Systolic and Diastolic Heart Failure (HFrEF and HFpEF) 2016

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Disclosures

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Heart Failure Terminology

- Heart failure is a global term for the physiological state in which cardiac output is insufficient for the body's needs. Heart Failure is a condition in which a problem with the structure or function of the heart impairs its ability to supply sufficient blood flow to meet the body's needs.

Heart Failure Pathophysiology

Heart failure is caused by any condition which reduces the efficiency of the myocardium leading to overload on the myocardium. Over time the increased workload will produce changes to the heart:

- Reduced contractility, or force of contraction, due to overloading of the ventricle.
- A reduced stroke volume, as a result of a failure of systole, diastole or both.
- Increased heart rate, stimulated by increased sympathetic activity in order to maintain cardiac output.
- Hypertrophy of the myocardium, caused by the terminally differentiated heart muscle fibers increasing in size in an attempt to improve contractility.
- Enlargement of the ventricles, contributing to the enlargement and spherical shape of the failing heart.
Heart Failure Statistics

Prevalence
• Heart failure (HF) affects an estimated 5.1 million Americans ≥ 20 years of age.
• 400,000 new cases of heart failure are diagnosed in the United States annually.

Incidence
• One-percent of adults 50 to 60 years of age.
• Seventy-five percent of HF cases have antecedent hypertension.
• Ten-percent of adults 80 years of age or older.

Mortality and Morbidity
• The lifetime risk for people with BP > 160/90 mmHg is double that of those persons with BP < 140/90 mmHg
• At 40 years of age, the lifetime risk of developing HF for both men and women is 1 in 5; at 80 years of age, the lifetime risk of developing new HF is 20%.
• Most frequent cause of hospitalizations in the elderly and is responsible for 7 to 12 percent of all hospital admissions.
• Contributes to approximately 275,000 deaths every year.

Heart Failure Is Associated with High Hospitalization and Readmission Rates

• In 2010, there were 1 million hospitalizations in the US with HF as the principal diagnosis1
  – Hospitalization rate did not change significantly from 20001
• Average length of hospital stay
  – Approximately 5 days (US)2
  – 11 days (Europe)3
• HF is also associated with high readmission rates:
  – ~25% all-cause readmission within 30 days and ~50% within 6 months4

Data from Organization for Economic Cooperation and Development, 2009.

1. CDC NCHS National Hospital Discharge Survey, 2000-2010

Categorization of Heart Failure

There are many different ways to categorize heart failure, including:

- Which side of the heart involved (left heart failure versus right heart failure)
- Whether the abnormality is due to contraction (systolic dysfunction) or relaxation of the heart (diastolic)
- Degree of functional impairment conferred by the abnormality (as in the NYHA functional classification)
- Whether the problem is primarily increased venous back pressure (behind) the heart, or failure to supply adequate arterial perfusion (in front of) the heart (backward vs. forward failure)
- Whether the abnormality is due to low cardiac output with high systemic vascular resistance or high cardiac output with low vascular resistance (low-output heart failure vs. high-output heart failure)

Anatomy of the Heart

The 4 Chambers of the Heart

- Right Atrium
- Left Atrium
- Right Ventricle
- Left Ventricle
Left-sided Heart Failure

Left-sided heart failure or "forward" failure is the most common type of heart failure. The left ventricle is the main pumping chamber. When it fails, oxygen-rich blood is not pumped to the rest of the body; instead, it can back up into the left atrium and into the lungs, where it builds up.

Left-sided heart failure causes fatigue because the body is not receiving enough blood and shortness of breath with or without exertion because of congestion in the lungs. A person may experience orthopnea and paroxysmal nocturnal dyspnea. Compromise in function can result in symptoms of poor systemic circulation such as dizziness, confusion and cool extremities at rest.

Left-sided Heart Failure

Signs

- Tachypnea
- Increased "work" of breathing (non-specific signs of respiratory distress).
- Rales or crackles, heard initially in the lung bases, and when severe, throughout the lung fields suggest the development of pulmonary edema (fluid in the alveoli).
- Cyanosis which suggests severe hypoxemia, is a late sign of extremely severe pulmonary edema.
Right-sided Heart Failure

*Right-sided heart failure* or "backward" failure usually happens as a result of left-sided heart failure. As the failing left ventricle causes fluid to build up in the lungs, the right ventricle finds it harder to pump blood to the lungs to pick up oxygen. *Right-sided heart failure* can occur on its own, for example, when caused by lung disease (COPD) or heart valve disease.

*Right-sided heart failure* can cause blood to back up in the veins, leading to swelling in the ankles, legs or belly, resulting in shortness of breath. In progressively severe cases, ascites and hepatomegaly may develop, leading to impaired liver function, jaundice and coagulopathy.

*Right-sided heart failure* can cause fatigue when the LV doesn’t fill with enough blood and can’t supply the body with oxygen-rich blood.

**Right-sided Heart Failure**

**Signs**

- Peripheral edema
- Ascites
- Hepatomegaly.
- Jugular venous pressure is frequently assessed as a marker of fluid status, which can be accentuated by the hepatojugular reflux.
- If the right ventricular pressure is increased, a parasternal heave may be present, signifying the compensatory increase in contraction strength.
Bi-Ventricular Failure

- Left sided "forward" failure overlaps with right sided "backward" failure.
- Most common cause of right-sided heart failure is left-sided heart failure, therefore, patients present with both sets of signs and symptoms.
- Dullness of the lung fields to finger percussion and reduced breath sounds at the bases of the lung may suggest the development of a pleural effusion and a more common sign of biventricular failure.

