Cardiac failure: natural history and diagnostic workup

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"Guido Berlucchi Foundation" PET Center

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• 17.4 MeV Cyclotron – targets for F18, C11, N13H3
• GE 690 PET/CT (Lyso, TF, 64/128 slices CT, dose reduction)
• GE Discovery DST PET/CT (BGO, 3D, dose reduction)
• GE Hawkeye 4 SPECT/CT (dose reduction)
• GE Hawkeye SPECT/CT (dose reduction)
• GE Millenium SPECT
• ADAC Vertex
• GE single headed SPECT
• 16 monitored beds for TRT
• Internal dosimetry
• NM part of Imaging Dpt (2 Radiology Units, Neuroradiology, Pediatric Radiology, Health physics)
• NM Senior staff: 10 NM certified MDs, 2 Physicists, 1 Biologist, 1 Pharmacist
• 6 NM fellows of Post-graduate school in NM
• 20 NM technologists (NM activities, Cyclotron, RPh)
• 11 Nurses
• 5 administrative

Prevalence of Heart Failure

ESC – 51 countries $\rightarrow$ 900 million
At least 15 million patients with HF

Italy $\rightarrow$ $>$57 million
$\approx$ 1 million patients with HF
The Lifetime Risk for Developing Congestive Heart Failure is 1 in 5 for both men & women

The Framingham Heart Study

3757 men & 4472 women followed up from 1971 to 1996. 583 subjects developed CHF during follow-up

% Lifetime risk for CHF (95% CI)

<table>
<thead>
<tr>
<th>Index Age, ys</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>21.0 (19 - 23)</td>
<td>20.3 (18 - 22)</td>
</tr>
<tr>
<td>50</td>
<td>20.9 (19 - 23)</td>
<td>20.5 (18 – 23)</td>
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<td>60</td>
<td>20.5 (18 – 23)</td>
<td>20.5 (18 – 23)</td>
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<tr>
<td>70</td>
<td>20.6 (18 – 23)</td>
<td>20.2 (18 – 23)</td>
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<tr>
<td>80</td>
<td>20.2 (16 – 24)</td>
<td>19.3 (16 – 22)</td>
</tr>
</tbody>
</table>

Lloyd-Jones et al., Circulation. 2002;106:3068-3072


Euroheart Failure

Distribution of ejection fraction

11,015 patients in 115 hospitals in 24 countries

Left Ventricular Ejection Fraction (%)

Percentage of patients

LVEF ≥ 40%:
49% of men
72% of women

Cleland et al Euroheart Survey EHJ 2003
Projected Increases in the US Population >65 Years of Age

Projected increase in HF incidence

From Mann’s Heart Failure. A companion to Braunwald’s heart disease textbook. 2011;350
Twenty-year projections for U.S. heart failure prevalence and associated direct medical costs based on current trends.

Projected US Heart Failure Prevalence and Direct Costs

Projected US Prevalence of Heart Failure (%)

- 2010: 1.5%
- 2015: 2.0%
- 2020: 2.5%
- 2025: 3.0%
- 2030: 3.5%

Projected US Direct Costs for Heart Failure (billions 2008$)

- 2010: 30 billions
- 2015: 40 billions
- 2020: 50 billions
- 2025: 60 billions
- 2030: 70 billions

Konstam M A Circulation 2012;125:820-827
The Epidemiology of Heart Failure

- **Prevalence**
  - 2-3% of the general population
  - 10-20% of people in 70-80 years old

- **Incidence**
  - 20% lifetime risk of developing HF

- **Forms of HF**
  - HF-REF
  - HF-PEF
  - Asymptomatic LV dysfunction
  - Acute Heart Failure

ESC guidelines 2008 & 2012
HF-REF & HFPEF: two different diseases?

