

Pathophysiology of Heart Failure

Valorie Speegle-Snell, BSN, RN, ACM

October 9, 4014

Objectives

- Describe the clinical presentation of a patient in left sided HF and right sided HF
- Describe the physiological and treatment differences between systolic and diastolic heart failure
- Describe S/S of worsening Heart Failure

Definition of Heart Failure

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

AHA / ACC HF Guidelines 2001

Clinical symptoms / signs secondary to abnormal ventricular function

ESC HF Guidelines 2001

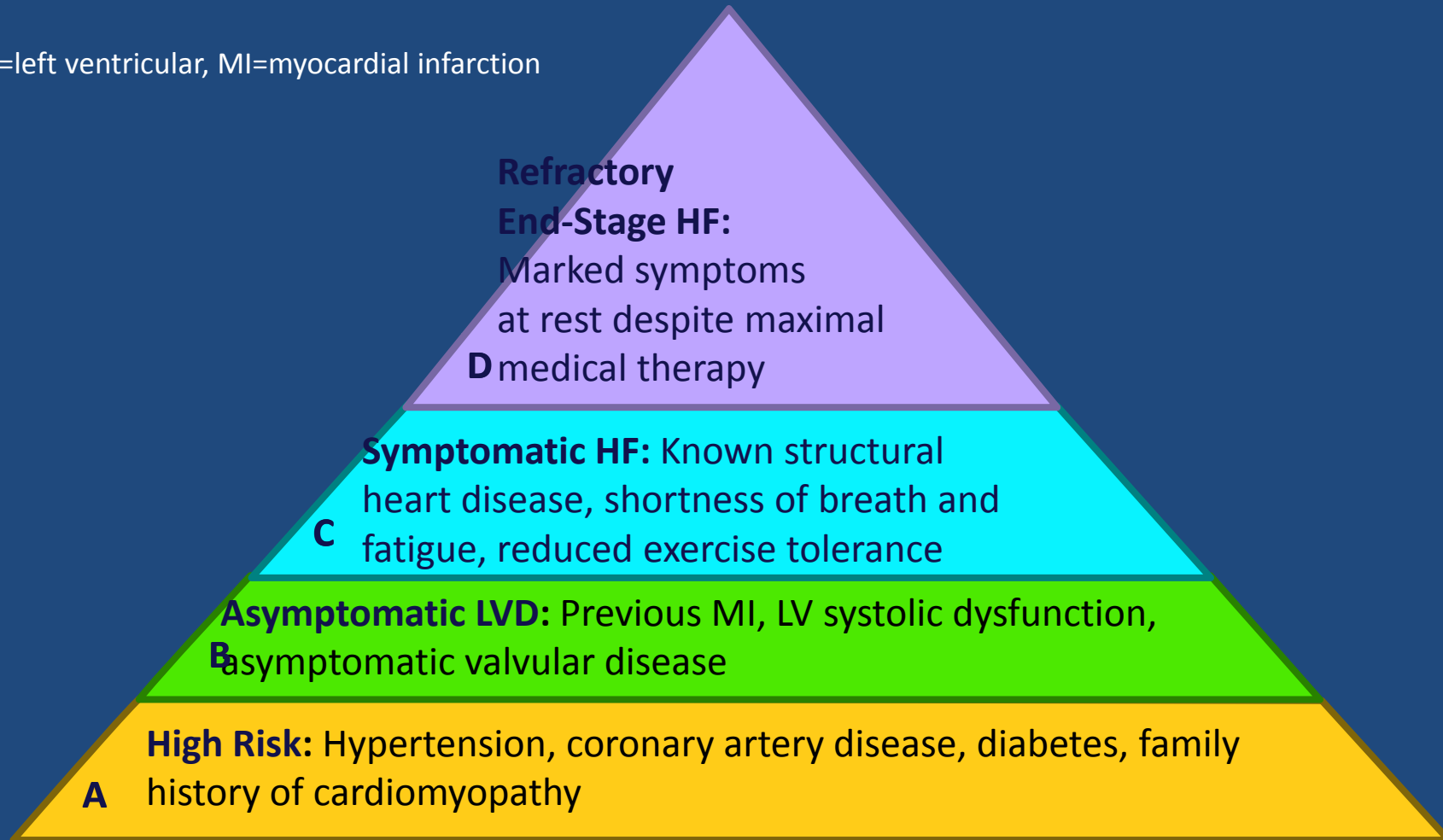
Acute Decompensated Heart Failure

HF, a complex clinical syndrome, can result from any structural or functional cardiac disorder that impairs ability of ventricle to fill with or eject blood.

Cardinal symptoms are fatigue and dyspnea, and clinical signs are fluid retention and exercise intolerance

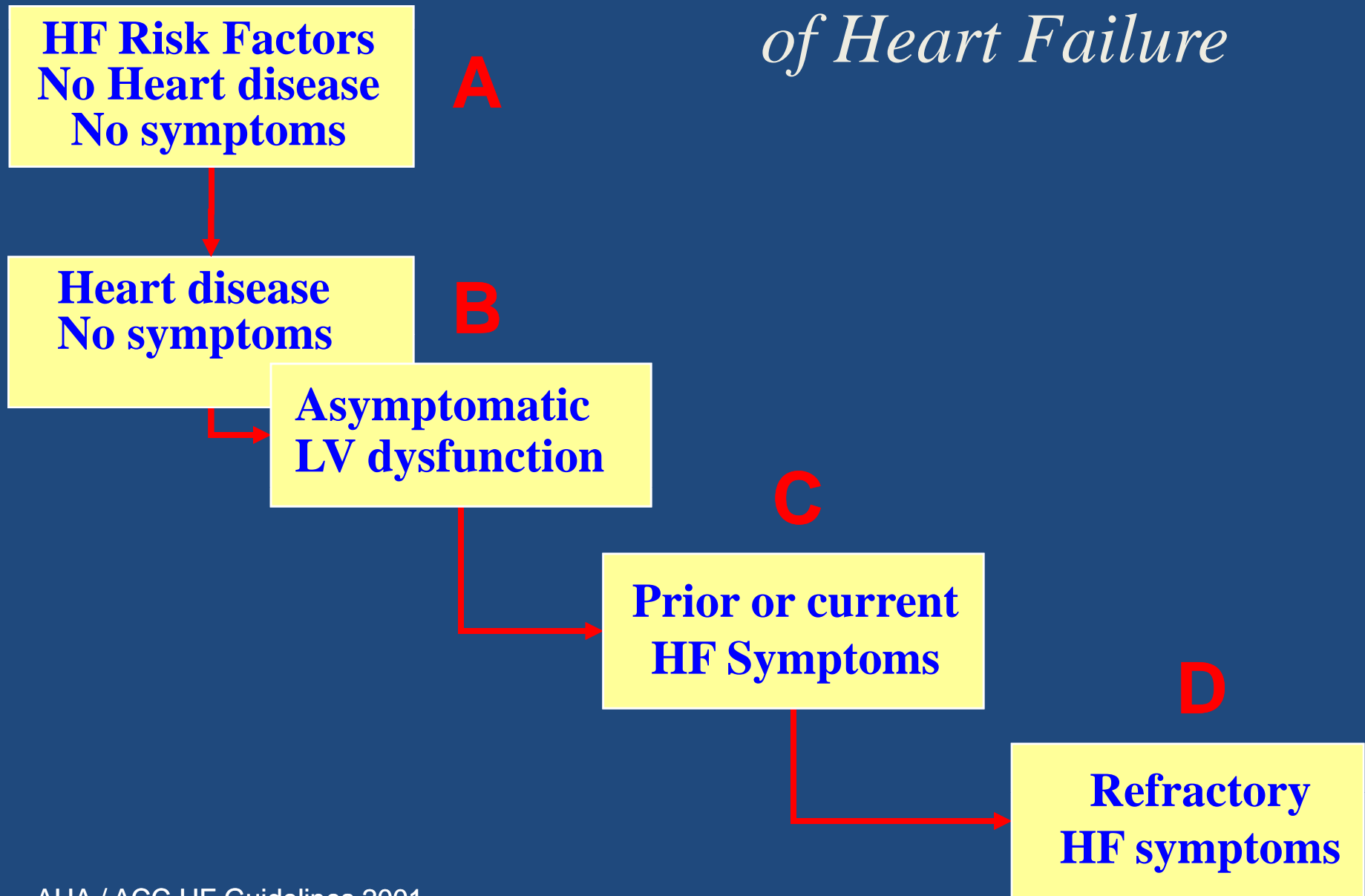
Heart Failure Disease Progression: ACC/AHA Heart Failure Stages

