

# Heart Failure: Mending a Broken Heart

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# Objectives:

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1. Discuss heart failure in terms of etiology, diagnosis and management.
2. Outline the primary differences between acute and chronic heart failure in terms of symptoms and management.
3. Compare and contrast systolic and diastolic heart failure. (Heart failure with preserved ejection fraction (HFpEF) and Heart failure with reduced ejection fraction (HFrEF)).
4. Outline the New York Heart Association (NYHA) classification of CHF
5. Create treatment plans for patients with each type of heart failure
6. Recognize signs of poor prognosis in patients with heart failure

# Epidemiology & Burden of disease

- Incidence and prevalence of HF increases with age.
- There are an estimated 6 million people with HF in the US.
- In 2014, there were 1,068,412 ED visits; 978,135 hospitalizations and 83,705 deaths attributed to primary HF.
  - The numbers for comorbid HF in the same year were at least tripled.
- Average hospitalization for a primary HF patient in 2014 was ~\$11,552

# What is Heart Failure?

Complex clinical syndrome resulting from structural or functional impairment of the ventricle meeting the metabolic demand of the body.

- Bottom line: either filling of, or ejection from the ventricle is not sufficient to meet the needs of the body.



# Risk factors

- Coronary heart disease
- Cigarette smoking
- Hypertension

- Obesity
- Diabetes
- Valvular Heart disease

If HF is anything that prevents the heart from pumping enough blood to meet body's metabolic demand...What are the causes?

Heart Muscle

Valves

Electrical - Rhythm

If HF is anything that prevents the heart from pumping enough blood to meet body's metabolic demand...

## Heart Muscle

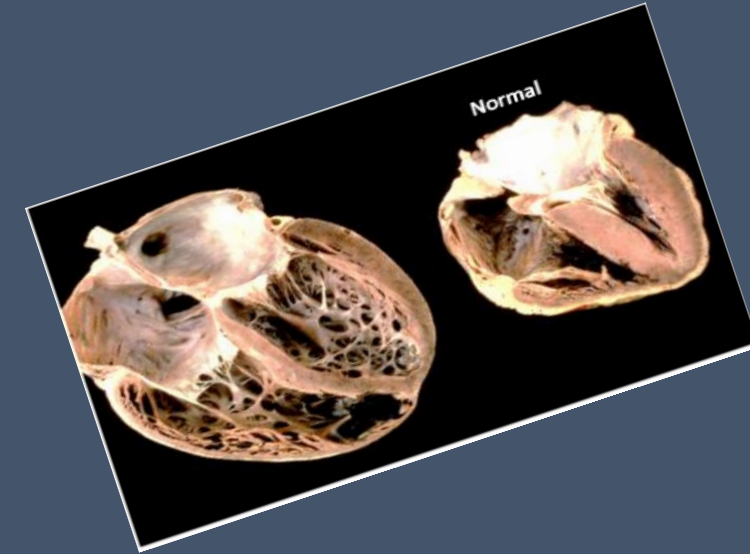
- Myocardial infarction, Hypertrophy, Muscle damage from – Virus, drug, infiltrating (inflammatory) disease, genetic defect

## Valve

- What valve problems block blood from getting to the aorta or overwhelm the ventricle... more on this later

## Electrical – Rhythm

- Too slow not enough outflow
- Too fast- not enough filling time or uncoordinated, chaotic ventricle is ineffective



# HF – Major Categories

## ➤ Left Sided

### ➤ Why does this happen?

- Left ventricle is backing up into left atrium and ultimately into the lungs

### ➤ What are the causes?

- There are many causes - anything that stresses the left ventricle
- #1 cause is coronary ischemia/ myocardial infarction

## Signs and Symptoms of Left Heart Failure

### • Symptoms

- Dyspnea
- Orthopnea
- PND
- Fatigue
- MS Changes
- Cough
- Weight gain

### • Signs

- Tachycardia
- Tachypnea
- Gallop (S3 or S4)
- Crackles, Pulmonary edema
- JVD \*\*
- Edema \*\*
- Hepatojugular reflux \*\*
- Jaundice \*\*

\*\* Late or Advanced Finding

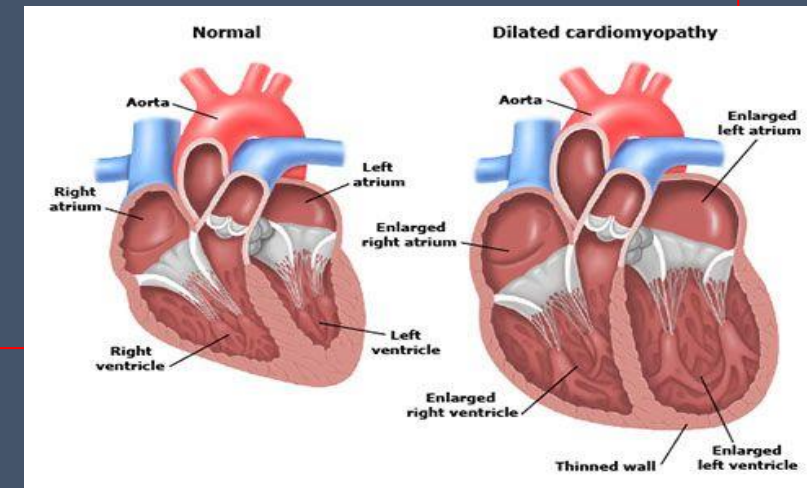


# Reduced Ejection Fraction Heart Failure

- ▶ Heart failure with reduced ejection fraction (HFrEF) (formerly systolic dysfunction) → characterized by a left ventricular ejection fraction of  $\leq 40\%$ , often with increased LV volume
  - ▶ Coronary heart disease
  - ▶ Idiopathic dilated cardiomyopathy
  - ▶ HTN
  - ▶ Valvular disease

# HF – Major Categories

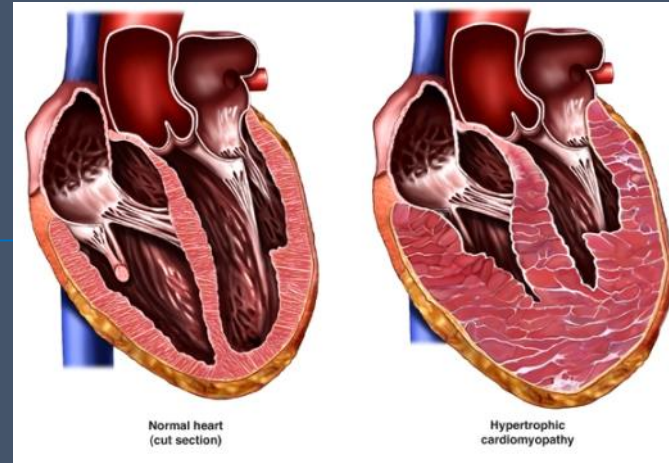
- Reduced (HFrEF)
- With a dilated LV the atrium fills the ventricle just fine
- Ventricle is weak so can't eject enough blood to meet metabolic needs
- Pumping problem
- Example if EDV is high at 150 ml
  - $EF = 30\% = SV/150$
  - $SV = 45$  ml of blood ejected per beat
    - Not enough to meet demand



# Preserved Ejection Fraction Heart Failure

- ▶ Heart failure with preserved ejection fraction (HFpEF) (formerly diastolic dysfunction) → characterized by a left ventricular ejection fraction of  $\geq 50\%$ , may have normal LV volume.
- ▶ Pt. with an EF between 41-49% may be considered HFpEF borderline and have characteristics similar to patients with HFpEF.
  - ▶ HTN
  - ▶ Coronary heart disease
  - ▶ Restrictive cardiomyopathy
  - ▶ Hypertrophic obstructive cardiomyopathy