<table>
<thead>
<tr>
<th></th>
<th>HF-REF</th>
<th>HF-PEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>Males, CAD</td>
<td>Females, elderly, hypertensive</td>
</tr>
<tr>
<td>Pathogenesis</td>
<td>Progressive worsening LV function, remodelling</td>
<td>↑aortic impedance /↓LV compliance / acute BP changes</td>
</tr>
<tr>
<td>Clinical presentation</td>
<td>Chronic</td>
<td>Acute</td>
</tr>
<tr>
<td>Cause of hospitalisation</td>
<td>Peripheral congestion, peripheral oedema</td>
<td>Acute pulmonary oedema</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>Normal to low</td>
<td>Normal to high</td>
</tr>
<tr>
<td>Treatment</td>
<td>ACEi/ARBs, BB, AldoAntag, Diur, Dig</td>
<td>Diuretics ???</td>
</tr>
</tbody>
</table>
Progression of Heart Failure

Stage A
At high risk but without structural disease or symptoms

Stage B
Structural heart disease but without HF symptoms

Stage C
Structural heart disease with prior or current HF symptoms

Stage D
Refractory HF requiring specialized interventions

Patients with:
- hypertension
- CAD
- diabetes

Development of symptoms of HF

Patients with:
- previous MI
- LV systolic dysfunction
- asymptomatic valve disease

Patients with:
- known structural heart disease
- shortness of breath, fatigue, reduced ex. tolerance

Patients with marked symptoms at rest despite maximal medical therapy

(ACC/AHA Guidelines, JACC 2001; 38:2092)
From Risk Factors to Heart Failure

Hypertension
Coronary artery disease
Diabetes
...

Remodeling stimuli
- Wall stress
- Cytokines
Neurohormonal
Oxidative stress

Myocyte hypertrophy

Altered interstitial matrix

Myocyte death

Fetal gene expression

Altered Ca++-handling proteins

Ventricular enlargement

Systolic and diastolic dysfunction
Background on Remodelling

Acute infarction (hours)

Infarct expansion (hours to days)

Global remodelling (days to months)
Hypertensive Patients Are at Increased Risk for Cardiovascular Events.
36-Year Follow-up Framingham Study

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>Men</th>
<th>Women</th>
<th>Men</th>
<th>Women</th>
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<th>Women</th>
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<tr>
<td>Coronary Disease</td>
<td>22.7</td>
<td>11.8</td>
<td>12.4</td>
<td>9.1</td>
<td>6.2</td>
<td>3.8</td>
<td>4.9</td>
<td>5.3</td>
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<tr>
<td>Stroke</td>
<td>3.3</td>
<td>3.3</td>
<td>2.4</td>
<td>2.4</td>
<td>5.0</td>
<td>3.5</td>
<td>2.1</td>
<td>3.5</td>
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<td>Peripheral Artery Disease</td>
<td>6.3</td>
<td>4.2</td>
<td>7.3</td>
<td>7.3</td>
<td>9.9</td>
<td>3.5</td>
<td>13.9</td>
<td>7.3</td>
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<tr>
<td>Cardiac Failure</td>
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<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
<td>6.3</td>
<td>6.3</td>
<td>13.9</td>
<td>6.3</td>
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</tbody>
</table>

Risk Ratio: 2.0 2.2 3.8 2.6 2.0 3.7 4.0 3.0
Excess Risk: 22.7 11.8 9.1 3.8 4.9 5.3 10.4 4.2

Hypertension and Diabetes as Independent Risk Factors for Congestive Heart Failure: NHANES I Epidemiologic Follow-up Study

- 13,643 men and women without a history of CHF at baseline
- Risk factors measured in 1971 - 75
- Mean Follow-up, 19 ys
- 1,382 new cases of CHF

Ogden et al., Arch Intern Med 2001; 161:996

Multivariate analysis

Relative risk (95% CI)

Low physical activity

Cigarette smoking

Overweight

Hypertension

Diabetes
Conclusion: In this large prospective study, asymptomatic DM participants had

(1) more ischemia by MPI (26%) than by ECG during exercise (14%),

(2) more ischemia by MPI but not by ECG than a control group with other coronary risk factors

(3) ischemia by MPI was less in women than men.
Diabetes as a Risk Factor for Heart Failure

**Incidence**

Risk of developing HF in diabetes (Framingham, JAMA 1979)
- 4 fold increase in young diabetic males (≤ 65 years)
- 8 fold increase in young diabetic females (≤ 65 years)

**Prevalence**

Proportion of Patients with Diabetes

- SOLVD: 25%
- ATLAS: 20%
- RESOLVD: 27%
Prognostic Impact of Diabetes Mellitus According to the Etiology of Heart Failure

SOLVD Prevention

SOLVD Treatment

Dries et al., J Am Coll Cardiol 2001; 38:421
From Risk Factors to Heart Failure

Hypertension
Coronary artery disease
Diabetes
...

