Evaluation of Left Ventricular Systolic Function Using TEE

Tamas Seres, M.D.
UCHSC

Myocardial Remodeling

- Cardiac remodeling is thought to be an important aspect of disease progression in HF regardless of cause.
- It is manifested clinically by changes in cardiac size, shape, and function in response to cardiac injury or increased load.

Myocardial Remodeling

- Remodeling can be a physiologic or pathologic condition:
  - Physiologic remodeling is a compensatory change in the proportions and function of the heart; this type of remodeling is seen in athletes.

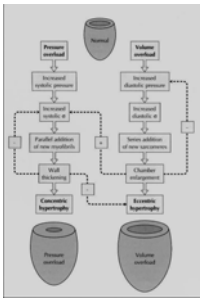
Myocardial Remodeling

- Pathologic remodeling may occur:
  - After myocardial infarction
  - With pressure overload (eg, aortic stenosis, hypertension)
  - Inflammatory myocardial disease (myocarditis)
  - With idiopathic dilated cardiomyopathy
  - With volume overload (eg. valvular regurgitation)

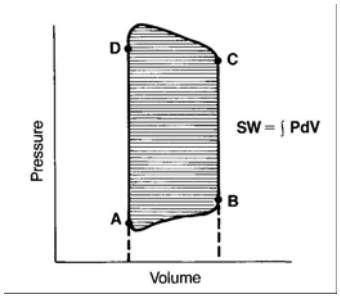
Myocardial Remodeling

- Altered loading conditions (eg, increased preload) stretch cell membranes and increase wall stress, which may play a role in inducing the expression of hypertrophy associated genes.
- In cardiac myocytes, this may lead to the synthesis of new contractile proteins and the assembly of new sarcomeres.

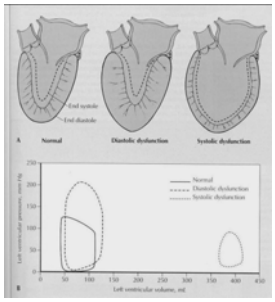
Myocardial Remodeling



Pressure-Volume Loop



Myocardial Remodeling



Systolic Dysfunction

- Systolic dysfunction, is characterized by progressive chamber dilation, eccentric remodeling, and abnormalities in systolic function.

Definition of HF

- Heart failure (HF) is a complex clinical syndrome that can result from any structural or functional cardiac disorder that impairs the ability of the ventricle to fill with or eject blood.

Definition of HF

- HF is characterized by specific symptoms, such as dyspnea and fatigue, and signs, such as fluid retention.

Definition of HF

- There are two basic pathophysiologic mechanisms by which reduced cardiac output and HF occur:
  - Systolic dysfunction
  - Diastolic dysfunction

Definition of Systolic HF

- Systolic HF is a complex clinical syndrome that can result from any structural or functional cardiac disorder that impairs the ability of the ventricle to eject blood.

NYHA functional class

- Class I — No limitation during ordinary activity
- Class II — Slight limitation by shortness of breath and/or fatigue during moderate exertion or stress
- Class III — Symptoms with minimal exertion that interfere with normal daily activity
- Class IV — Inability to carry out any physical activity; these patients typically have marked neurohumoral activation and muscle wasting.

Stages of HF

- Stage A — High risk for HF, without structural heart disease or symptoms
- Stage B — Heart disease with asymptomatic left ventricular dysfunction
- Stage C — Prior or current symptoms of HF
- Stage D — Advanced heart disease and severely symptomatic or refractory HF

Stages of HF

- This staged system, in contrast to the NYHA classification, emphasizes the progressive nature of HF and defines the appropriate therapeutic approach for each stage.

Predicting Survival of Patients with Systolic HF

1. High New York Heart Association (NYHA) functional class
2. Reduced left ventricular ejection fraction (LVEF) and reduced cardiac index (CI)
3. Concomitant diastolic dysfunction, as established by a mitral flow velocity pattern on Doppler echocardiogram

Predicting Survival in Patients with Systolic HF

4. QRS prolongation and LBBB
5. Reduced right ventricular function
6. Enlarged EDV
7. Enlarged ESV
8. Regional Wall Motion Abnormality

NYHA Functional Class

- Prospective studies evaluating the use of ACE inhibitors have demonstrated a strong relationship between the functional class and mortality
- These findings in control groups not receiving an ACE inhibitor can be summarized as follows:

NYHA Functional Class

- Asymptomatic patients (class I) have a 1 and 4 year mortality rate of 5 and 19 %.

  N Engl J Med 1992; 327: 685-91.
- Patients with NYHA class II or III have a 1 and 4 year mortality rate of 15 and 40 %.

  N Engl J Med 1991; 325: 293-302.
- Patients with NYHA class IV have a 6 and 12 month mortality rates of 44 and 64 %.

  N Engl J Med 1987; 316: 1429-35.