LV=left ventricular, MI=myocardial infarction

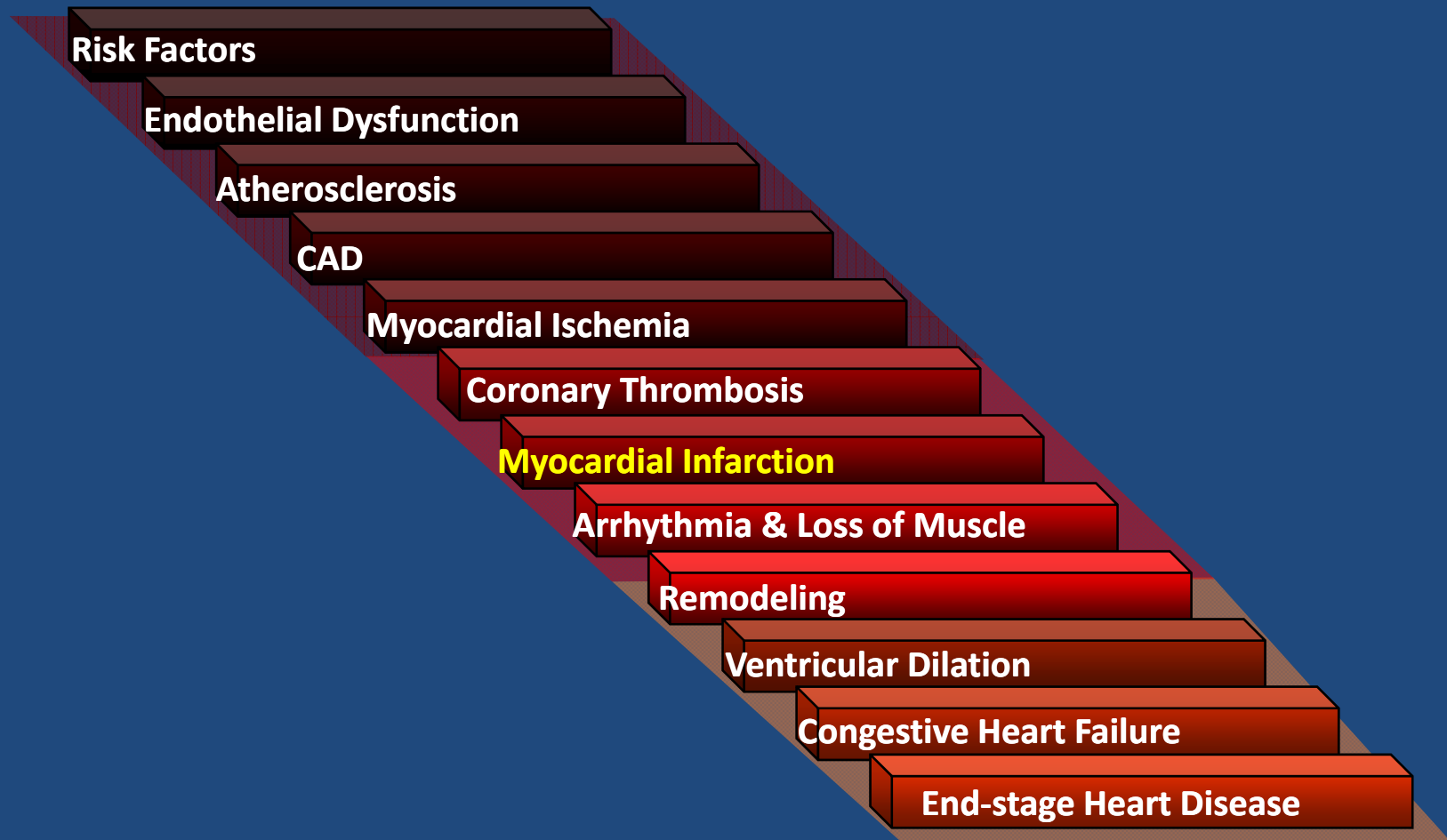


Reference: Adapted from Jessup M et al. *NEJM*. 2003;348:2007-18.

Stages in the Evolution of Heart Failure



Stairway to Heaven...



2006 HFSA Comprehensive Heart Failure Practice Guideline. *JCF* 2006;6:1e-199e.

ACC/AHA 2005 Guideline Update for the Diagnosis and Management of Chronic Heart Failure in the Adult. *Circulation* 2005;112:1825-1852.

The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure: The JNC 7 Report *JAMA* 2003;289(19):2560-71.

A Growing Medical Challenge

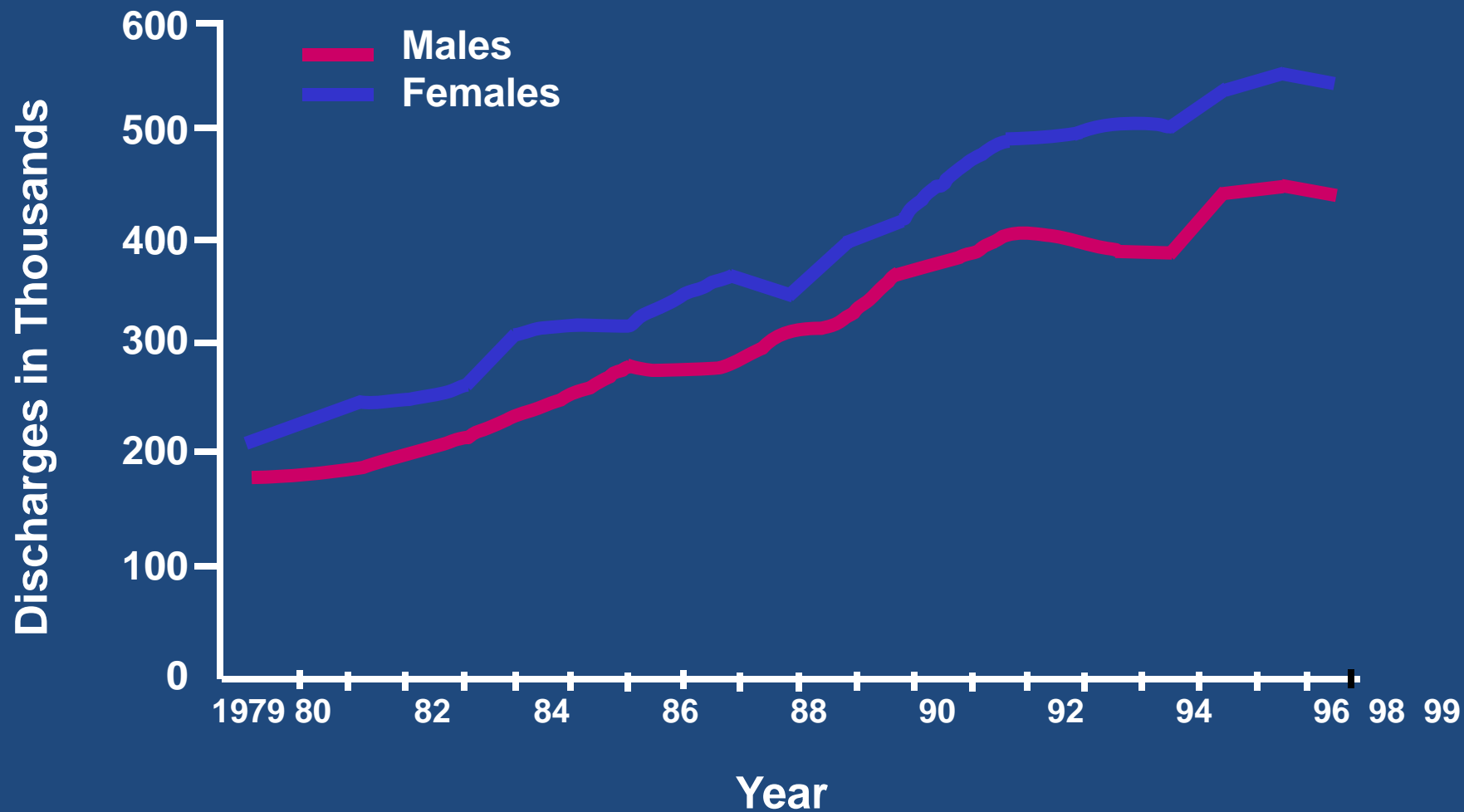
- Compliance is tremendous problem
- 50% of patients have 3 or more comorbidities
- Average of 6 medications
- 78% have at least 2 hospitalizations a year
- 10% complete their annual prescription regimen
- 33% never refilled any HF prescription!