Remodeling stimuli
- Wall stress
- Cytokines
**Neurohormonal**
Oxidative stress

Myocyte hypertrophy
Altered interstitial matrix
Myocyte death
Fetal gene expression
Altered Ca^{++}-handling proteins

Ventricular enlargement
Systolic and diastolic dysfunction
Relationship Between Plasma Norepinephrine And Mortality

Cumulative mortality (%)

- PNE > 900 pg/ml
- PNE 600 - 900 pg/ml
- PNE < 600 pg/ml

Overall

\( P < 0.0001 \)

Francis et al. Circulation 1993; 87:140
**US Carvedilol Programme**

- **Survival**
  - Carvedilol (n=696)
  - Placebo (n=398)

**Risk reduction = 65%**

- Survival curve showing a significant difference with p<0.001.

**CIBIS-II**

- **Survival**
  - Bisoprolol
  - Placebo

**Risk reduction = 34%**

- Survival curve showing a significant difference with p<0.0001.

**COPERNICUS:**

- **Survival**
  - Carvedilol
  - Placebo

**Risk reduction = 35%**

- Survival curve showing a significant difference with p = 0.000013.

**MERIT-HF**

- **Mortality (%)**
  - Placebo
  - Metoprolol CR/XL

**Risk reduction = 34%**

- Mortality curve showing a significant difference with p=0.0062.

References:

- Packer et al (1996)
- Packer et al (2001)
- CIBIS-II Investigators (1999)
- The MERIT-HF Study Group (1999)
LV Remodelling and Inflammatory Mediators

- **Myocyte biology**
  - Hypertrophy
  - Contractile abnormalities
  - Fetal gene expression

- **Extracellular matrix**
  - MMPs activation
  - Degradation of ECM
  - Increased fibrosis

- **Myocyte loss**
  - Necrosis
  - Apoptosis
Hypertension
Coronary artery disease
Diabetes

Remodeling stimuli
- Wall stress
- Cytokines
- Neurohormonal
- Oxidative stress

Myocyte hypertrophy
- Altered interstitial matrix
- Myocyte death
- Fetal gene expression
- Altered Ca++-handling proteins

Ventricular enlargement
Systolic and diastolic dysfunction

From Risk Factors to Heart Failure
Increased LV Mass is a Potent Predictor of Mortality

Hypertension
Coronary artery disease
Diabetes

Remodeling stimuli
- Wall stress
- Cytokines
- Neurohormonal
- Oxidative stress

Myocyte hypertrophy
Altered interstitial matrix
Myocyte death
Fetal gene expression
Altered Ca^{++}-handling proteins

Systolic and diastolic dysfunction
Ventricular enlargement

From Risk Factors to Heart Failure
Mechanical Disadvantages
Created by LV Remodeling

- Increased wall stress (afterload)
- Afterload mismatch
  - LV wall thinning
- Subendocardial hypoperfusion
- Increased oxygen utilization
- Mitral regurgitation
  - Hemodynamic overloading
- Increased activation of “pathogenic” mechanisms
  - Stretch-activated genes (AII, endothelin, TNF)
  - Cell death (apoptosis)

Modified from Mann DL, Circulation 1999; 100:999
The Cascade of Advanced Heart Failure

- **Ageing of the population / ↑ treatment ↑ HF prevalence**
- **Use of neurohormonal antagonists / CRT ↓ mortality**

↓ ↓ ↓ patients with severe symptoms / poor QOL / high WHF mortality
Advanced Chronic HF

