3 point semi auto
  - CO=(EDV-ESV)*HR

- Swan Ganz standard measure CO

- **Rule 5: 3D is the future of heart failure imaging**

**Prognostic Importance of Diastolic Function**

- n=314, 2 years
- Metabolic Bike and Echo Doppler
  - MVO2<14
    - RFP=20%
    - NRFP=6% mort
  - MVO2>14
    - RFP=48%
    - NRFP=20%

**Thohan V. Curr Op Cardiol 2004 Adapted Yamamoto T. JACE 2003**

- Measurement of cardiac output by real-time 3D echocardiography in patients undergoing assessment for cardiac transplantation
ACC/AHA HF Guidelines: Management of Heart Failure (Stage C)

**Life Prolonging Medical Therapy**
- **ACE-I or ARB** (Class I, evidence A) all patients without contraindications or intolerance
- **β-Blockers** (Class I, evidence A) all patients without contraindications or intolerance
- **Aldosterone antagonists** (Class IIa, evidence A) all patients with Class III-IV HF in past 2 months without contraindications or intolerance
- **Hydralazine** Nitrate reasonable and can be effective in African Americans with NYHA class III-IV HF (Class I, evidence A). Others may benefit similarly, but this has not yet been tested

**Challenges with medical therapy**
- They only work when they are prescribed
- 50% β-blocker utilization most contemporary clinical trials
- 30% community practice
- **Poly-pharmacy**
  - 50% have three or more co-morbidities
  - Average of six medications
- They only work when they are taken
  - 10% complete their annual prescriptions
  - 15-30% withdrawal of medical therapy for side effects
  - 1/3 never refill any CHF meds

**Cardiac Resynchronization Therapy**
- **Prevent Progression of disease**
- **Prevent Morbidity**
  - Hospitalization
  - Functional Class
  - Surrogates (ECHO, Exercise)
- **Prevent Mortality**

**QRS duration as a marker of illness**

**QRS complex and mortality**

- **VEST study analysis**
- NYHA class II-IV
- 3,654 ECGs
- QRS duration was found to be an independent predictor of mortality

Adapted from V Gottipaty, MD.
Validation of an echocardiographic multiparametric strategy to increase responders patients after cardiac resynchronization: a multicentre e-study


**Results of the Predictors of Response to CRT (PROSPECT) Trial**

Eugene S. Chung, MD; Angel R. Leon, MD; Lothar Witte, MD; Jing-Ping Sun, MD; Patrick Monvoisin, MD; John Mokri, MD; William T. Abraham, MD; Mehran GRS, MD; Christyana Lederman, MD; Jeanne A. Reis, MD; Chiao-Han Yu, MD; MD; RCP; Johan De Sutter, MD, PhD; Jaime Morillo, MD

**Could ECHO assist in selection of CRT application beyond current recommendations?**

**Clinical Remodeling (6 mo)**

- **Clinical Response**
- **Unable to implant**
- **No clinical response**

**R=0.56 p<0.0001**

**R=0.57 p<0.0001**

- **10%**
- **30%**
- **45%**

**Cardiac Remodeling (6 mo)**

- **65%**

- **103/181 (57% reduction in LVESV)**
- **>15% reduction in LVESV**
- **76% clinical improvement (92% reduction LVESV)**
- **7.5% of patients no criteria for**

**CONCLUSIONS**

- **Compatibility with dysynchrony.**
- **3D-TDI/3D-RT3D are the best parameters.**
- **Better accuracy of dyssynchrony compared with glucose remodeling.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Index</th>
<th>SD</th>
<th>P-value</th>
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<tbody>
<tr>
<td>EF</td>
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<td>VT</td>
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<td>ESV</td>
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**Individual echo parameters may be reliable to select patients and not others.**

**Individual echo measures have low yield in predicting remodelling.**

**Multiple parameters reduce false positives and improve PPV.**
Usefulness of Three-Dimensional Speckle Tracking Strain to Quantify Dyssynchrony and the Site of Latest Mechanical Activation

Hidekazu Tanaka, MD, Hideyuki Hara, MD, Samir Saba, MD, and John Gorcsan III, MD

(n=67 (57 HF, 10 control)
5/57 excluded for poor windows
3D dyssynchrony/latest activation
Pyramidal 3D volume sets
4 smaller wedge volume (25-30°)
4 cardiac cycles with breath hold
Off line postprocessing (16 segments)
94% segments could be analyzed
4.7 minutes additional time
97% inter and intra-observer

RESULTS
• 85% latest activation post or lateral segments
- 11 patients serial echo
  MOWD: 300 to 94 ms (p=0.001)
  SD peak strain: 119 to 49 ms (p=0.001)
  EF: 24 to 31% (p<0.05)

Un-Natural History of Heart Failure

Location may not be the only determinant of success...

Mechanical Assist Applications 21st Century
Important Information

- **Clinical status**
  - Symptoms / vitals / LVAD alarms

- **Type of LVAD**
  - Pulsatile
  - Continuous

- **Structure**
  - LV, LA, RV
  - Inflow, Outflow grafts
  - % Aortic valve opening

- **Function**
  - RV failure
  - Ween

- **Hemodynamics**
  - MR, LAP, PASP, RAP

Some Normals...

Some abnormalities

Clinical Scenario

- **Low Pump Flow**
  - Continuous
  - RPM 9000
  - Flow 2 L/min
  - SOB faint pulse

  - ABP
    - Low

  - CVP
    - High
    - Low

  - RV failure
  - Tamponade
  - Pump failure

On Presentation

- MV inflow
  - 4.1 m/s

- TR velocity
  - 2.5 m/s

After Therapy

- HV flow
Clinical Scenario

Low Pump Flow
- Continuous
- 9400 RPM
- Flow low
- Hypotensive

ABP
- Low

CVP
- High
- Low

RV failure
- Tamponade
- Pump failure

Case …

What you never want to see!!!

Any confusion???