Are we victims of our own success?

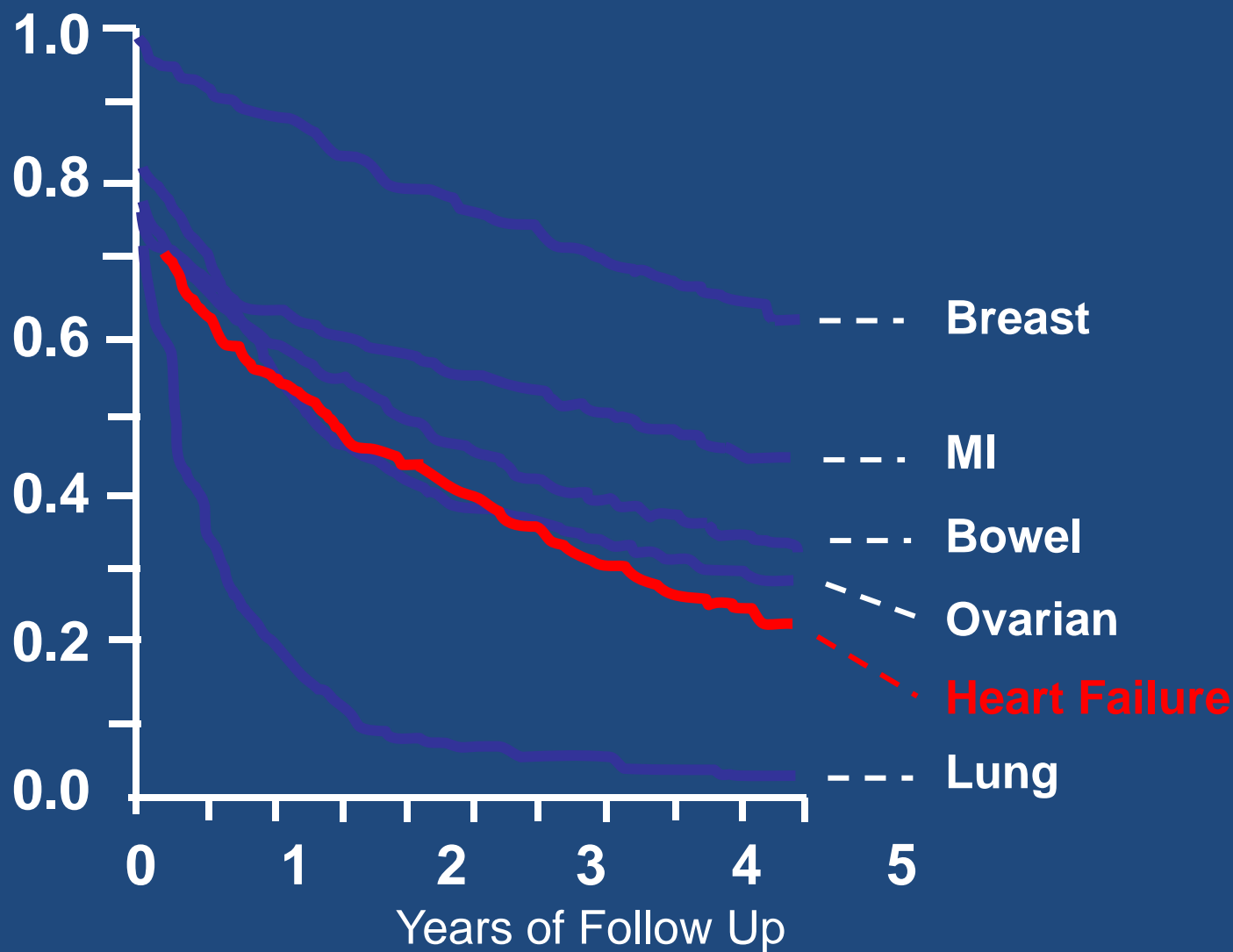
- Major advances in :
 - Prevention of disease
 - Revascularization
 - Understanding of molecular and hormonal processes of cardiovascular disease
 - More people survive MI, CAD, valvular disease and SCD to then develop HF

HOSPITAL DISCHARGES FOR CHF BY SEX

(U.S. 1979-99)



SURVIVAL IN WOMEN: HF versus CANCER



Ejection Fraction

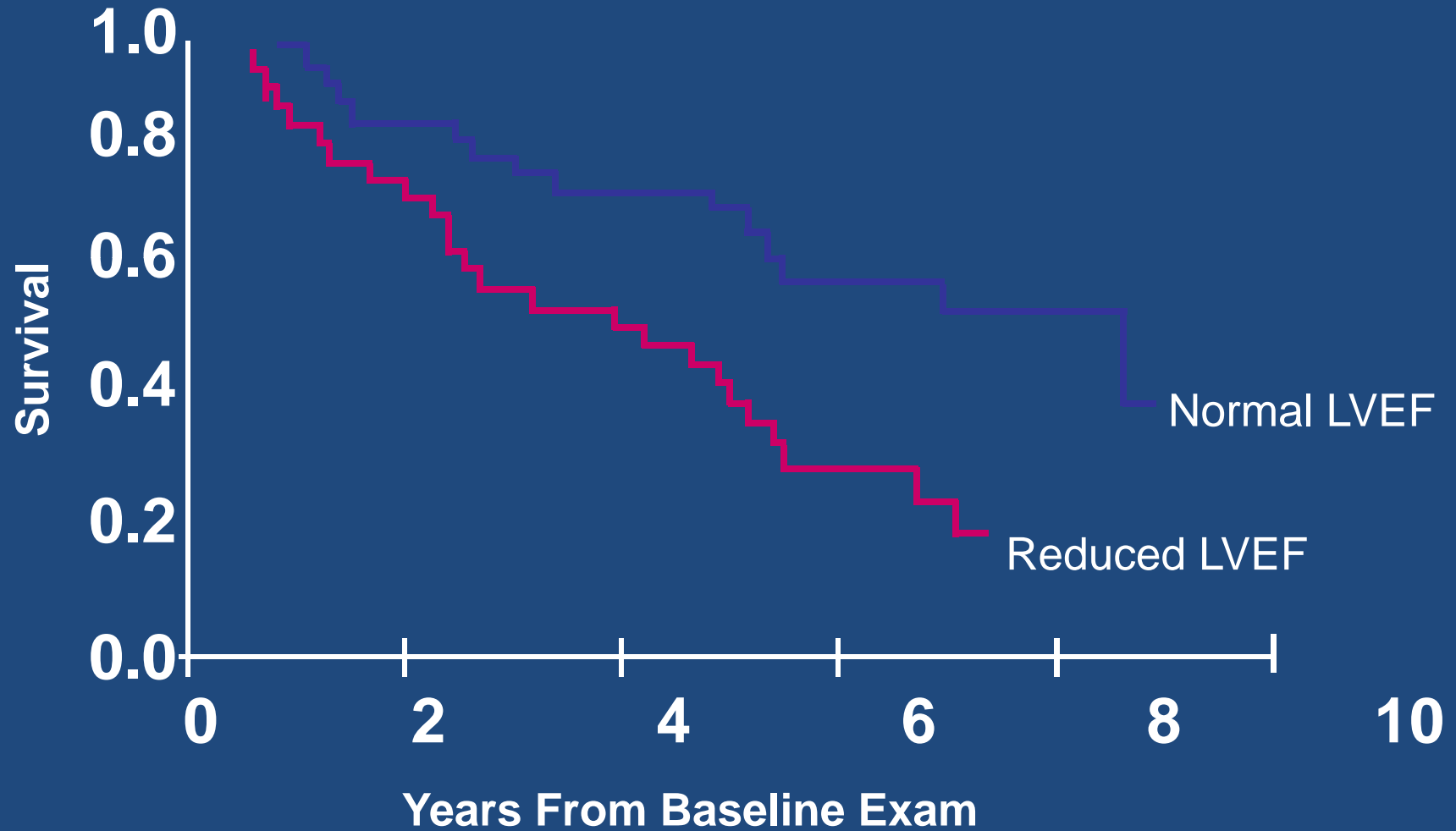
- The percentage of blood that is pumped FORWARD from the left ventricle into the aorta with each contraction
- Normal EF is 55%-65% , **never 100%**
- Patient's often get confused with the numbers. *Explain it to them!*

Important to Remember!