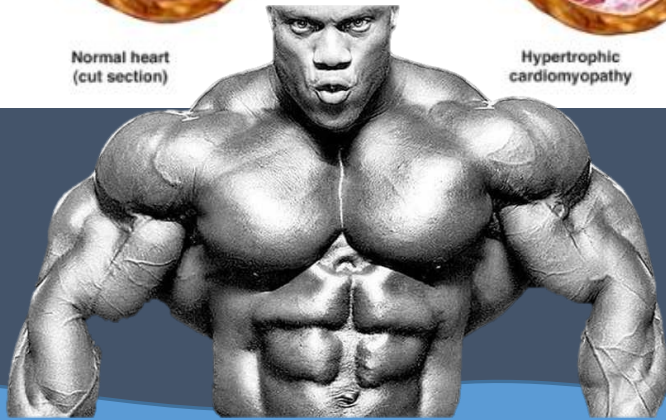
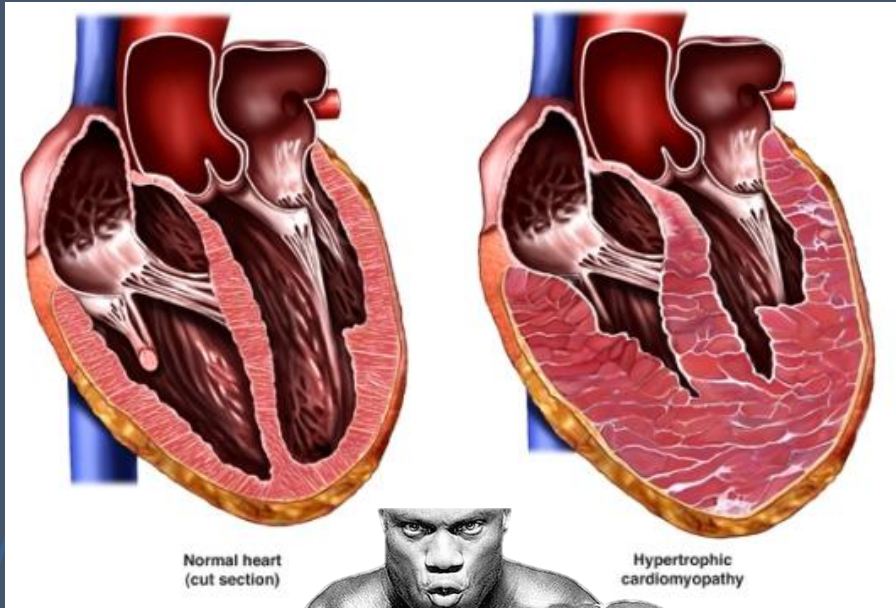
# HF – Major Categories



- Preserved (HFpEF)
- How can you have heart failure w/ normal EF?
- Normal Stroke Volume ~ 70ml
  - Beginning of Systole - Left Ventricle (LV) = 120ml also called End-Diastolic Volume (EDV)
  - End of Systole LV has ~ 50ml
  - $EF = \text{Stroke volume} / \text{EDV}$ 
    - $EF = 70 \text{ ml} / 120 \text{ ml} = \mathbf{58\% \text{ (Normal EF)}}$
- With a hypertrophied LV, the thin atrium can't push enough blood into thick, strong ventricle so EDV is not 120ml its lower. Filling problem.
  - Example if  $EDV = 80 \text{ ml}$
  - $EF = 58\% = SV/80$ 
    - $SV = 47\text{ml}$  of blood ejected per beat - Not enough to meet demand w/ activity

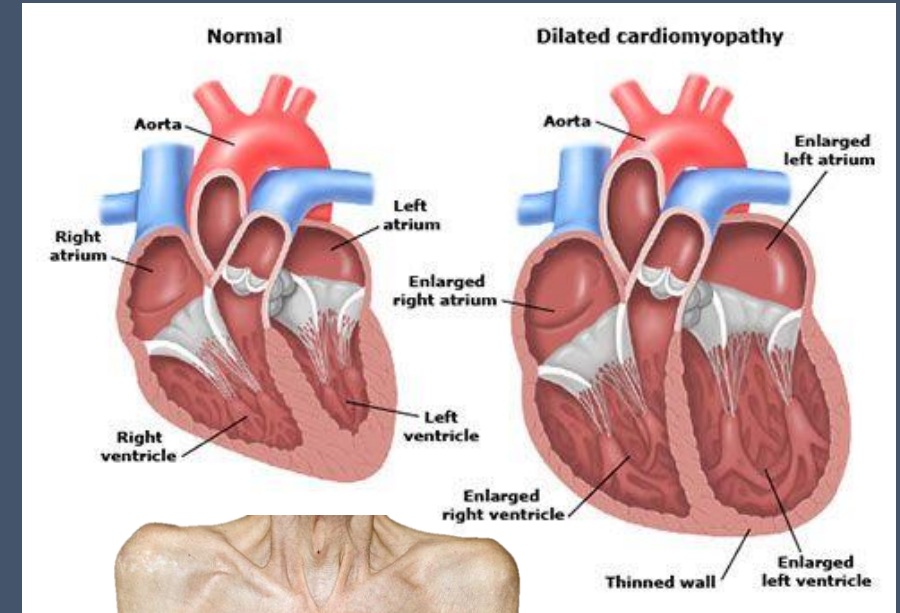
# HF – Major Categories

## Preserved (HFpEF)



Commonly Hypertrophic: Thick, stiff, Strong Heart  
Usually symmetrical – R and L same time

## Reduced (HFrEF)



Commonly Dilated: Large, Weak Heart  
Often Left affected first then Right Ventricle



# Signs and symptoms

- Dyspnea
  - Orthopnea, PND
- Fatigue
- Exercise intolerance
- S3, S4
- Palpitations
- Cough
- Edema
- JVD



# HF – Major Categories

## Heart Failure w/ Preserved Ejection Fraction (HFpEF)

### ➤ Symptoms

- DOE, SOB, Fatigue
- Edema- Ascites, JVD, Leg

### ➤ What is going on...

- % of blood leaving ventricle normal (55-60%)
- Blood volume leaving ventricle not enough for body needs

### ➤ Causes?

- Filling the ventricle problem (diastole)

Not the same as Right & Left Sided HF

## ➤ Heart Failure w/ Reduced Ejection Fraction (HFrEF)

### ➤ Symptoms

- DOE, SOB, Fatigue
- Edema- Ascites, JVD, Leg

### ➤ What is going on...

- % of blood leaving ventricle reduced (Below 40%)
- Blood volume leaving ventricle not enough for body needs

### ➤ Causes?

- Ventricle pumping problem (systole)

Can't really tell the dif. by symptoms alone

# HF – Major Categories - Causes

## Preserved (HFpEF)

- Causes: Things resulting in stiff heart muscle (usually on R & L same time)
  - **Hypertension** (HTN) → hypertrophy
  - **Diabetes** (DM)– 2-4 X incidence of CHF even w/o CAD or HTN
    - DM causes fibrosis – muscle & nerve damage leads to stiffness
  - Other diseases that infiltrate or stiffen muscle
    - Muscular dystrophy, Amyloidosis, Connective tissue diseases