NYHA Functional Class

- These observations indicate the importance of early treatment of HF in an attempt to slow progression to more severe disease.

Left Ventricular Ejection Fraction

- Clinically evident HF due to systolic dysfunction is generally not apparent until the LVEF falls below 35 to 40 percent, as determined by echocardiography or contrast or radionuclide angiography.

Left Ventricular Ejection Fraction

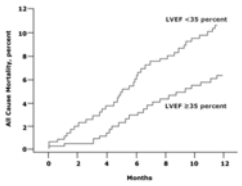
- There is no predictable relationship between symptoms or exercise tolerance and the LVEF.
- Some patients are asymptomatic with an LVEF below 20 percent, while others are moribund with an LVEF above 30 percent.

Left Ventricular Ejection Fraction

- In general, survival is shorter in patients with lower LVEFs.
- An LVEF below 20 percent is typically associated with poor survival.
- Some recommend cardiac transplantation in all such patients who are eligible.

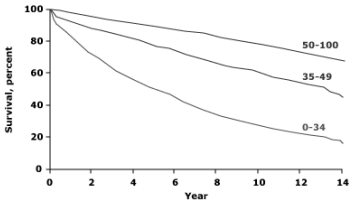
  Am J Cardiol 1990; 65: 903-8.

All-Cause Mortality and EF



J Am Coll Cardiol 2000; 35:1237.

Survival in Coronary Heart Disease is Related to LVEF in the CASS Trial

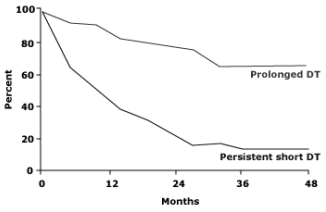


Circulation 1994; 90: 2645.

Concomitant Diastolic Dysfunction

- Concomitant diastolic dysfunction is associated with decreased survival among patients with HF and a reduced LVEF.

Transmitral Deceleration Time Predicts Outcome in Congestive Heart Failure



J Am Coll Cardiol 1998; 31:1591.

Systolic HF and Restrictive Pattern

- The role of the restrictive pattern comes from a study of 144 patients with HF who initially had a restrictive pattern on Doppler echocardiography.
- This test was repeated after six months of optimal medical therapy that included digoxin, diuretics, an ACE inhibitor, and a beta blocker.

Systolic HF and Restrictive Pattern

- At a mean follow-up of 26 months, patients with reversal of the restrictive pattern at six months had a lower cardiac mortality (11 versus 37%) and a lesser likelihood of being admitted to the hospital for worsening of HF (11 versus 54%) than those with persistence of the restrictive pattern.

J Am Coll Cardiol 1998; 31:1591-7.

Systolic HF and Restrictive Pattern

- The effect of dobutamine stress on a restrictive pattern also appears to have prognostic value.
- This was illustrated in a review of 69 patients with ischemic dilated cardiomyopathy: 42 had a restrictive left ventricular filling at rest, which reverted to a nonrestrictive pattern in 24.

Systolic HF and Restrictive Pattern

- Patients with a persistent restrictive pattern had a significantly lower rate of survival at 3 years compared to those with a reversible restrictive pattern or those with a nonrestrictive pattern at rest (49 versus 79 and 89 %, respectively).
- Persistence of the restrictive pattern was associated with a marked rise in left atrial pressure and a markedly attenuated inotropic response.

J Am Coll Cardiol 2005; 46: 488-96.

QRS prolongation and LBBB

- A QRS duration ≥ 120 msec is associated with a significant increase in both arrhythmic and nonarrhythmic mortality in patients with HF.
- The worse outcomes are due in part to ventricular dyssynchrony resulting from the conduction defect.
- Many such patients are treated with cardiac resynchronization (biventricular pacing), since randomized trials have shown a clear survival benefit.

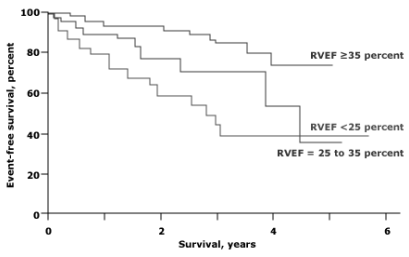
Am Heart J 2002;143: 398-405.

Right ventricular function

- Right ventricular systolic dysfunction also may contribute to prognosis in patients with HF.
- Echocardiographic measurements of reduced right ventricular function include a reduction in right ventricular ejection fraction (RVEF), right ventricular enlargement, and tricuspid regurgitation.

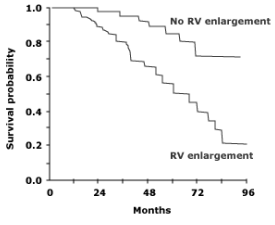
Eur Heart J 1997;18: 276-80.