↑ Indication / Use of ICDs
↓ ↓ ↓ Sudden death
Review

Advanced chronic heart failure: A position statement from the Study Group on Advanced Heart Failure of the Heart Failure Association of the European Society of Cardiology

Marco Metra a,*, Piotr Ponikowski b, Kenneth Dickstein c, John J.V. McMurray d, Antonello Gavazzi e, Claes-Hakan Bergh f, Alan G. Fraser g, Tiny Jaarsma h, Antonis Pitsis i, Paul Mohacsi j, Michael Böhm k, Stefan Anker l,m, Henry Dargie n, Dirk Brutsaert o, Michel Komajda p on behalf of the Heart Failure Association of the European Society of Cardiology
Definition of ACHF

1. Severe symptoms of HF (NYHA class III or IV)
2. Episodes of fluid retention and/or peripheral hypoperfusion
3. Objective evidence of severe cardiac dysfunction
4. Severe impairment of functional capacity
5. History of ≥1 HF hospitalisation in the past 6 months
6. Presence of all the previous features despite “attempts to optimise” therapy

Metra et al. HFA SG on ACHF. Eur J Heart Fail 2007; 9:684
The Burden of Hospitalized HF patients

- Acute HF is the most common cause of admission at >65 ys.
- High mortality
  - In-hospital, 4-9%
  - 6-months post-discharge, 9-15%
- High rehospitalisation rates
  - 30-45% in the 6 months post-discharge

More Malignant Than Cancer? Five Years Survival Following a First Admission for HF in 1991

Stewart et al., Eur J Heart Fail 3:315;2001
Heart Failure in the New Millennium

Heart Failure remains one of the most

• common
• disabling
• deadly
• costly

medical conditions encountered by a wide range of physicians in both primary and secondary care

Chronic Heart Failure in the United States. A Manifestation of Coronary Artery Disease
Mihai Gheorghiade, MD; Robert O. Bonow, MD
Circulation 1998;97:282-289

<table>
<thead>
<tr>
<th>Year</th>
<th>n</th>
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<tr>
<td>VHEFT-1</td>
<td>1986</td>
<td>642</td>
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<tr>
<td>CONSENSUS</td>
<td>1987</td>
<td>253</td>
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<tr>
<td>Milrinone</td>
<td>1989</td>
<td>230</td>
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<tr>
<td>PROMISE</td>
<td>1991</td>
<td>1088</td>
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<tr>
<td>SOLVD-T</td>
<td>1991</td>
<td>2569</td>
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<tr>
<td>VHEFT-2</td>
<td>1991</td>
<td>804</td>
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<tr>
<td>SOLVD-P</td>
<td>1992</td>
<td>4228</td>
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<td>RADIANCE</td>
<td>1993</td>
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<td>Vesnarinone</td>
<td>1993</td>
<td>477</td>
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<td>CHF-STAT</td>
<td>1995</td>
<td>674</td>
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<td>Carvedilol</td>
<td>1996</td>
<td>1094</td>
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<tr>
<td>PRAISE</td>
<td>1996</td>
<td>1153</td>
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<tr>
<td>DIG</td>
<td>1997</td>
<td>6800</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>20190</strong></td>
<td><strong>13789</strong></td>
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Diagnosis

- The key investigations are:
  - **echocardiography** to demonstrate structural heart disease
  - **electrocardiography (ECG)** to show rhythm, rate, and conduction
  - **chest radiography** to exclude primary pulmonary disease and identify oedema
  - **blood chemistry; and haematology.**
  - There is growing interest in use of **MRI** in heart failure.