Commonly Hypertrophic: Thick, Strong, Heart

## ➤ Reduced (HFrEF)

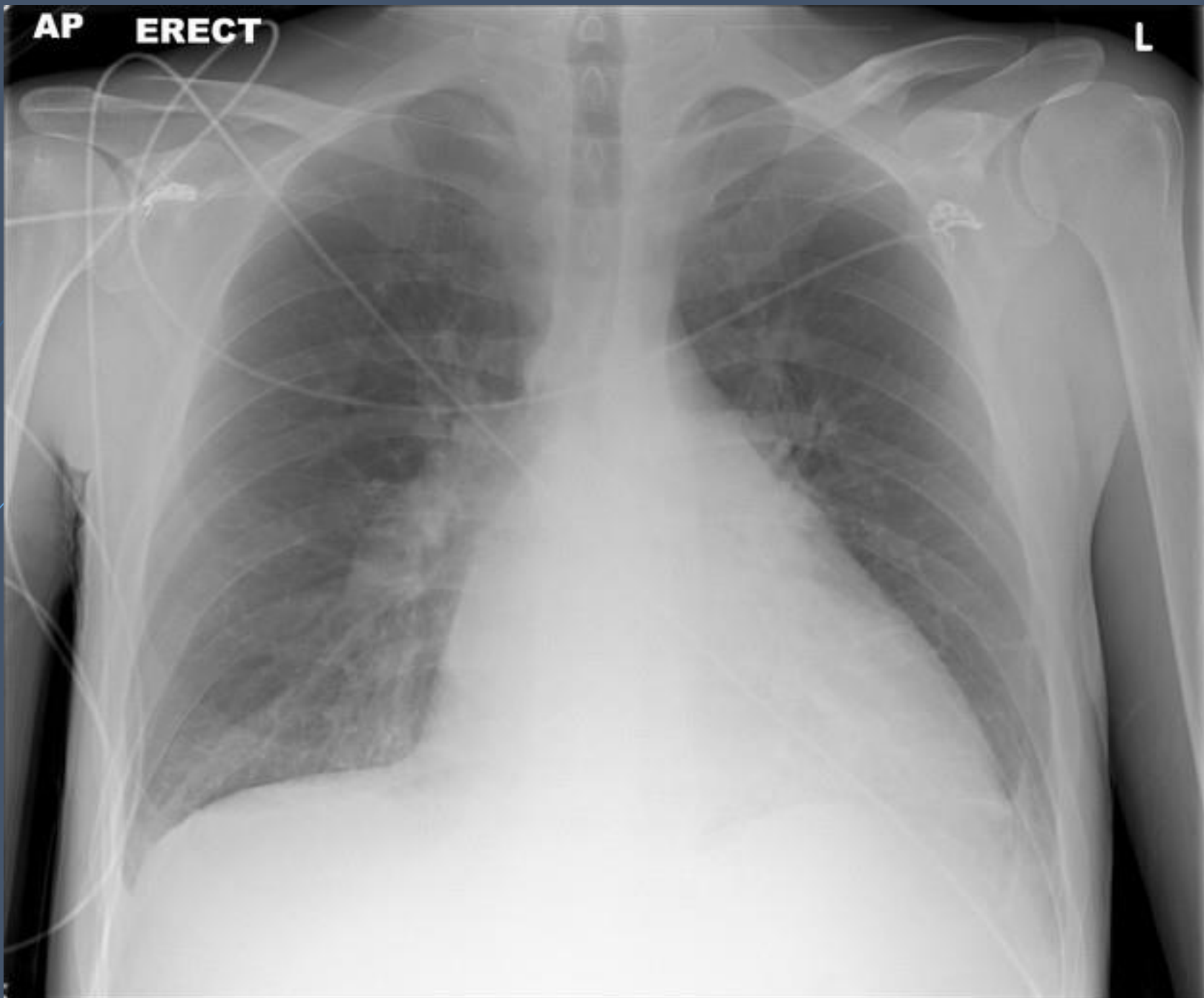
- Causes: Things that weaken the ventricle (usually Left)
  - **Coronary Artery Disease- MI #1 by far**
    - HTN, DM, smoking, obesity increase risk
  - Valve disease
  - Peri-partum
  - HIV or other virus
  - Arrhythmia
  - Idiopathic (cause unknown)

Commonly Dilated: Large, Weak, Heart







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- Refractory volume overload
  - Hypotension
  - Decreased renal function
  - Hyponatremia
  - Elevated serum natriuretic peptide

- CXR
- Exercise testing (6minute walk in those that can ambulate)
- Echo
- Right heart cath



X-Ray  
Break

NYHA Class	Level of Clinical Impairment
<b>I</b> 	No limitation of physical activity. Ordinary physical activity does not cause undue breathlessness, fatigue, or palpitations.
<b>II</b> 	Slight limitation of physical activity. Comfortable at rest, but ordinary physical activity results in undue breathlessness, fatigue, or palpitations.
<b>III</b> 	Marked limitation of physical activity. Comfortable at rest, but less than ordinary physical activity results in undue breathlessness, fatigue, or palpitations.
<b>IV</b> 	Unable to carry on any physical activity without discomfort. Symptoms at rest can be present. If any physical activity is undertaken, discomfort is increased.