- Reduced left ventricular ejection fraction (LVEF) remains the single most important risk factor for overall mortality and sudden cardiac death.¹

¹Prior SG, Aliot E, Blonstrom-Lundqvist C, et al. Task Force on Sudden Cardiac Death of the European Society of Cardiology. Eur Heart J, Vol. 22; 16, August 2001.

EFFECT OF EJECTION FRACTION ON SURVIVAL



Systolic vs Diastolic Dysfunction

- Patients who have an EF \leq 40% have systolic dysfunction.
 - Results from impaired contractility.
- If EF \geq 50% and CHF symptoms, patient has diastolic dysfunction.
 - Results from impaired ventricular relaxation and filling.

Diastolic Heart Failure

- Treat as HF with low LVEF
- Control:
 - Hypertension
 - Tachycardia
 - Fluid retention
 - Myocardial ischemia
- Ongoing research

- Cardiac Output = Heart Rate X Stroke Volume

- Stroke volume is volume of blood pumped out of heart to body with each beat (stroke) of the heart

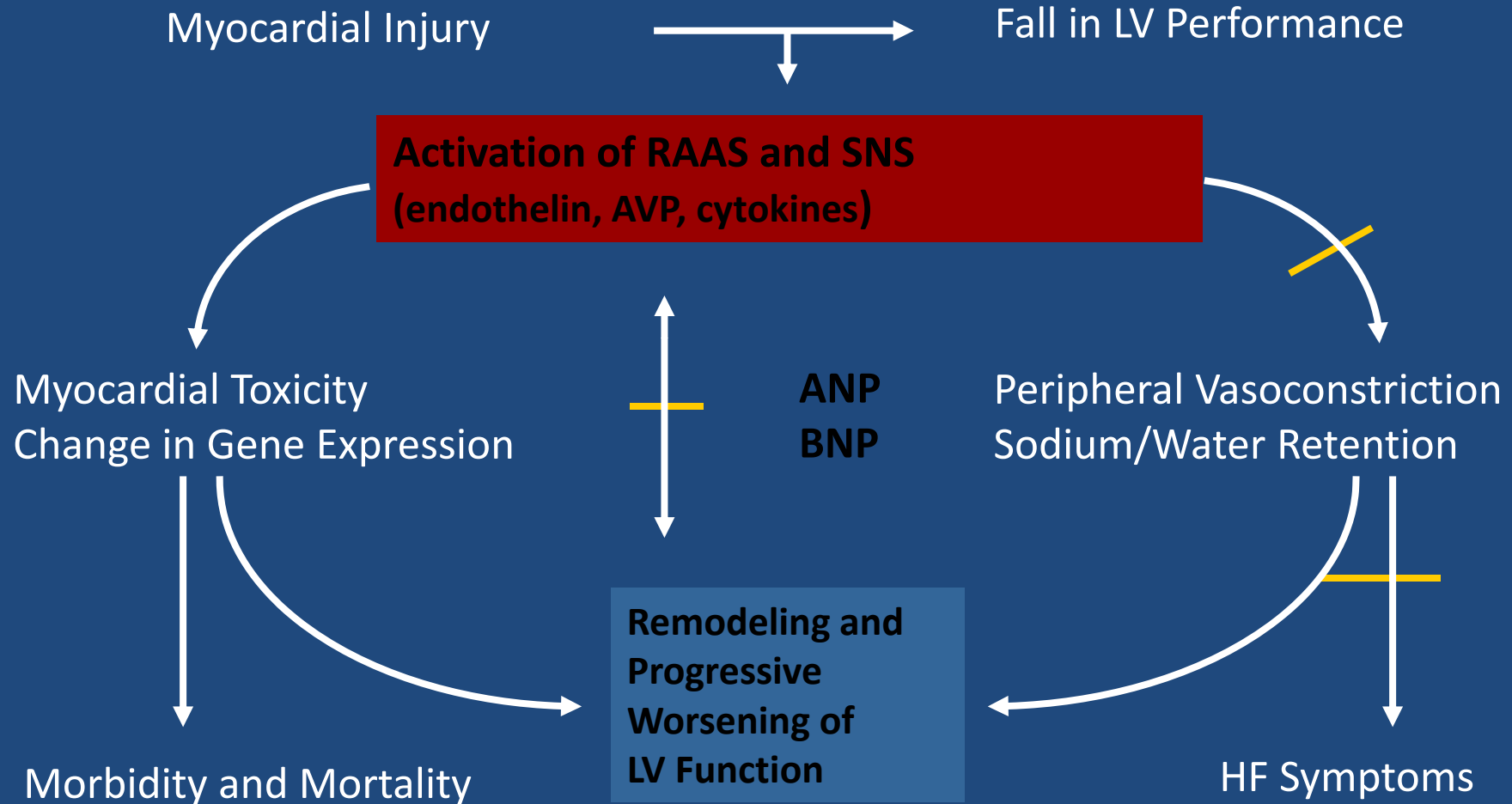
- Stroke volume determined by:

- Preload, afterload and contractility

Normal Values

- Cardiac Output: 4-7 liters/min
- Cardiac Index: (CO/BSA) 2.5-4.2 L/min
- Stroke Volume: 60-130 mL/beat
- Heart Rate: 60-100 bpm

Heart Failure Pathophysiology



ANP=atrial natriuretic peptide, AVP=plasma arginine vasopressin, BNP=endogenous B-type natriuretic peptide, LV=left ventricular, RAAS=renin-angiotensin-aldosterone system, SNS=sympathetic nervous system

Compensatory Mechanisms in HF

- Reduction in cardiac performance leads to:
 - Activation of of Neurohormonal adjustments
 - Boosts efficiency of heart
 - Maintains efficiency and integrity of circulation

Pathophysiology...

- Neurohormonal activity leads to ventricular remodeling
 - Increased sympathetic nervous system (SNS) activity
 - Increased Renin-Angiotensin-Aldosterone (RAA) activity

Physiologic Effects of Neurohormones

RAAS (Renin-Angiotensin-Aldosterone System)

Activation of AT ₁ receptors by angiotensin	Vasoconstriction Sodium retention Increased aldosterone release Increased cellular growth Increased sympathetic nervous activity
--	--

Natriuretic Peptide System

ANP, BNP	Vasodilation Sodium excretion Decreased aldosterone levels Inhibition of RAAS Inhibition of sympathetic nervous activity Antiproliferation of vascular smooth muscle cells
----------	---

ANP = atrial natriuretic peptide, AT₁ = angiotensin I, BNP = endogenous B-type natriuretic peptide

The Sympathic (Adrenergic) System..the short term response

- **Beta 1 receptors** -
 - Increases HR, contractility
 - Increases conduction velocity and refractory period
- **Beta 2 receptors** - found in bronchioles and smooth muscle
 - Produces bronchodilation
- **Alpha 1 receptors** - found in smooth muscle
 - When stimulated produce vasoconstriction
 - Predominant effect of SNS

SNS....