*McMurray & Pfeffer. Lancet May 28, 2005; 365:1877*
28/11/2006
EF=13%
EDV=350 ml

10/07/2007
Ef=60%
EDV=110 ml

Nuclear cardiology and heart failure.
Giubbini R, Milan E, Bertagna F, Mut F, Metra M, Rodella C, Dondi M.
Goals of imaging

- To evaluate (measure) LV performance
- To stratify Pt prognosis
- To predict efficacy of Tx
Differential Effects of β-Blockers in Patients With Heart Failure: A Prospective randomized, Double-Blind Comparison of the Long-Term Effects of Metoprolol Versus Carvedilol

Metra M, Giubbin R. Circulation 2000;102;546-551
• True 3-D
• Fully automated,
• operator independent
• No body size and shape limitations, no contraindications for contrast media
• reliable evaluation of
  LV volumes and mass
  EF
  RWM
  Syncronism of contraction

• The Emory Cardiac Toolbox™ option developed at Emory University
• Quantitative Gated SPECT option developed by Cedars-Sinai Medical Center
• 4D-MSPECT, developed at the University of Michigan Medical Center in Ann Arbor,
Left ventricular shape index assessed by gated stress myocardial perfusion SPECT

For each short axis plane in the end-diastolic (ED) image series, maximum dimension (A) of the LV is found from the 3D contours derived by the QGS algorithm, using the endocardial surface as the boundary. Global short-axis end-diastolic dimension (AED) is found as a maximum for all ED short axis slices. The short-axis slice and direction of AED is then used to calculate the maximum short-axis end-systolic dimension (AES) in the end-systolic image series, by measuring the distance between the endocardial points in the identical location (slice and direction) where AED was found.

The long-axis dimension of the myocardium is derived by calculating the distance (B) between the most apical point on the endocardial surface and the center of the valve plane. The ED long-axis dimension (BED) is calculated independently from the ES long-axis dimension (BES).

The diastolic shape index (LVSI) and the systolic shape index (LVSII) are derived by AED/BED and AES/BES, respectively.
A. NORMAL SHAPE INDEX

B. ABNORMAL SHAPE INDEX

EF = 29%; EDV = 182; ESV = 129; SSS = 30; LVSIs = 0.51
No CHF

EF = 26%; EDV = 174; ESV = 129; SSS = 19; LVSIs = 0.66
Severe CHF

LVSI in prediction of CHF hospitalization

Gated 99mTc-MIBI SPECT: MRI Validation

Inter-institution variability of EF and volumes by GSPECT: a multicentre study involving 106 hospitals

Relationship of Tc-99m tetrofosmin rest GSPECT MPI to death and hospitalization in HF pts: results from the nuclear ancillary study of the HF-ACTION trial

Relationship of Tc-99m tetrofosmin rest GSPECT MPI to death and hospitalization in HF pts: results from the nuclear ancillary study of the HF-ACTION trial

Prediction of MI vs. Cardiac Death by G-SPECT: Risk Stratification by the Amount of Stress-Induced Ischemia and the Poststress EF

A

Cardiac Death (%/year)

<table>
<thead>
<tr>
<th></th>
<th>EF&gt;50%</th>
<th>EF 30-50%</th>
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<tbody>
<tr>
<td>No ischemia</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Mild/Mod</td>
<td>0.7</td>
<td>*2.2</td>
</tr>
<tr>
<td>Large</td>
<td>*1.3</td>
<td>**2.5</td>
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</table>

# patients

1231 155 447 184 278 235

B

Cardiac Death (%/year)

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No ischemia</td>
</tr>
<tr>
<td>Mild/Mod</td>
</tr>
<tr>
<td>Large</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>39</td>
</tr>
<tr>
<td>49</td>
</tr>
<tr>
<td>68</td>
</tr>
</tbody>
</table>

# patients

7.5 6 10.3
Cine MR could be an optimal technique:

- Standard for LV function evaluation

- The late enhancement (LGE) technique is an excellent way to assess viability in both acute and chronic MI

- The LGE delineates inflammatory tissue with high spatial resolution allowing to recognize the typical pattern of inflammatory lesions and also enables accurate follow-up studies to assess responsiveness to treatment

- Conventional gadolinium-based CM exhibit a high affinity to the amyloid material, which results in specific CM kinetics. These CM kinetics can easily be assessed by the LGE technique and yield sensitivities and specificities for the diagnosis of cardiac amyloidosis of 80 and 94%, respectively

- CHF due to iron overload is the most frequent reason causing death in thalassaemia patients. T*2 measurements are now generally accepted as the method of choice to guide chelation therapy which could dramatically decrease the global and cardiac death rate.