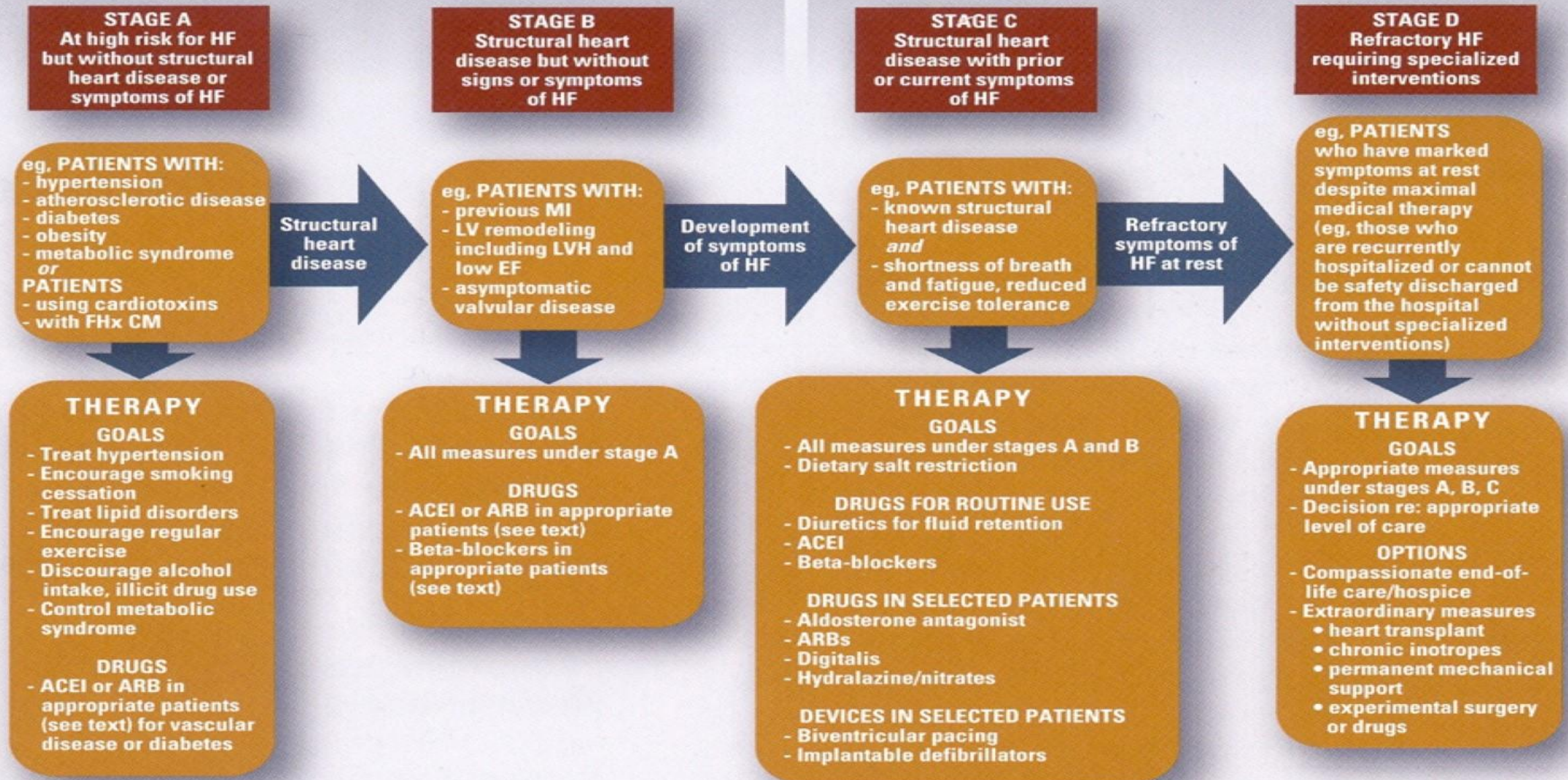
## ACC/AHA Stages

- ➡ Stage A → At risk for HF but no structural disease or symptoms
- ➡ Stage B → Structural disease but no signs or symptoms. This stage includes patients in NYHA class I without current symptoms or signs of HF.
- ➡ Stage C → Structural disease with prior or current symptoms. This stage includes patients in any NYHA class.
- ➡ Stage D → Refractory HF requiring specialized interventions. This stage includes patients in NYHA class IV with refractory HF.



## At Risk for Heart Failure

## Heart Failure



# Goals of treatment

- ▶ HFrEF – improve symptoms, slow or reverse deterioration in myocardial function, reduce mortality
- ▶ Diuretics; Loop (Furosemide, Bumetanide or Torsemide)
- ▶ Beta blockers (Carvedilol, Metoprolol, Bisoprolol)
- ▶ ACE inhibitors (Lisinopril, Enalapril or Quinapril), ARBs or Angiotensin receptor-neprilysin inhibitors (Sacubitril-Valsartan) (ARNI)
- ▶ Hydralazine plus nitrate (isosorbide dinitrate)
- ▶ Digoxin
- ▶ Aldosterone Receptor Antagonists (Spironolactone or Eplerenone)

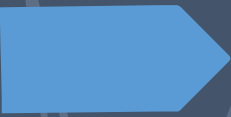


- ➡ Diuretic plus ACEI, ARNI or ARB recommended for all
- ➡ ARNI or ACE?
  - ➡ ARNI\* may be initiated in any NYHA class II or III patients with LVEF  $\geq 40$
- ➡ BB with proven benefit of reduced all cause mortality recommended for all

- Hydralazine plus oral nitrate:
  - When pt. cannot tolerate ACE/ARNI/ARB
  - In black patients with class III HF and LVEF <40 despite optimal therapy
- Ivabradine for patients with LVEF of  $\leq 35\%$  with a HR of at least 70bpm at rest, optimized on BB therapy
- Aldosterone receptor antagonist for:
  - patients with NYHA class II HF and LVEF  $\leq 30$  or NYHA class III or IV and LVEF  $\leq 35$
  - Post STEMI patients already receiving therapeutic doses of ACEI with LVEF  $\leq 40$  and either symptomatic HF, or DM
- Digoxin should be reserved for patients who continue to have NYHA class III and IV despite optimal therapy and/or a LVEF of 25 or less



- HFpEF → treatment is largely directed toward associated conditions and symptoms
- Still not a lot of good evidence in this group of HF patients regarding treatment!
- HTN – managing systemic blood pressure is a key component → prevention of morbidity
- Diuretics should be used to relieve symptoms due to volume overload
- Aldosterone receptor antagonist may have a role – monitoring is important

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- ▶ HFpEF - treatment is largely directed toward associated conditions
    - ▶ Treat contributing factors (HTN, lung dz, CAD, obesity, anemia, DM, Kidney dz)
      - ▶ Diuretics, control HR (esp. in a-fib) prefer restoration and maintenance of sinus if possible otherwise rate control
        - ▶ Don't use BB unless there is another indication like angina
      - ▶ Nitrates in pts with LV diastolic dysfunction (small and stiff) leading to underfilling → fall in cardiac output, hypotension. (they are susceptible to preload reduction)
      - ▶ Similar morbidity as patients with HFrEF



# Drug therapy for Heart Failure - Compensated

► Here are a list of Drugs and classes that may help:

1. **Beta blocker**
2. **Ace inhibitor/Angiotensin receptor blocker**
  - Angiotensin blocker and Neprilysin inhibitor
3. **Aldosterone receptor antagnoists (spironolactone, eplerenone)**
4. **Diuretic**
5. **Hydralazine + Nitrate**
6. **Digoxin**

► Which improve survival?

► Which improve symptoms only (feel better, less hospital stays)?





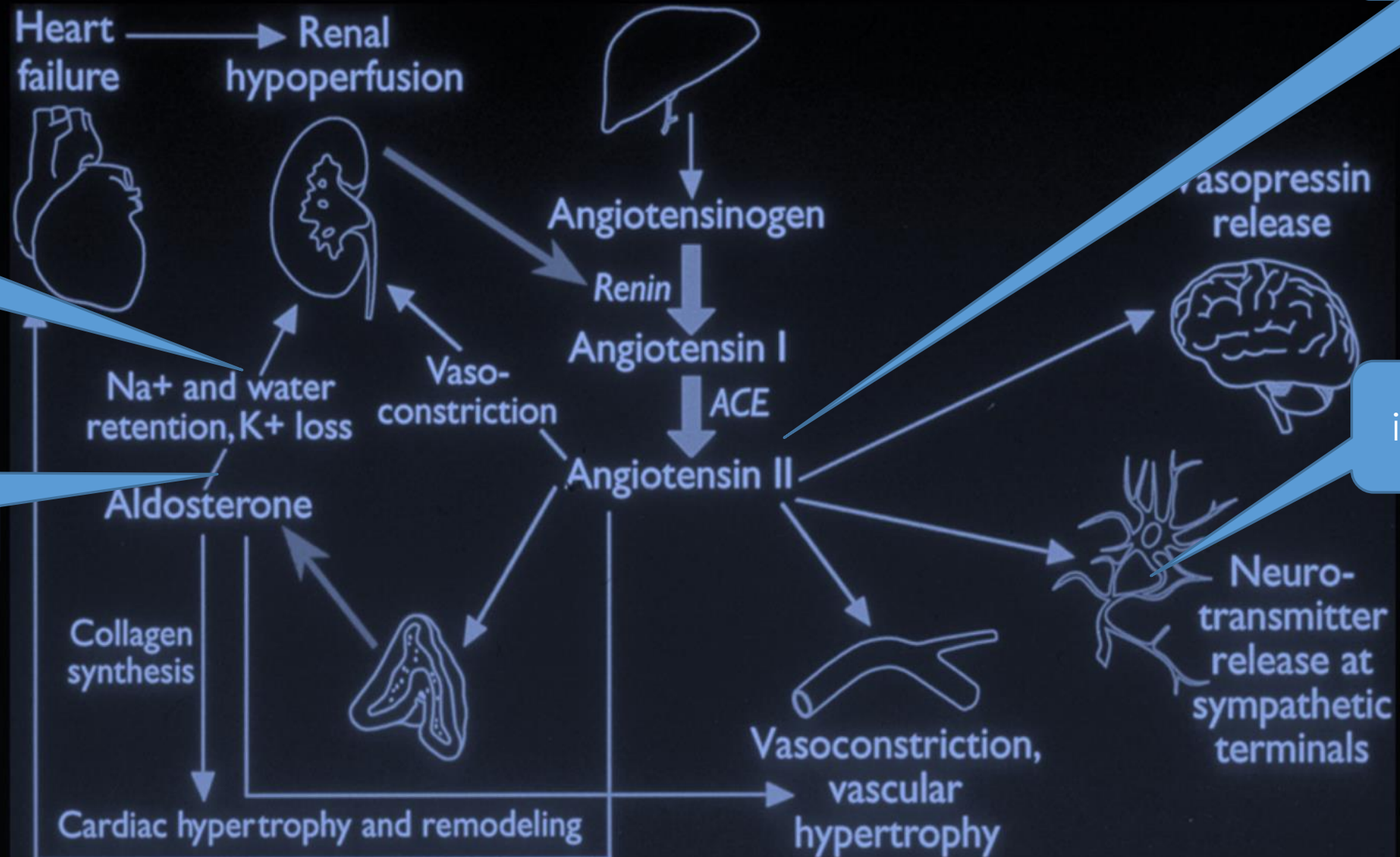
# Cardiac Rehabilitation

- Indicated for both types of HF
  - Approved for payment by all payers (Medicare, Medicaid and third party)
- A 2016 study of >14,000 patients in 2016 showed (various cardiovascular conditions)
  - A lower risk of cardiovascular death (relative risk [RR] 0.74, 95% CI 0.64-0.86)
  - A lower risk of hospital admission (RR 0.82, 95% CI 0.70-0.96)
- Despite this utilization rates are low
  - ?referral rates