- Norepinephrine - secreted from nerve endings
- Primary agent of the SNS...
- “Fight or flight” hormone
- Epinephrine - secreted from adrenal medulla

Renin-Angiotensin-Aldosterone system...the short term benefit

- As perfusion to kidneys fall, the RAA system is activated
- Renin is released
- Renin leads to secretion of Angiotensin I
- Leads to increased reabsorption of Na and plasma water
- Leads to increased intravascular volume

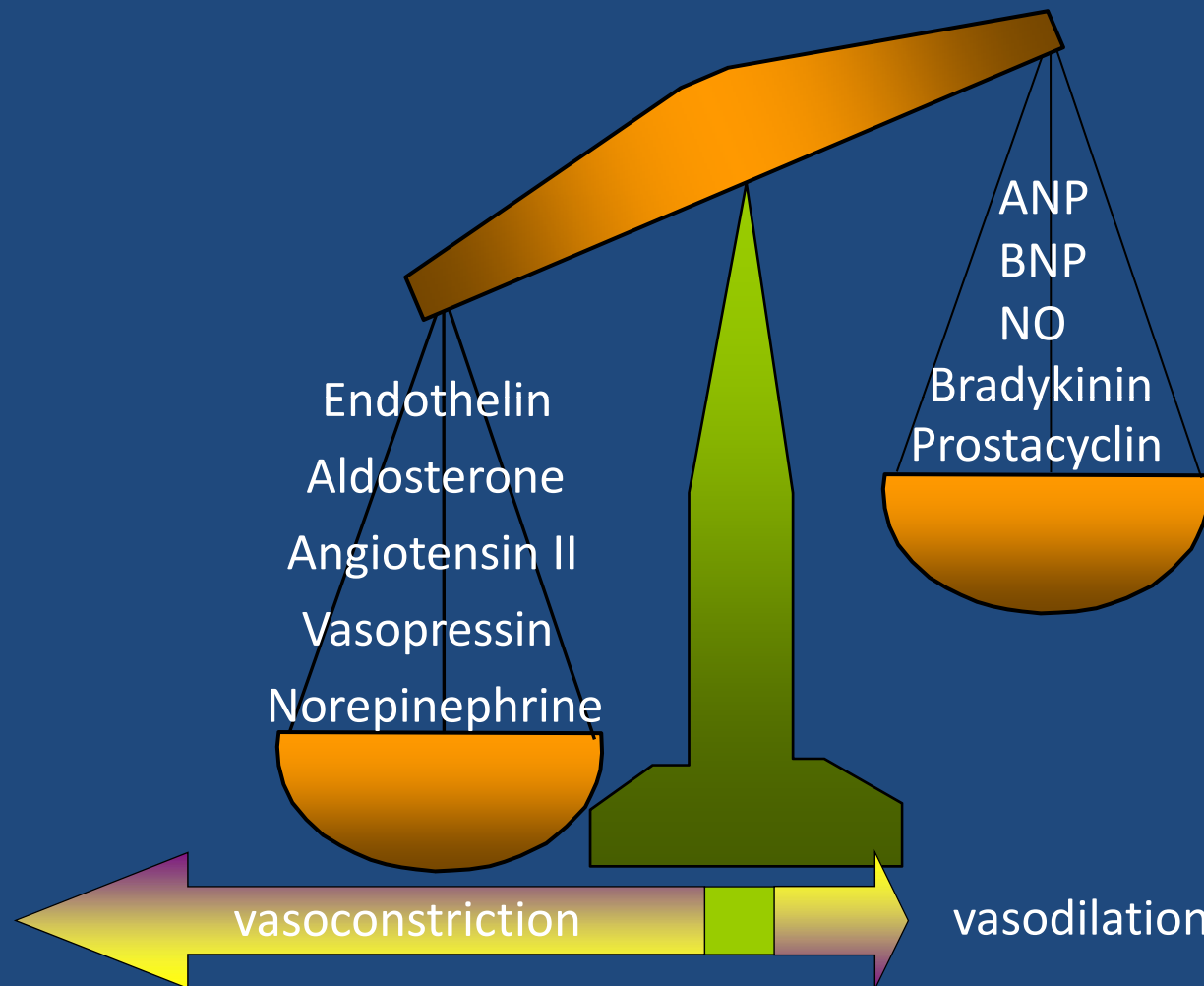
Neurohormones ...the Good Guys

- Natriuretic Peptides
 - **ANP** (Atrial natriuretic peptide) - secreted by the atria in response to increased atrial wall tension
 - **BNP** (Brain natriuretic peptide) - secreted by the ventricles in response to wall stress and muscle stretch

Good Guys...

- Natriuretic peptides promote balanced vasodilatation
- Reduces preload and afterload
- Reduces Na⁺ and water retention
- Reduce production and action of vasoconstrictive peptides

Neurohormonal Imbalance in Decompensated Heart Failure

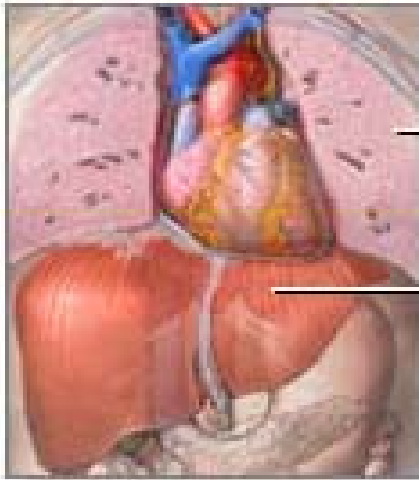


ANP=atrial natriuretic peptide; BNP=endogenous B-type natriuretic peptide; NO=nitric oxide

- Compensatory mechanisms are good in the short term to maintain adequate cardiac output
- Overtime, activation of these neurohormonal systems lead to ventricular remodeling and progressive heart failure

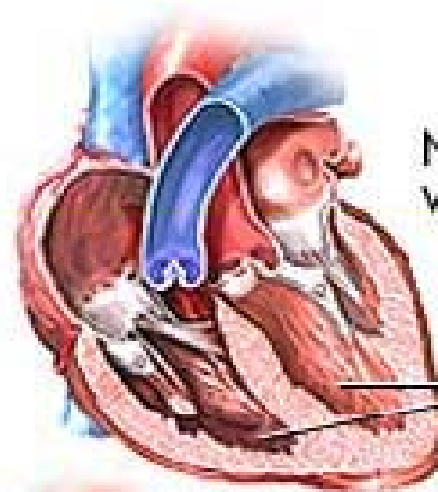
Ventricular Remodeling...

- The ultimate negative consequence of long term activation of the compensatory mechanisms of the heart
- We need to **PREVENT, REVERSE** or **SLOW PROGRESSION** of ventricular remodeling!!

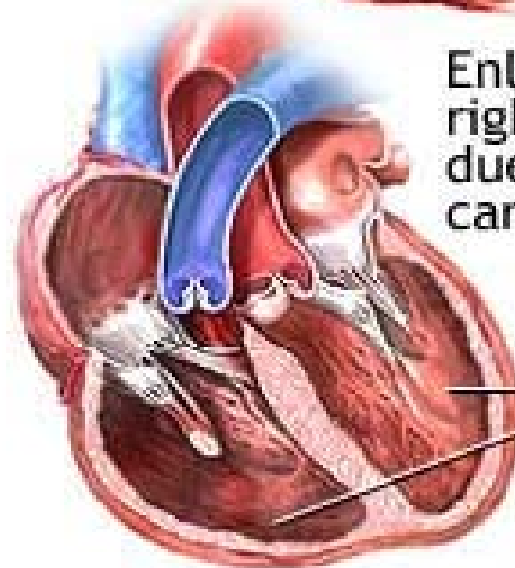


Lung

Liver



Normal ventricles



Enlarged left and right ventricles due to dilated cardiomyopathy

Characteristics of Heart Failure Patients Enrolled in Clinical Trials

- Average age: 55-65 years
- Women: 20-25%
- Ischemic etiology (CAD): \approx 50%
- Renal insufficiency: usually excluded (mean Cr 1.1-1.3)
- Preserved LV systolic function: usually excluded (LVEF usually $<$ 35-40)
- Atrial fibrillation: $<$ 25%
- Diabetes: 25-30%

Reference: Adams K et al. Characteristics and outcomes of patients hospitalized for heart failure in the United States: Rationale, Design, and Preliminary observations from the first 100,000 cases in the Acute Decompensated Heart Failure National Registry (ADHERE). *Am Heart J.* 2005;149:209-16.

Characteristics of Heart Failure Patients Enrolled in the ADHERE[®] Registry

- Average age: 72.5 years
- Women: 52%
- Ischemic etiology (CAD): 60%
- Renal insufficiency (SCr >1.5 mg/dL): 30%
- Preserved LV systolic function: ≈50%
- Atrial fibrillation: 31%
- Diabetes: 44%

Reference: Adams K et al. Characteristics and outcomes of patients hospitalized for heart failure in the United States: Rationale, Design, and Preliminary observations from the first 100,000 cases in the Acute Decompensated Heart Failure National Registry (ADHERE). *Am Heart J.* 2005;149:209-16.