Cine MR could be an optimal technique, but....
Primary prevention with ICD in chronic heart failure & LV dysfunction: 2005 Guideline Updates

- **ESC**: ICD therapy is reasonable
  - Selected patients with LVEF ≤ 30–35%
  - > 40 days post-MI
  - Optimal background therapy (appropriate ACE-i, ARB, BB, and AA)

- **ACC/AHA**: ICD is recommended
  - Patients with nonischemic cardiomyopathy or IHD
  - ≥40 days post-MI
  - LVEF ≤ 30%
  - NYHA class II or III

*Swedberg et al., Eur Heart J. 2005;26:1115-40*
*Hunt et al., Circulation. 2005;112*
The Diagnostic Burden of HF

“2002 ESC Guidelines Heart Failure”

Symptoms + LV Systolic Dysfunction

Asymptomatic LV Systolic Dysfunction
Prevalence of Echo-determined LV Systolic Dysfunction Among 433 >75-Year-old Subjects

Hedberg et al., EHJ 2001; 22:676
Effect of enalapril on 12-year survival and life expectancy in patients with left ventricular systolic dysfunction: a follow-up study

Jong P, Yusuf S, Rousseau MF, Ahn SA, Bangdiwala SI
The Lancet - Vol. 361, Issue 9372, 31 May 2003, Pages 1843-1848
Euroheart Failure
Distribution of ejection fraction

11,015 patients in 115 hospitals in 24 countries

Percentage of patients

- **LVEF <40%:**
  - 51% of men
  - 28% of women

Left Ventricular Ejection Fraction (%)

Cleland et al Euroheart Survey EHJ 2003
Transient LV dilation

- Rest
- Stress

Functional ischemia of subendocardial layer due to hypertrophy

Mild to moderate ischemia

LV stunning due to severe ischemia
The Diagnostic Burden of HF

“2002 ESC Guidelines Heart Failure”
Symptoms + LV Systolic Dysfunction

Asymptomatic LV Systolic Dysfunction

LV Diastolic dysfunction
LV systolic and diastolic dyssynchrony as assessed by multi-harmonic phase analysis of GSPECT MPI in pts with end-stage renal disease and normal LVEF.

LV systolic and diastolic dyssynchrony as assessed by multi-harmonic phase analysis of GSPECT MPI in pts with end-stage renal disease and normal LVEF

• HF with symptoms and depressed LV Function
• Asymptomatic LV dysfunction
• HF with preserved systolic function and Diastolic dysfunction
Delay in Revascularization Is Associated With Increased Mortality Rate in Patients With Severe Left Ventricular Dysfunction and Viable Myocardium on Fluorine 18-Fluorodeoxyglucose Positron Emission Tomography Imaging

Myocardial Viability PET Study

University of Ottawa Heart Institute
Cardiac PET Centre

Beanlands R Circulation 1998;98(19S)
Prognostic value of tomographic rest-redistribution Tl-201 imaging in medically treated patients with coronary artery disease and left ventricular dysfunction

J Nucl Cardiol 1996; 3:150-6

Mantel-Cox = 5
P = 0.03
Sensitivity, specificity, and predictive accuracies of non-invasive tests, singly and in combination, for diagnosis of hibernating myocardium

MIBG

- Metaiodobenzilguanidine (MIBG) is an analogue of the false neurotransmitter guanetididine, a potent neuron blocking agent that acts selectively on sympathetic nerves.
- MIBG and noradrenaline have a similar molecular structure and share the same uptake and storage mechanisms in the sympathetic nerve endings.
- MIBG is not metabolized by monoamine oxidase; thus, localization of MIBG relates to the presence of sympathetic nerves and to tissue noradrenaline content.
- MIBG is currently labelled with 123-I for diagnostic purposes and with 131-I for therapy.
I-123-\textit{mIBG} myocardial imaging for assessment of risk for a major cardiac event in HF Pts

I-123-\textit{m}IBG myocardial imaging for assessment of risk for a major cardiac event in HF Pts