# Acute Heart Failure

- Acute decompensated heart failure (ADHF) → a clinical syndrome of new or worsening HF signs and symptoms that often lead to hospitalization or a visit to the Emergency Department. (high post discharge readmit rates)
- Can result from HFpEF or HFrEF
- Diagnosis is clinical; can be supported with test results but should not be made based off a single test
- Admission to the hospital is common

# Systemic Effects of RAS Activation in CHF



How do we interrupt this process?

How do we interrupt this process?

How do we interrupt this process?

How do we interrupt this process?

# How do you get from Acute to Chronic CHF?

## ➤ Chronic HF –Compensated

- Still have underlying cardiac problem but meds, rehab, diet

→ reduced symptoms

- Sympathetic Nervous System – Epi & Norepi – Blocked by Beta Blocker

- HR decreases

- Renin- Angiotensin – Aldosterone – Blocked by Ace – inhibitor, Angiotensin receptor blocker, Aldosterone receptor antagonist (spironolactone)

- Reduces vasoconstriction, fluid and sodium retention

- Antidiuretic Hormone- Reversed by diuretic

## Precipitants of heart failure

Dietary indiscretion
Vigorous fluid administration
Noncompliance to medical regimen
Worsening renal failure
Uncontrolled hypertension
Anemia
Systemic infection
Pulmonary embolism
Myocardial ischemia
Tachyarrhythmias and bradyarrhythmias
Electrolyte disturbances
Severe emotional or physical stress
Hyperthyroidism and hypothyroidism
Cardiodepressant and other drugs
Anti-inflammatory drugs
Antiarrhythmic drugs
Calcium channel blockers
Beta adrenergic blocking agents



# Common presentation - ADHF

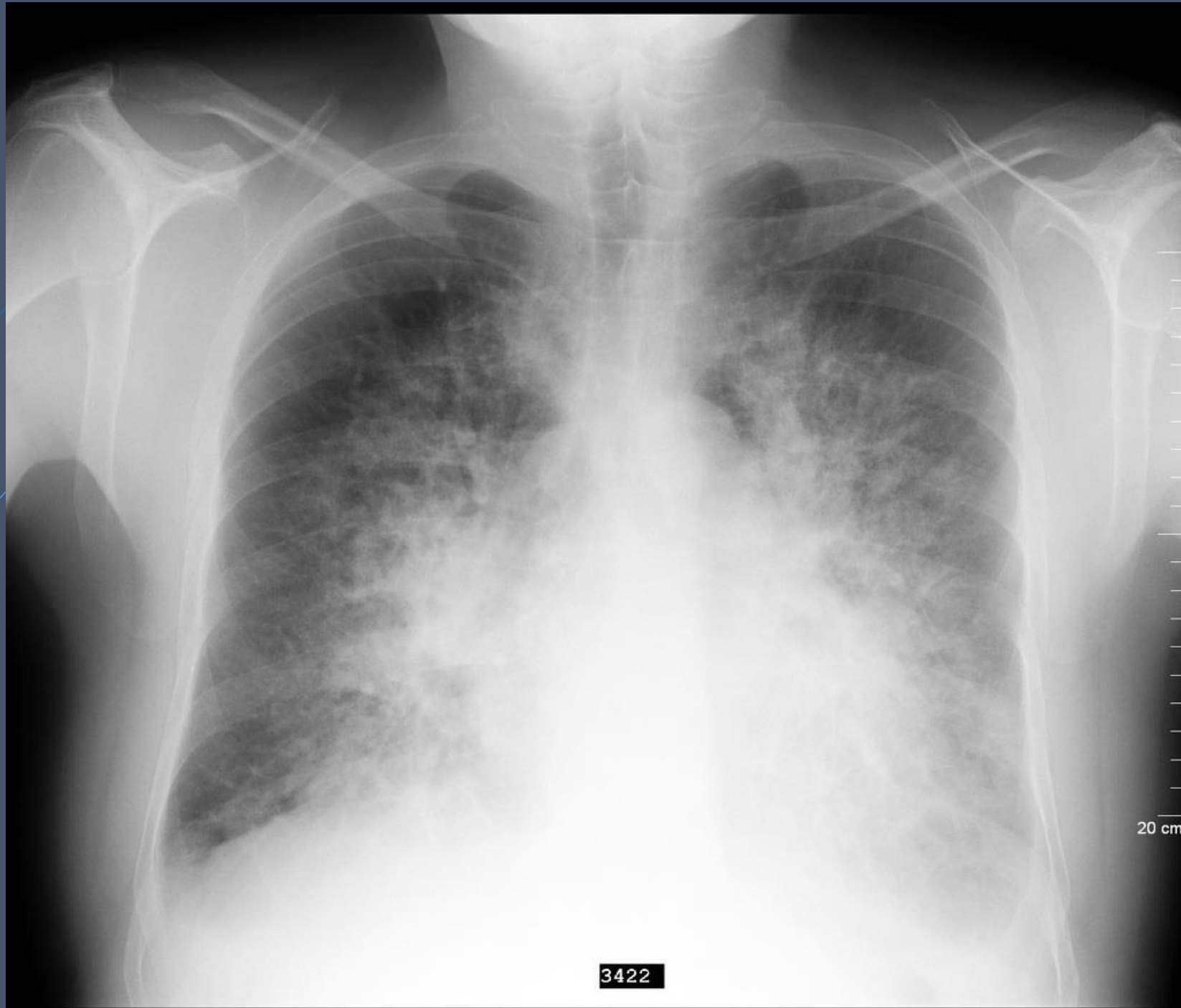
Acute dyspnea,  
orthopnea,  
tachypnea,  
tachycardia, HTN

Hypotension in  
severe disease

Accessory  
muscle use

Diffuse  
pulmonary  
crackles, possible  
wheezing

Elevated JVD,  
peripheral  
edema, an S3



# BNP – Brain Natriuretic Peptide



Breathing **N**ear Im**P**ossible

# BNP – Brain Natriuretic Peptide

Also Pro BNP or NT-Pro BNP

- **BNP**
  - Released from ventricles
  - Role is to counteract the renin-angiotensin system, endothelin, and sympathetic system
  - Shown to be better than clinical assessment
  - $<100\text{pg/ml}$  very high negative predictive value
  - $>400\text{pg/ml}$  in dyspneic patient very likely HF
  - Has been shown to predict mortality and degree of decompensation