Medicare Requirements for Cardiac Rehab

- EF < 35%
- Out of hospital for 6 weeks

Direct Causes of Heart Failure

- Coronary artery disease - #1 cause in Caucasian population
- Hypertension -#1 cause in African-American population
- Dysfunctional valves: regurgitation and stenosis
- Dysfunctional pericardium

Causes...

- Abnormal myocardium
- Diabetes: Type I or II
- Toxins: alcohol, cocaine, chemotherapy

Aggravating Factors

- Medications
- New heart disease
- Myocardial ischemia
- Pregnancy
- Arrhythmias (AF)
- Infections
- Thromboembolism
- Hyper/hypothyroidism
- Endocarditis
- Obesity
- Hypertension
- Physical activity !!
- Dietary excess

Factors...

- Development of unrelated illness, i.e. renal disease, BPH, anemia that leads to transfusions, infections including flu
- Denial/defiance/depression/confusion
- Emotional or physical stress

Left Ventricle vs Right Ventricle

- SOB, cough, nocturnal dyspnea
- Pulmonary rales, crackles, increased PCWP
- Anorexia
- Tachycardia
- Gallop sound, S3
- Confusion, anxiety
- Weakness, fatigue
- Nocturia
- Weight gain
- Peripheral edema
- Ascites, hepatomegaly
- Anorexia, nausea
- JVD
- Weakness, fatigue

Treatment

AII

- Prevention and control of risk factors
- Life style
- Treat etiologic cause / aggravating factors
- Drug therapy
- Personal care and Team work
- Revascularization if ischemia causes HF

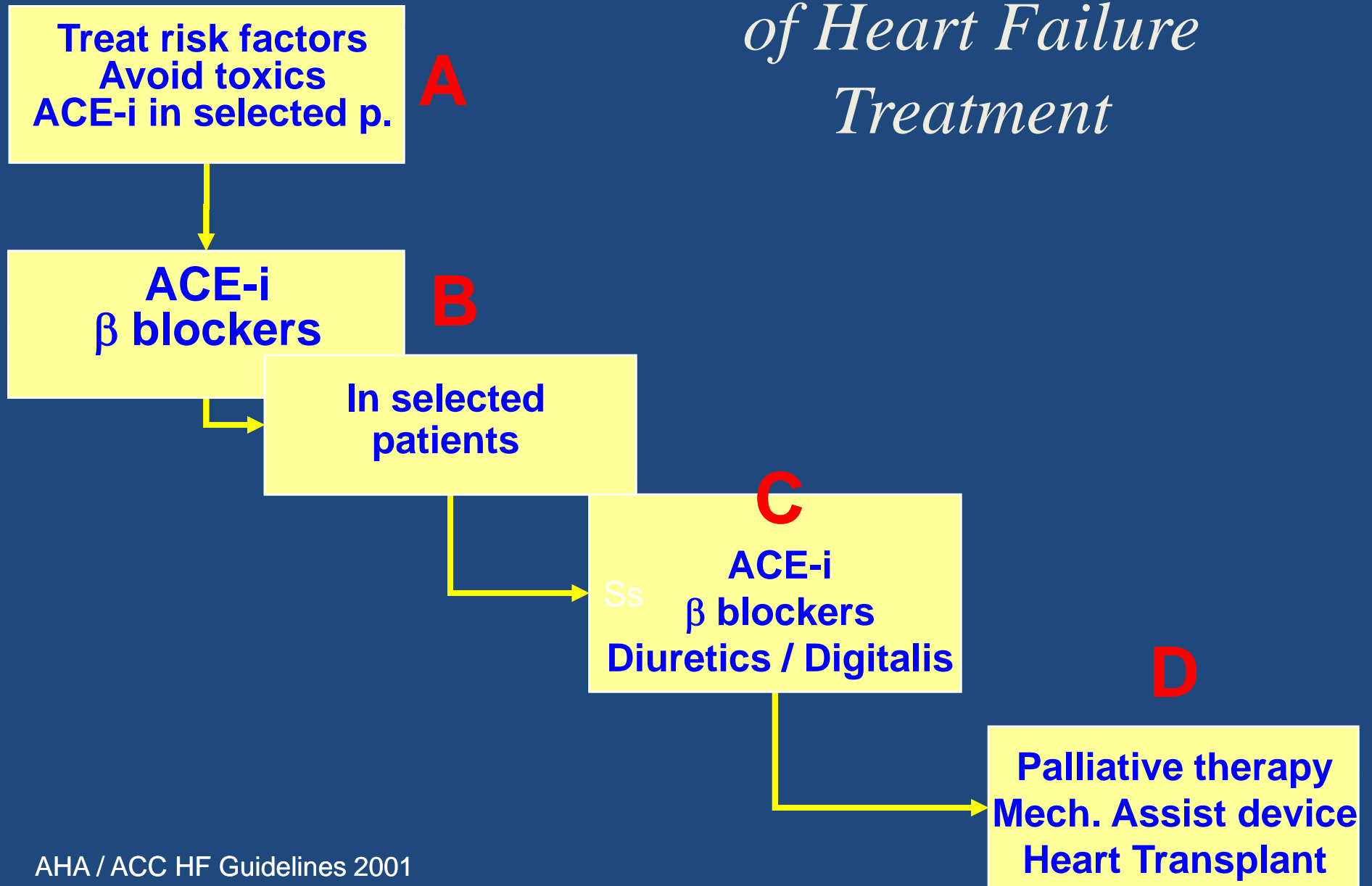
Selected patients

- ICD (Implantable Cardiac Defibrillator)
- Ventricular resynchronization
- Ventricular assist devices
- Heart transplant
- Artificial heart
- Neoangiogenesis, gene therapy

Drugs used in Therapy

- Chronic Therapy
 - ACEI
 - β -Blockers
 - Diuretics
 - Spironolactone
 - Digoxin
 - Hydralazine+nitrates
in Black population
- Acute Therapy
 - Dobutamine
 - Dopamine
 - Nitroglycerin
 - Natreacor
 - Milrinone
 - IV Diuretics

Stages in the Evolution of Heart Failure Treatment



Beta-Blockers

- Indicated in all HF patients due to LV dysfunction w/o contraindication
- Inhibits the adverse cardiac effects of the sympathetic nervous system in HF
- Decreases HR and myocardial oxygen demand
- Possesses antihypertensive and antiarrhythmic properties

β -Blocker Adverse Effects

- Hypotension
 - Fluid retention
 - Worsening HF
 - Fatigue
 - Bradycardia / Heart Block
- ♥ Discontinue only in the case of a severe adverse event

Angiotensin Converting Enzyme Inhibitors – ACEI/ARB

- Cornerstone for HF therapy
- Reduces preload and afterload through arterial and venous dilatation
- Indicated in all HF patients with LV systolic dysfunction w/o contraindications

Clinical Benefits of ACEI

- Improves symptoms
- Reduces the risk of death
- Decreases hospitalizations
- Reduces cardiac remodeling and disease progression
- Improves patients' sense of well-being

Aldactone[®] (Spironolactone)

- Indicated in patients with symptomatic HF in addition to other medications
- Blocks the action of aldosterone:
 - Inhibits cardiac and vascular remodeling
 - Prevents edema and arrhythmias
- RALES trial - reduced mortality, hospitalizations, and symptoms in NYHA III & IV
- Recommended dose 12.5 - 25 mg QD

DIGOXIN

- Isolated from the plant Foxglove
- Inhibits the Na^+/K^- ATPase in cardiac cells
- Positive inotropic effect
- Increases vagal tone and slows AV node conduction (\downarrow HR)
- Promotes excretion of Na^+
- Blunts the sympathetic nervous system

Drugs to Avoid in HF

- Antiarrhythmic and CCBs
 - Negative inotropic effects
- Drugs causing Na⁺ and water retention
 - NSAIDS - may also block action of ACEI
 - Thiazolidinediones (glitazones)
 - Corticosteroids
- Tricyclic Antidepressants
- Inotropes

Surgical/Mechanical Treatments for HF

- PTCA/Stent
- CABG
- Valvular repair or replacement
- Dor Procedure
- ICDs and CRT
- Circulatory assist devices
- Transplant

- ***Education of primary importance!!!!!!***
- Must be formal and informal
- Formal education most often provided by case manager, dietician
- Informal education should be provided by all staff: RNs, CNAs, DCPs, MDs

Education.....