I-123-\textit{mIBG} myocardial imaging for assessment of risk for a major cardiac event in HF Pts

Univariate analysis with Cox proportional hazard model for prediction of cardiac events in each cardiac diseases

<table>
<thead>
<tr>
<th>Event/N</th>
<th>WR</th>
<th>H/M</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Exp</td>
<td>95% CI</td>
</tr>
<tr>
<td>Whole</td>
<td>1.026</td>
<td>1.015–1.037</td>
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<tr>
<td>IHD</td>
<td>1.022</td>
<td>1.005–1.039</td>
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<td>HCM</td>
<td>1.043</td>
<td>1.011–1.077</td>
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<td>DCM</td>
<td>1.047</td>
<td>1.023–1.072</td>
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<tr>
<td>HHD</td>
<td>0.821</td>
<td>0.609–1.106</td>
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<td>1.007</td>
<td>0.978–1.028</td>
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<tr>
<td>PVD</td>
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<tr>
<td>VTF</td>
<td>0.996</td>
<td>0.983–1.010</td>
</tr>
</tbody>
</table>

CHF congestive heart failure, MI myocardial infarction, IHD ischemic heart disease, HCM hypertrophic cardiomyopathy, DCM dilated cardiomyopathy, HHD hypertensive heart disease, VVD volume-load valvular disease, PVD pressure-load valvular disease, VTF ventricular tachycardia or fibrillation, UAP unstable angina pectoris

I-123 MIBG imaging and heart rate variability analysis to predict the need for an implantable cardioverter defibrillator

Denervation in areas of myocardial viability

MIBG power to predict ICD shock

- **HMR** of less than 1.95
- **plasma BNP level** of more than 187 pg/mL
- **LVEF** of less than 50%
- **positive predictive values**
  - 82% (MIBG-HMR + BNP)
  - 58% (MIBG-HMR + LVEF)
- **negative predictive values**
  - 73% (MIBG-HMR + BNP)
  - 77% (MIBG- + LVEF);

Candesartan and Sympathetic Nerve Activity

Kasama et al. JACC Vol. 45, No. 5, 2005:661-7
Attività somministrata: 370 MBq
Acquisizione precoce: 28/11/2006 10.51

<table>
<thead>
<tr>
<th>Metodo 1</th>
<th>Precoce</th>
<th>Tardiva</th>
<th>Metodo 3</th>
<th>Precoce</th>
<th>Tardiva</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cuore</td>
<td>Mediastino</td>
<td>Cuore</td>
<td>Mediastino</td>
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<tr>
<td>Totale</td>
<td>107306</td>
<td>71225</td>
<td>58279</td>
<td>49346</td>
<td>715328</td>
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<tr>
<td>Minimo</td>
<td>527</td>
<td>298</td>
<td>268</td>
<td>202</td>
<td>363</td>
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<td>Massimo</td>
<td>768</td>
<td>446</td>
<td>420</td>
<td>322</td>
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<td>Area</td>
<td>167</td>
<td>192</td>
<td>168</td>
<td>193</td>
<td>1330</td>
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Conteggi corretti per il decadimento

<table>
<thead>
<tr>
<th>Metodo 1</th>
<th>Precoce</th>
<th>Tardiva</th>
<th>Metodo 3</th>
<th>Precoce</th>
<th>Tardiva</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Cuore</td>
<td>Mediastino</td>
<td>Cuore</td>
<td>Mediastino</td>
<td>Cuore</td>
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<tr>
<td>CD/MBq</td>
<td>1,74</td>
<td>1,00</td>
<td>1,15</td>
<td>0,85</td>
<td>1,45</td>
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</table>