# Acute decompensated HF : Management

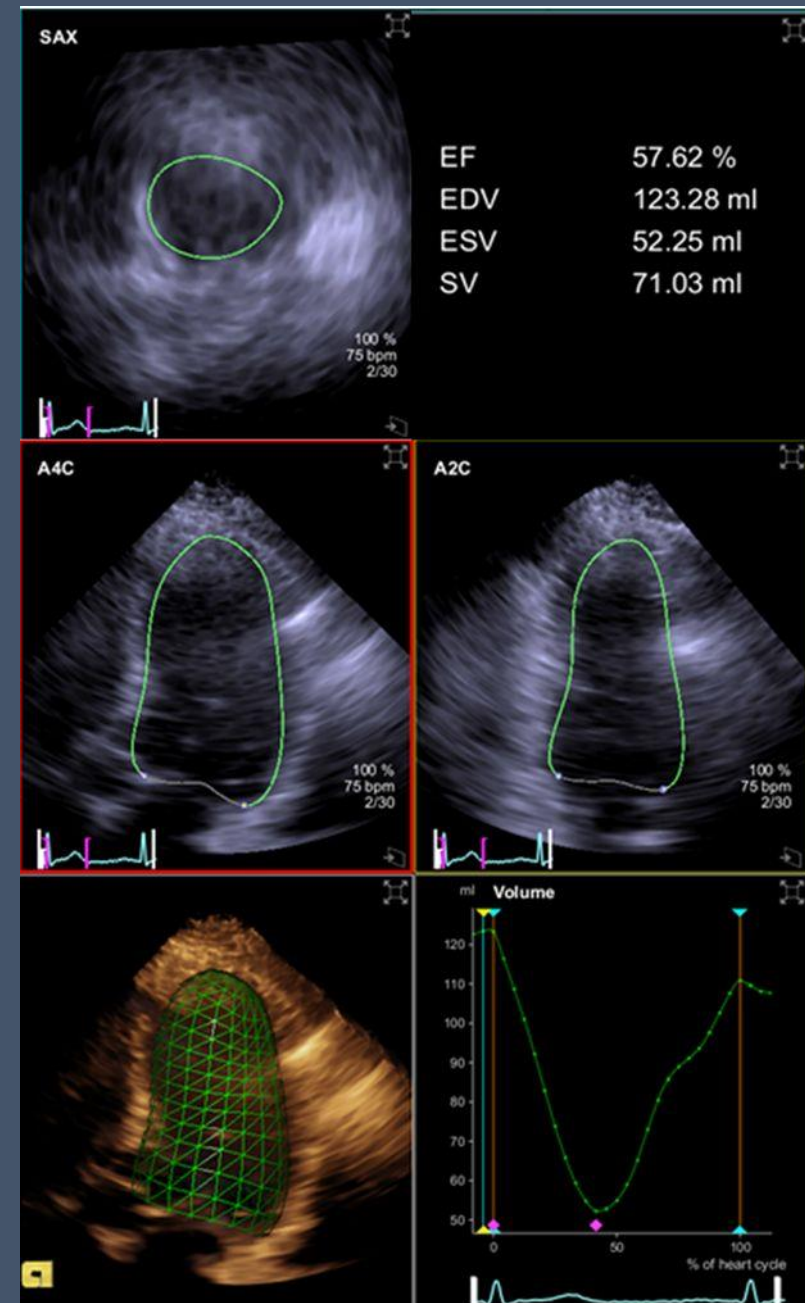
- Treat any underlying cause
  - Possible: ACS, Acute HTN, Worsening Valve, Arrhythmia, etc.
- Treat hypoxia - assisted ventilation if needed
- Diuresis
- Consider afterload reduction (Vasodilation)
- If known HFrEF and appear to be in cardiogenic shock → discontinue BB therapy, Give IV inotrope and/or mechanical support
- If known HFpEF and appear to be in cardiogenic shock → IV fluid (unless pulmonary edema present) and give IV vasopressor (Do not give inotrope) If outflow obstruction is suspected BB may be indicated
- If unknown → Give inotrope with or without vasopressor, assess for mechanical support



If I can't tell if patient has HFpEF or HFrEF from exam & history...

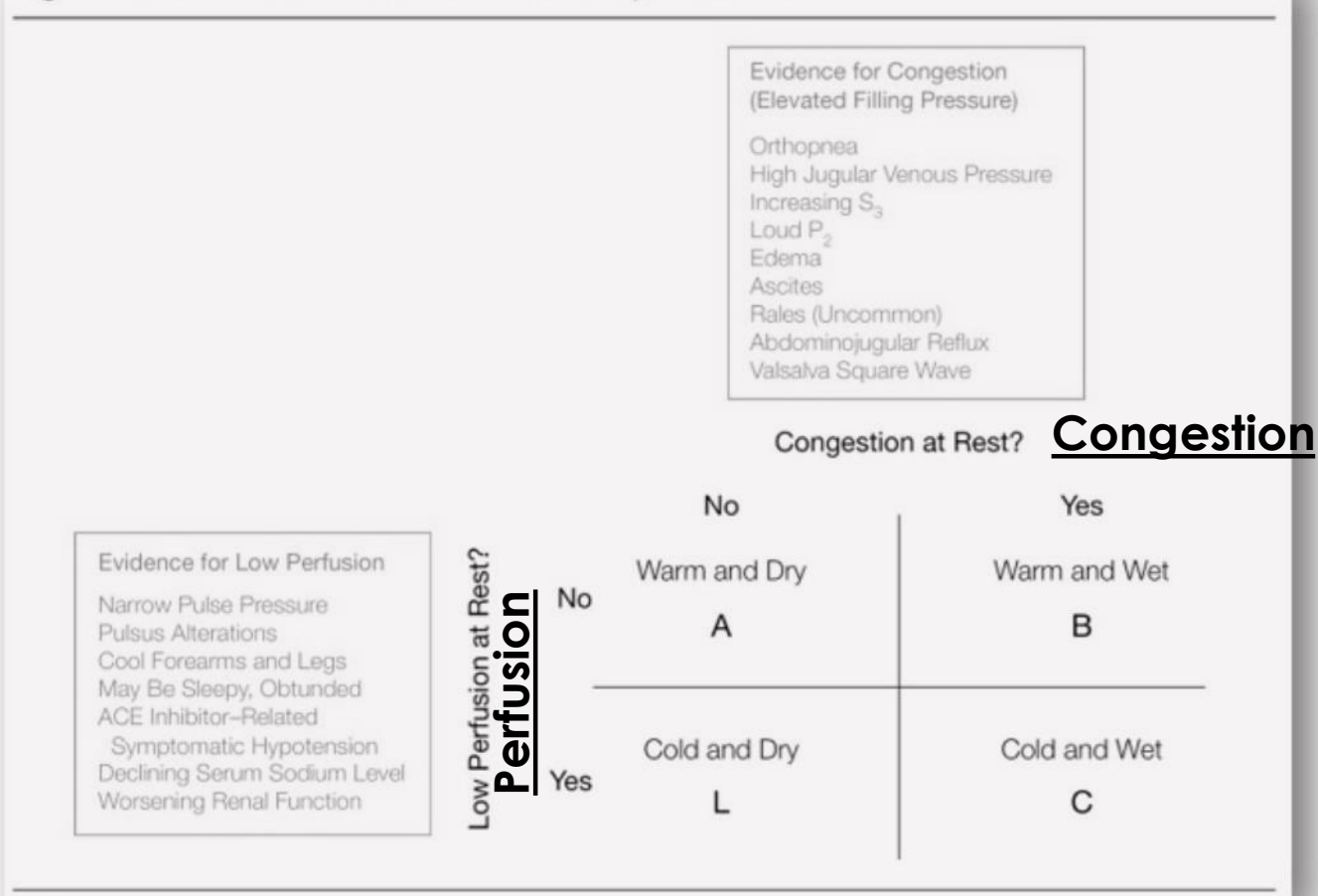
## Echocardiogram

- ▶ Computer measures volume before and after systole and calculates an EF%
- ▶ Valves: You can measure Stenosis, Regurgitation
- ▶ Can tell you where the LV is damaged:
  - ▶ HTN, DM, viruses, drugs tend to cause all over damage to the LV
  - ▶ A blocked artery tends to cause a region of the LV to not move so well.