Right Ventricular EF Predicts Outcome in CHF



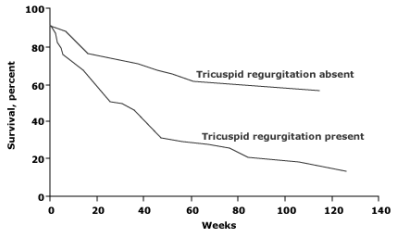
J Am Coll Cardiol 1998; 32:948.

Right Ventricular Enlargement Increases Mortality in DCM



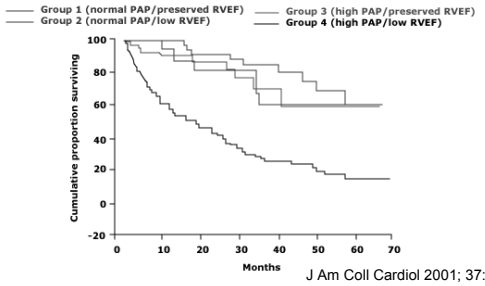
Am J Cardiol 1997; 80:1583.

Tricuspid Regurgitation Predicts Poorer Outcome in CHF



Am J Cardiol 1998; 82:1301.

Right Ventricular Dysfunction Predicts Poor Outcome only when Associated with Elevated Pulmonary Pressures



J Am Coll Cardiol 2001; 37:183.

EDV and HF

Echocardiographic Predictors of Outcome in 336 Patients with Advanced HF

- LV end-diastolic volume index (>120 ml/m^2)
- Mitral deceleration time (<150 ms)
- Vena contracta width of MR (>0.4 cm)

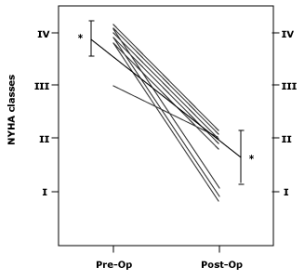
Echocardiographic Predictors of Outcome in Advanced HF

- These variables indicate that LV remodeling, increased LV stiffness, and MR are independent predictors of outcome in patients with advanced HF.

J Am Coll Cardiol, 2005; 45:1064-1071

MR and HF

Mitral Valve Repair for MR in Heart Failure Improves Symptoms at 17 Weeks



Am Heart J 1995; 129:1165.

MR and HF

- At long-term follow-up of 419 patients, there was no significant difference in patients who did or did not undergo mitral valve repair in terms of mortality (48 versus 38% with medical therapy alone) or in the combined end point of death, implantation of a left ventricular assist device, or urgent heart transplantation (49 versus 41%).

J Am Coll Cardiol 2005; 45: 381-7.

MR and HF

- The 2006 Heart Failure Society of America (HFSA) practice guidelines note that isolated mitral valve repair or replacement for severe mitral regurgitation secondary to ventricular dilatation in the presence of severe LV systolic dysfunction is not generally recommended.

J Card Fail 2006:12:e1

ESV and HF

- End-systolic volume index is the major predictor of survival after coronary artery bypass graft surgery in 193 patients with impaired left ventricular function (EF ≤ 40%).

Circulation 1994; 90: 2899-2904.

Regional Wall Motion Abnormality

- The presence of qualitative WM abnormalities has been demonstrated to be an independent predictor of cardiovascular events in groups of patients with myocardial infarction (MI), unstable angina, typical chest pain, and congestive heart failure (CHF).

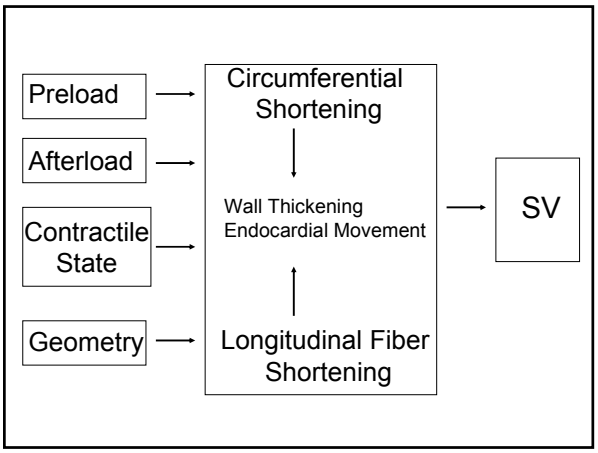
Circulation. 2007;116:143-150.

Regional Wall Motion Abnormality

- Echocardiographic left ventricular WM abnormalities in adults without overt cardiovascular disease are associated with 2.4- to 3.4-fold higher risks of cardiovascular morbidity and mortality, independent of established risk factors.

Circulation. 2007;116:143-150

TEE Characterization of Patients with Systolic Dysfunction in the OR



TEE Parameters to Characterize Systolic Dysfunction

- EDV
- ESV
- SV
- EF
- CO/CI
- Regional Wall Motion Abnormality
- Valvular Function
- RV Function
- Diastolic Function