Cardiac I-123 MIBG

<table>
<thead>
<tr>
<th>Parametro</th>
<th>Metodo 1 Media ± SD</th>
<th>Metodo 3 Media ± SD</th>
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</thead>
<tbody>
<tr>
<td>Washout</td>
<td>33,6% 23,0 ± 6,4</td>
<td>28,9% 22,3 ± 8,1</td>
</tr>
<tr>
<td>H Precoce</td>
<td>1,74 1,48 ± 0,25</td>
<td>1,45 2,01 ± 0,43</td>
</tr>
<tr>
<td>H Tardiva</td>
<td>1,15 0,93 ± 0,22</td>
<td>1,03 1,30 ± 0,30</td>
</tr>
<tr>
<td>M Precoce</td>
<td>1,00 0,77 ± 0,12</td>
<td>1,00 0,91 ± 0,15</td>
</tr>
<tr>
<td>M Tardiva</td>
<td>0,85 0,47 ± 0,10</td>
<td>0,85 0,58 ± 0,10</td>
</tr>
<tr>
<td>H/M Precoce</td>
<td>1,73 1,89 ± 0,14</td>
<td>1,45 2,15 ± 0,30</td>
</tr>
<tr>
<td>H/M Tardiva</td>
<td>1,36 1,93 ± 0,16</td>
<td>1,22 2,16 ± 0,17</td>
</tr>
<tr>
<td>Parametro</td>
<td>Metodo 1</td>
<td>Metodo 3</td>
</tr>
<tr>
<td>----------------</td>
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<td>----------</td>
</tr>
<tr>
<td></td>
<td>Media ± SD</td>
<td>Media ± SD</td>
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<tr>
<td></td>
<td>H Precoce</td>
<td>H Tardiva</td>
</tr>
<tr>
<td>Washout</td>
<td>22,1% 23,0 ± 6,4</td>
<td>22,2% 22,3 ± 8,1</td>
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<tr>
<td>H Precoce</td>
<td>1,14 1,48 ± 0,29</td>
<td>0,98 2,01 ± 0,43</td>
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<tr>
<td>H Tardiva</td>
<td>0,89 0,93 ± 0,22</td>
<td>0,76 1,30 ± 0,30</td>
</tr>
<tr>
<td>M Precoce</td>
<td>0,55 0,77 ± 0,12</td>
<td>0,55 0,91 ± 0,15</td>
</tr>
<tr>
<td>M Tardiva</td>
<td>0,51 0,47 ± 0,10</td>
<td>0,51 0,58 ± 0,10</td>
</tr>
<tr>
<td>H/M Precoce</td>
<td>2,07 1,89 ± 0,14</td>
<td>1,78 2,15 ± 0,30</td>
</tr>
<tr>
<td>H/M Tardiva</td>
<td>1,74 1,93 ± 0,16</td>
<td>1,50 2,16 ± 0,17</td>
</tr>
</tbody>
</table>
• Both Viability and LV Innervation studies may be important for prognostic stratification
Survival benefit after revascularization is independent of left ventricular ejection fraction improvement in patients with previous myocardial infarction and viable myocardium

<table>
<thead>
<tr>
<th>Variable</th>
<th>chi²</th>
<th>Hazards ratio</th>
<th>95% CI</th>
<th>P value</th>
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<tbody>
<tr>
<td>Ejection fraction at baseline</td>
<td>1.4</td>
<td>1.0</td>
<td>0.9–1.1</td>
<td>0.2</td>
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<tr>
<td>Viable segments</td>
<td>6.7</td>
<td>1.2</td>
<td>1.1–1.5</td>
<td>&lt;0.01</td>
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<tr>
<td>Non-viable segments</td>
<td>0.1</td>
<td>0.9</td>
<td>0.7–1.2</td>
<td>0.8</td>
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<td>Coronary revascularization</td>
<td>12.2</td>
<td>0.3</td>
<td>0.1–0.6</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

123I-MIBG washout rate value and 18F-FDG PET/CT score: useful tools to predict beta-blocker therapy outcome in congestive heart failure?
Forecasts...

- Prevalence
  - Increasing

- Hospitalizations
  - Increasing

- Economic impact
  - Severely increasing

- Mortality
  - Likely decreasing (slightly)

- Quality of life
  - ??
Nuclear Cardiology and HF

GSPECT ?

MIBG ?

PET-FDG ?
When you are in deep trouble, look straight ahead, keep your mouth shut and say nothing!

Thanks!