- Adult learners do best with repeated exposure to the same material

Education to Include...

- Disease process
- Signs and symptoms
- Medications
 - Indications
 - Side Effects
 - Contraindications
 - Cost
 - Avoidance of OTC NSAIDs, Na Bicarb
- Diet/fluid restrictions
- Daily weight monitoring
- Exercise/activity guidelines
- Smoking cessation – smoked within last 12 months
- Follow-up appointments

Compliance with Instructions

*The majority of HF patients do not comply with
Medical Plan*

WHY?

*I'll eat when I'm hungry, I'll
drink when I'm dry. If drinking
don't kill me, I'll live 'til I die.*

Compliance...WHY NOT

- Complexity of plans
 - Multiple medications
 - Cost of medications
 - Radical changes in diet/fluid intake
 - Frequent office visits
 - Fatigue, Depression
 - Poor Social Support

Signs and Symptoms of Worsening Heart Failure

- Weight gain of > 3 lbs/24 hours or > 5lbs/week
- Increased resting HR
- Increased swelling in extremities
- Decreased exercise tolerance
- Arrhythmias i.e., Atrial Fib or Ventricular Ectopy
- Increased SOB, @ rest, nighttime SOB, sudden need to sleep in recliner

Questions?

- ICDs are considered to be first-line therapy for the primary prevention of sudden cardiac arrest.

ICD+ CRT...

- Large number of patients studied in randomized clinical trials
- Concordant proof that CRT improves quality of life, exercise capacity, functional capacity
 - Improvements persist through 1 year
- CRT reduces the risk of mortality and heart failure due to worsening HF
- CRT + ICD reduces risk of mortality
- CRT improves cardiac function and structure

HFSA 2010 Practice Guideline

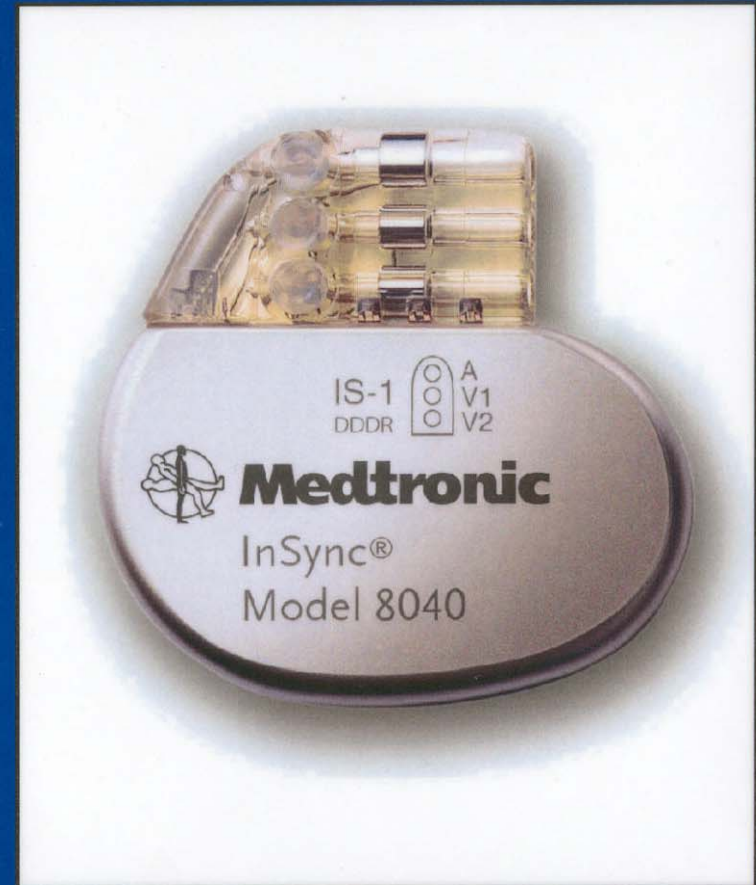
“Bridge to Decision”

- *Recommendation 10.7 (NEW in 2010)*
- The following patients **should be considered** for urgent mechanical circulatory support as a “bridge to decision”:
 - Patients with refractory HF and hemodynamic instability
 - and/or compromised end-organ function
 - with relative contraindications to cardiac transplantation or permanent mechanical circulatory assistance, who are expected to improve with time or restoration of an improved hemodynamic profile
- These patients should be referred to a center with expertise in the management of patients with advanced HF

Strength of Evidence = C

Indications for the Medtronic InSync® Cardiac Resynchronization System

- Medtronic's InSync system is indicated for the reduction of symptoms in patients that meet the following criteria:
 - Moderate to severe heart failure (NYHA Class III/IV)
 - QRS \geq 130 ms
 - LV ejection fraction \leq 35%
 - Symptomatic despite stable, optimal medical therapy



New FDA Indications for ICD Therapy

- Ejection Fraction less than 35%
- If Nonischemic Cardiomyopathy, EF must be < 35% for at least 9 months
- If Ischemic Cardiomyopathy, patient must be without interventions, ie, CABG or PCI for at least 6 months