# Medical Management of Advanced Heart Failure

**Figure 1.** Two-Minute Assessment of Hemodynamic Profile



- Safest place to be is Warm and Dry
  - Good Perfusion no congestion
- Worst for patient is Cold and Wet
  - Poor perfusion and + congestion
  - Cardiogenic Shock
  - Needs a Pressor and a diuretic potentially

# Pharmacotherapy for Heart Failure: Summary

## Acute HF

- Focus on restoration of normal perfusion and relief of congestion.
- Need drugs that work fast & reduce symptoms.
  - Diuretics – Loop (furosemide) – for Wet
  - Pressors/Inotropes – (Dopamine, Dobutamine, others) – For Cold (perfusion)
  - Change high dose IV meds for acute failure, to doses that are oral and lower potency when ready for discharge


## Chronic HF

- Focus on maintenance of fluid, electrolyte status & hormone blocking
- Drugs that reduce morbidity & mortality
  - Beta Blocker
  - ACE – inhibitor, ARB, ARNI
  - Aldosterone antagonists - if EF below 35%



# Treatment: General approach to managing CHF - Improve the underlying condition

- HTN
- Ischemia
- Valve disease
- Renal Failure
- Arrhythmia
- Anemia
- Sleep apnea
- PE



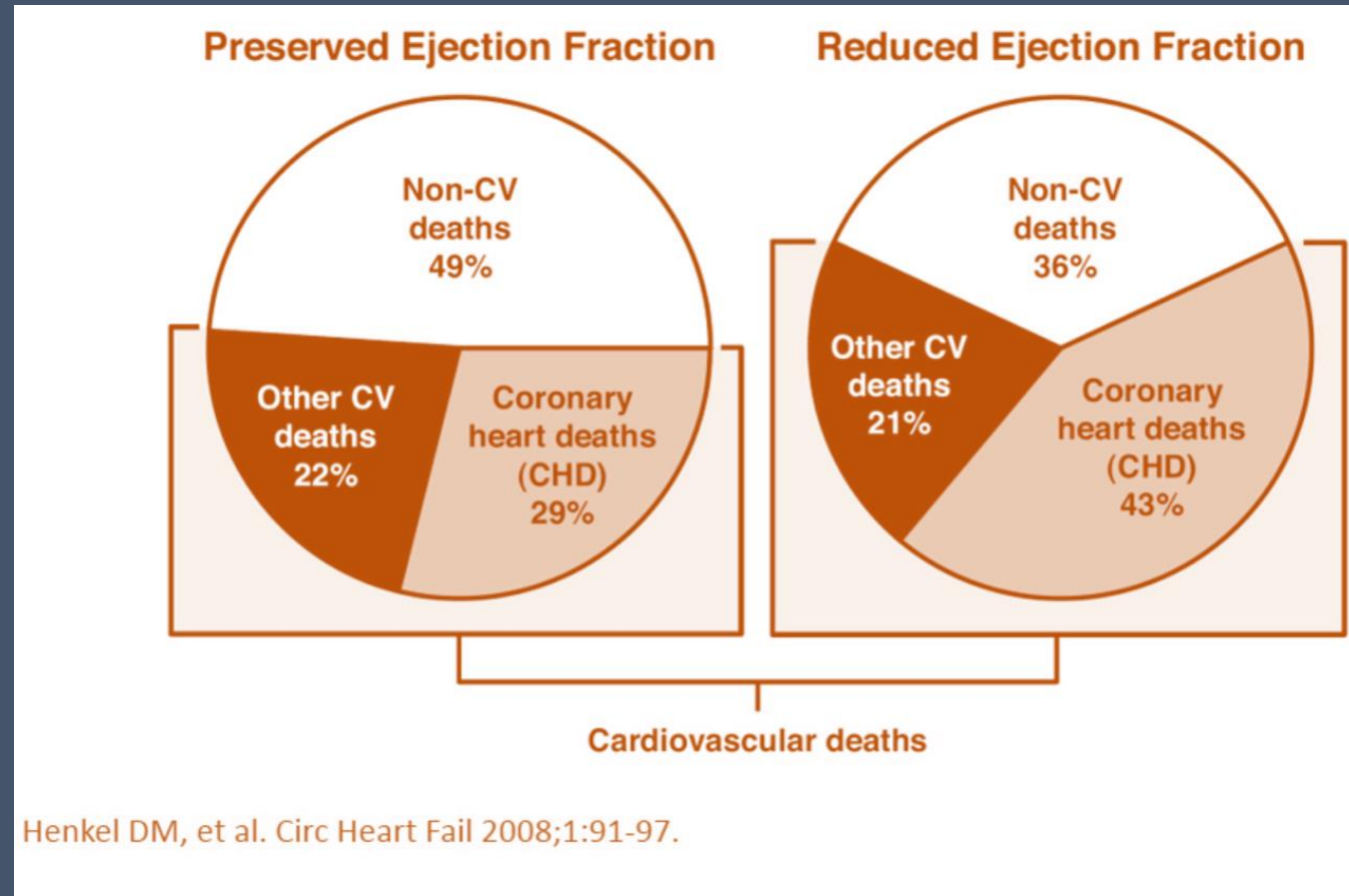
These can be the root cause of initial CHF episode or be a chronic contributor to worsening

# Heart Failure - Natural History

- 6 mil Americans, 3% of general population, 20% of elderly
- \$40 Billion in annual health care costs
- Survival: **Average 16 months from first hospitalization**

NYHA CHF Class	1 yr Mortality
I - Mild	5-10%
II-III - Moderate	15-30%
IV - Severe	50-60%

# Which has better prognosis? HFpEF or HFrEF?



- ➡ Off all cases of HF about 34% are HFpEF and 66% are HFrEF



## Planning in CHF is difficult

- ▶ Patients w/ condition who have a Do not resuscitate (DNR) order:
  - ▶ 5% in CHF
  - ▶ 47% in Cancer
- ▶ Only 4% of patients dying of HF get palliative care
  - ▶ 40% in cancer

# Prognostication in Heart Failure

- ▶ Markers of poor prognosis  
( $< 6$  months expected survival)
  - ▶ Low Sodium
  - ▶ Liver failure, renal failure, delirium
  - ▶ Unable to tolerate meds due to low BP
  - ▶ Symptoms at rest
  - ▶ Frequent hospitalizations
  - ▶ Cachexia
  - ▶ Lymphopenia