HFSA 2010 Practice Guideline

Biventricular Pacing

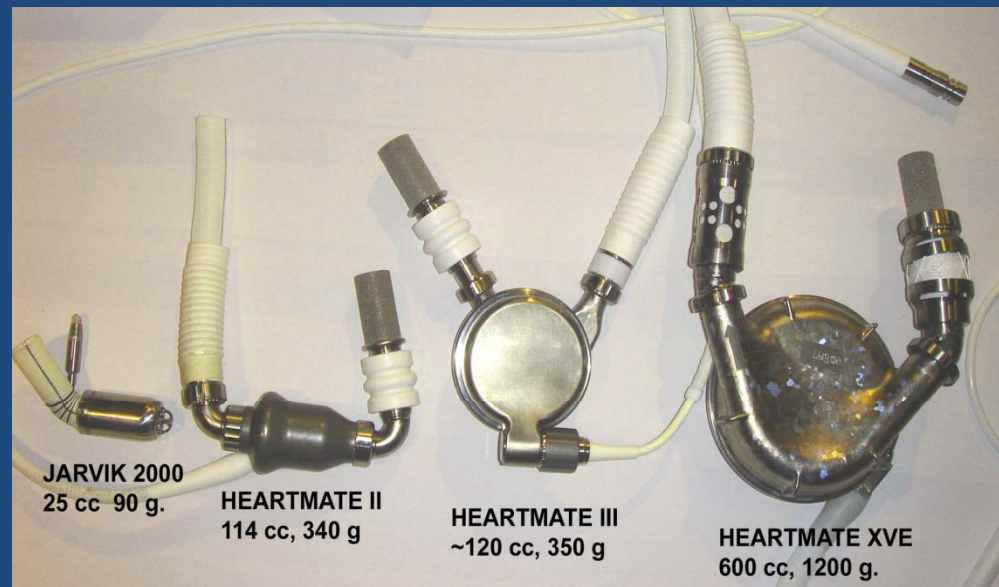
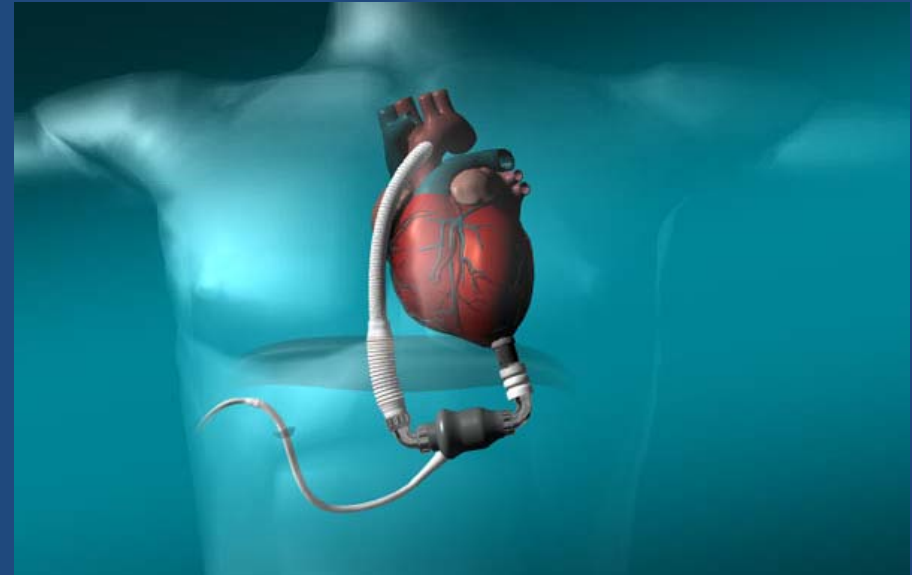
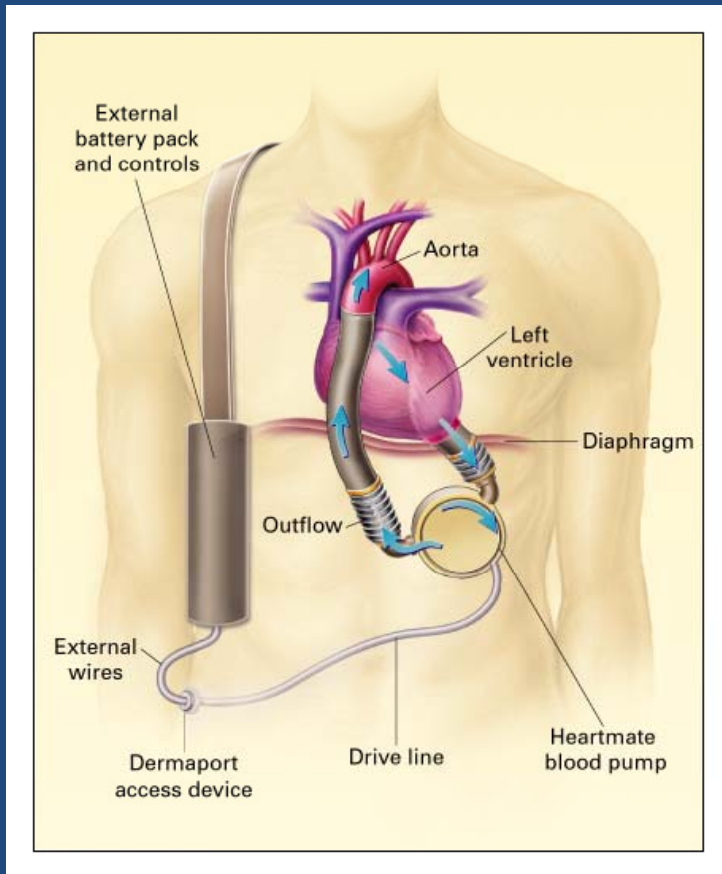
• *Recommendation 9.8 (NEW in 2010)*

• Biventricular pacing therapy **may be considered** for patients with AF with a widened QRS interval (≥ 120 ms) and severe LV systolic dysfunction (LVEF $\leq 35\%$) who have persistent, moderate to severe HF (NYHA III) despite optimal medical therapy.

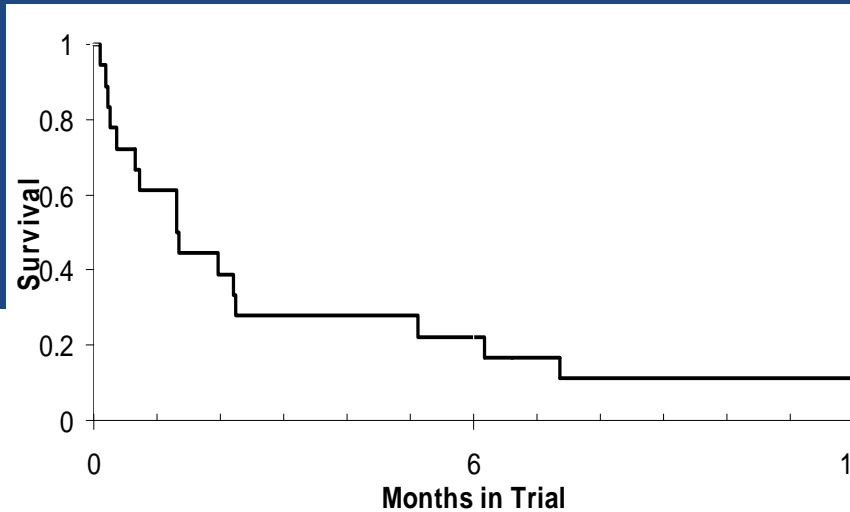
•

Strength of Evidence = A

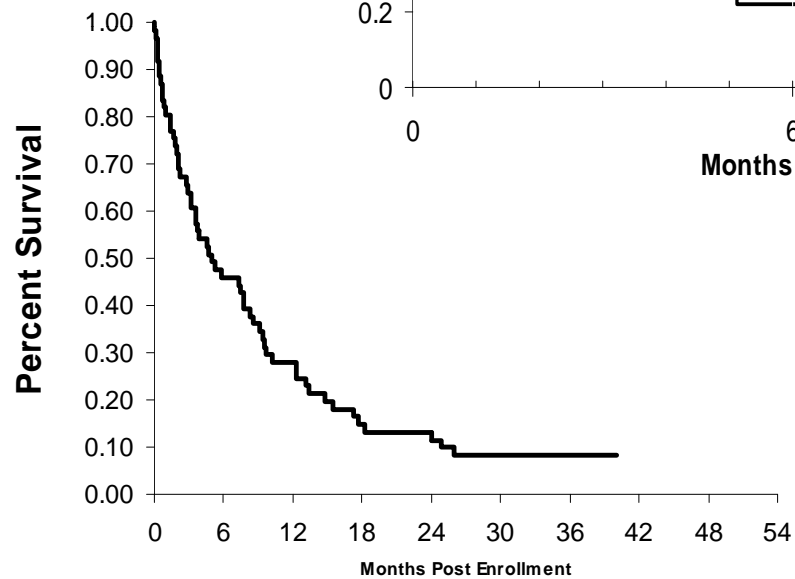
Mechanical Circulatory Support



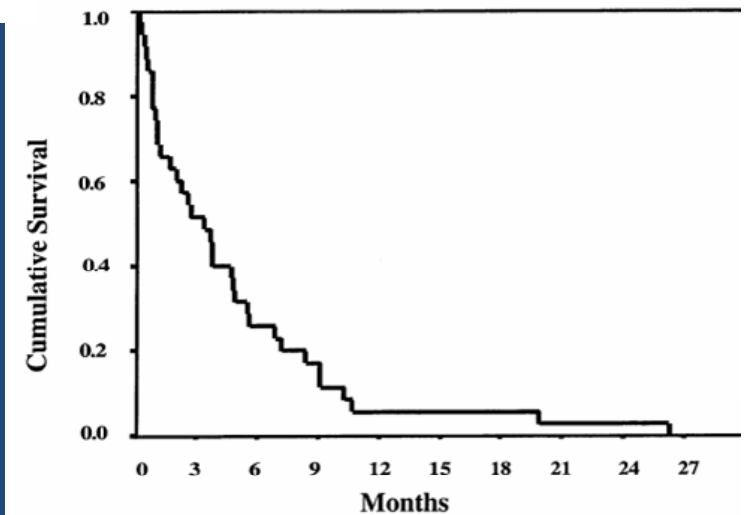
Survival of Stage D Patients Treated with Optimal Medical Therapy



J Cardiac Failure 2003;9:180-7



N Engl J Med 2001; 345:1435-43



J Am Coll Cardiol 2007; 50:741-7

HFSA 2010 Practice Guideline

End-of-Life Care

•*Recommendation 8.16 (NEW in 2010)*

•**It is recommended** that, as part of end-of-life care, patients and their families/caregivers have a plan to manage a sudden decompensation, death, or progressive decline.

•Inactivation of an implantable defibrillation device should be discussed in the context of allowing natural death at end of life. A process for deactivating defibrillators should be clarified in all settings in which patients with HF receive care.

Strength of Evidence = C