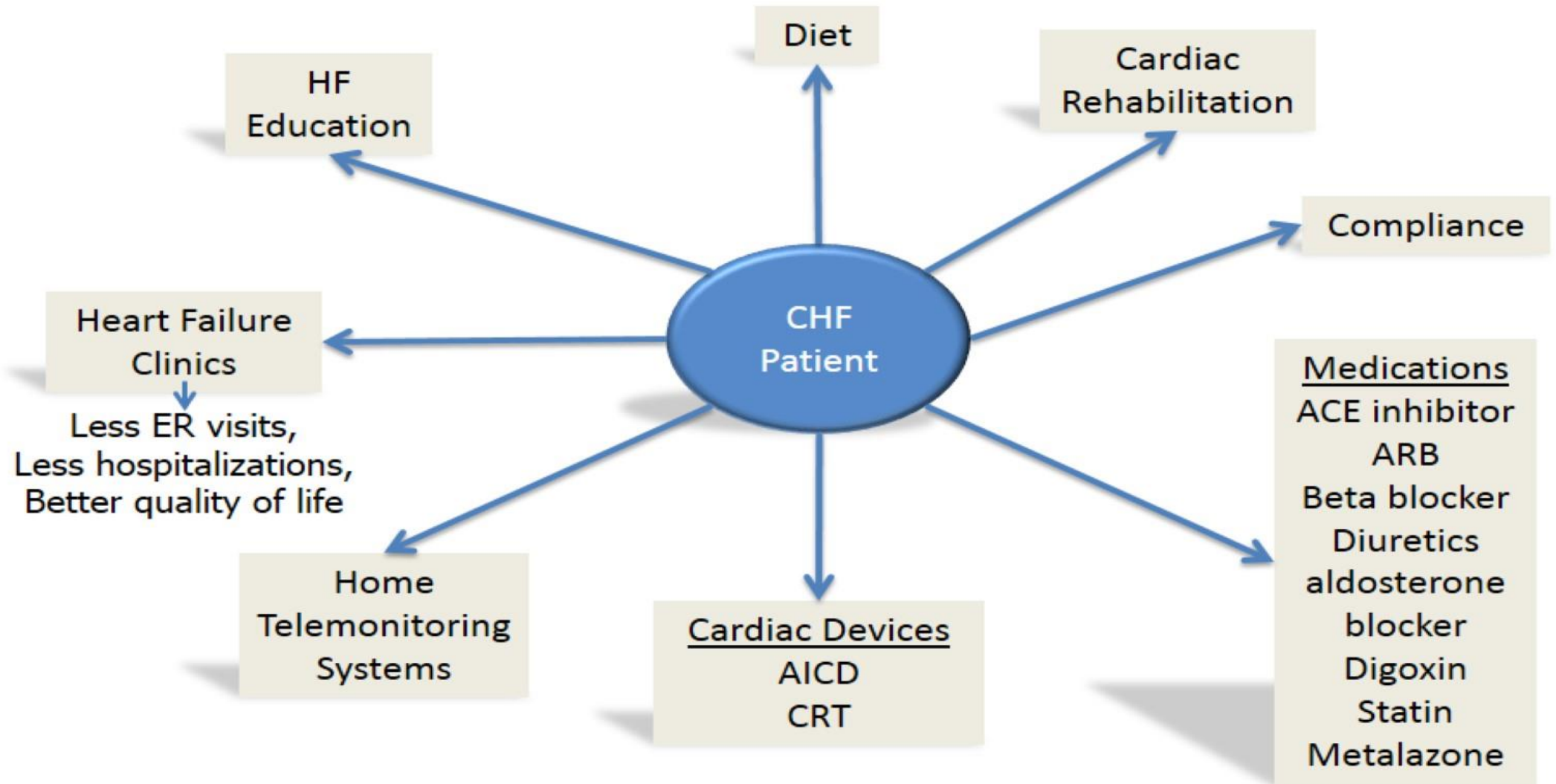


When to get Cardiology or Cardiac Surgeon involved?

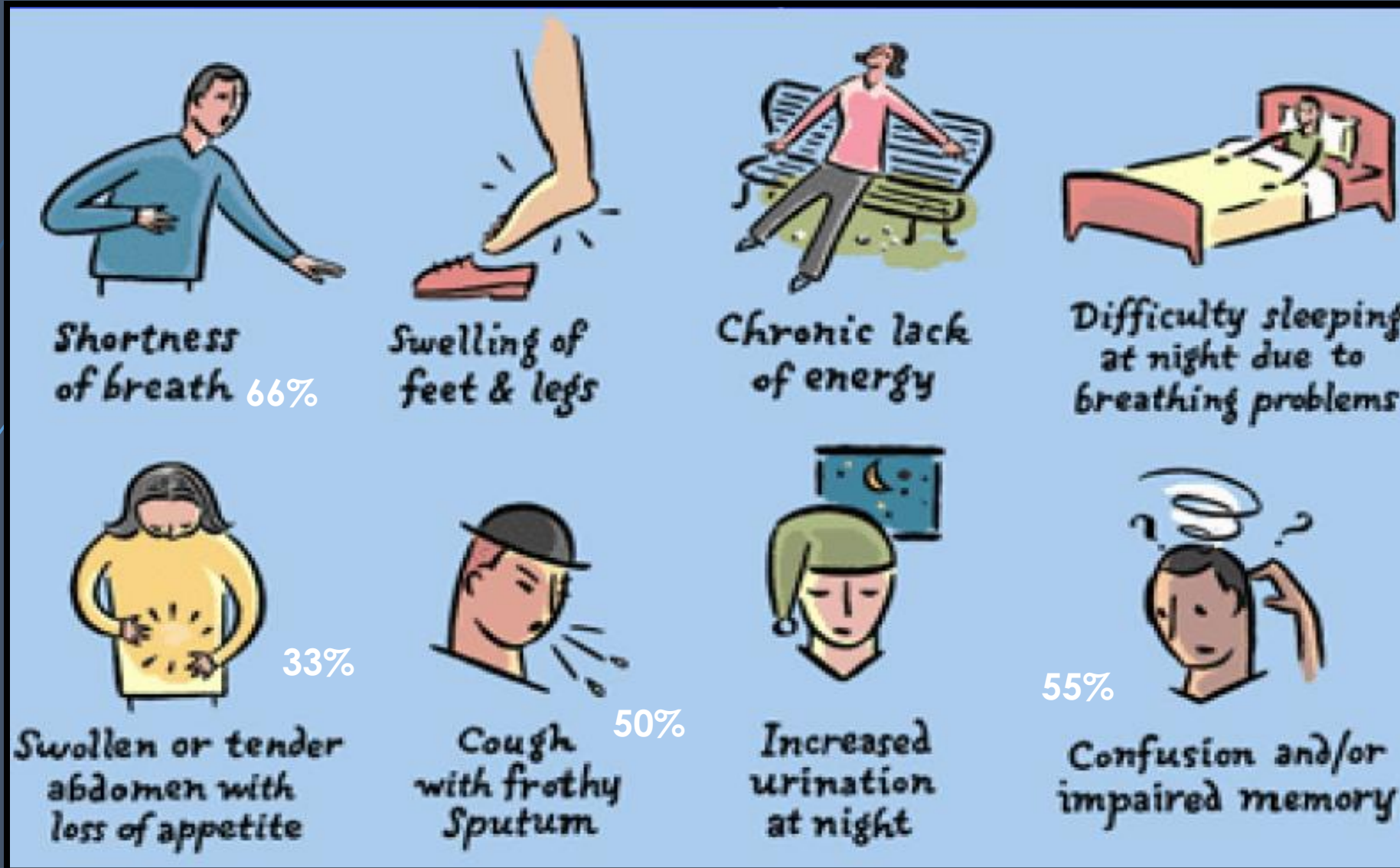
## Referrals for Advanced Heart Failure: *Dos and Don'ts*

- **Do:**
  - Discuss and consider advanced HF therapies when class III
    - Hyponatremia (NA <136)
    - BUN >45, Crea >2.5
    - BNP >4x upper normal limit
    - Diuretic dose >2.0 mg/kg/dl
    - Inability to take ACE/ARB/BB
  - Consider if frequent arrhythmia
- **Don't:**
  - Wait for progressive renal dysfunction
  - Wait for multiple pressors
  - Wait for cardiac cachexia

# Successful Treatment of Congestive Heart Failure = Complex Multidisciplinary Management Strategy



CHF symptoms at end of life: Ask/ address/ palliate symptoms even if heart function can't be improved.



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In HFpEF treatment should be aimed at associated conditions

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Diuretics, (ACEI, ARB, ARNI), BB for all patients with HFrEF

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ACEI, ARB, ARNI, BB, Hydralazine + Nitrate (in those that need it) improve survival

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Consider multidisciplinary management strategy for treatment of HF patients



Take home points

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Thank you!