Types of Heart Failure

Classification of heart failure is based on which heart function or which side of the heart is most affected by the condition.

- **Systolic heart failure (HFrEF)** – failure of contraction to pump blood out of the chambers. This is measured by ejection fraction (EF) or the percentage of blood that is ejected out of the ventricle. Normal is 50% or higher.
- **Diastolic heart failure (HFpEF)** – failure of relaxation to fill the chambers with blood
HFrEF and HFpEF

Each beat of the heart consists of contraction in systole and relaxation in diastole. When the heart contracts, chambers of the heart (ventricles) pump out blood into the lungs and the rest of the body. When the heart relaxes and expands, the ventricles fill completely with blood.

Characteristics of HFpEF as Compared with Those of HFrEF

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Diastolic Heart Failure</th>
<th>Systolic Heart Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical features</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptoms (e.g., dyspnea)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Congestive state (e.g., edema)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Neurohormonal activation (e.g., brain natriuretic peptide)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Left ventricular structure and function</td>
<td>Normal</td>
<td>Decreased</td>
</tr>
<tr>
<td>Ejection fraction</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td>Left ventricular mass</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td>Relative wall thickness</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td>End diastolic volume</td>
<td>Normal</td>
<td>Increased</td>
</tr>
<tr>
<td>End diastolic pressure</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td>Left atrial size</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td>Exercise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise capacity</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Cardiac output augmentation</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>End diastolic pressure</td>
<td>Increased</td>
<td>Increased</td>
</tr>
</tbody>
</table>

* The clinical features of diastolic heart failure are similar to those of systolic heart failure, but left ventricular structure and function are distinctly different.

* The descriptor of left ventricular geometry is the relative wall thickness, defined as the ratio of left ventricular wall thickness to the radius of the left ventricular cavity.
NYHA Functional Classification

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (Mild)</td>
<td>No limitation of physical activity - ordinary physical activity doesn't cause tiredness, heart palpitations, or shortness of breath</td>
</tr>
<tr>
<td>II (Mild)</td>
<td>Slight limitation of physical activity, comfortable at rest, but ordinary physical activity results in tiredness, heart palpitations, or shortness of breath</td>
</tr>
<tr>
<td>III (Moderate)</td>
<td>Marked or noticeable limitations of physical activity, comfortable at rest, but less than ordinary physical activity causes tiredness, heart palpitations, or shortness of breath</td>
</tr>
<tr>
<td>IV (Severe)</td>
<td>Severe limitation of physical activity, unable to carry out any physical activity without discomfort. Symptoms also present at rest. If any physical activity is undertaken, discomfort increases.</td>
</tr>
</tbody>
</table>

AHA/ACC 2009 - Staging System of Heart

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>People at high risk for developing heart failure but without structural heart disease or symptoms of heart failure. Encompasses &quot;pre heart failure&quot; where intervention with management can overt Progression to symptoms</td>
<td>CAD (coronary artery disease), diabetes, hypertension, metabolic syndrome, obesity, using cardiotoxins or alcohol, family history of cardiomyopathy, cerebrovascular accident (CVA), personal history of rheumatic fever</td>
</tr>
<tr>
<td>B</td>
<td>People with structural heart disease but without signs and symptoms of heart failure NYHA Class I</td>
<td>Left ventricular hypertrophy (LVH) or reduced left ventricular ejection fraction (LVEF), asymptomatic valvular heart disease, previous MI</td>
</tr>
<tr>
<td>C</td>
<td>People with structural heart disease with prior or current symptoms of heart failure NYHA Class II and III</td>
<td>Known structural heart disease with dyspnea, fatigue, inability to exercise</td>
</tr>
<tr>
<td>D</td>
<td>People who have advanced heart failure and severe symptoms difficult to manage with standard treatment NYHA Class IV</td>
<td>Marked symptoms at rest despite maximal medical therapy, with recurrent hospitalizations</td>
</tr>
</tbody>
</table>
Systolic Heart Failure - HFrEF

Etiologies of HFrEF

- Coronary Artery Disease (65%)
- Idiopathic dilated cardiomyopathy
- Alcohol/toxin-induced cardiomyopathy
- Infectious/inflammatory process
- Familial dilated cardiomyopathy
- Postpartum cardiomyopathy
- Stress induced cardiomyopathy
- Endocrine/nutritional causes
- Iron overload cardiomyopathy
- Tachycardia mediated cardiomyopathy
Characteristics of HFrEF

- More readily recognized.
- Described as failure of the pump function of the heart.
- Characterized by a decreased ejection fraction (less than 45%).
- The strength of ventricular contraction is attenuated and inadequate for creating an adequate stroke volume resulting in inadequate cardiac output.
- Caused by dysfunction or destruction of cardiac myocytes or their molecular components.
- Most common mechanism of damage is ischemia causing infarction and scar formation dead myocytes are replaced by scar tissue decreased function of myocardium causing wall motion abnormality.

Characteristics of HFrEF

- Since the ventricle is inadequately emptied, ventricular end-diastolic pressure and volumes increase affecting the atrium.
- On the left side of the heart, the increased pressure is transmitted to the pulmonary vasculature extravasation of fluid into the lung parenchymal extravasation of fluid into the lung parenchyma pulmonary edema.
- On the right side of the heart, the increased pressure is transmitted to the systemic venous circulation and systemic capillary beds extravasation of fluid into the tissues of target organs and extremities dependent peripheral edema.
- Ejection fraction drops below 40%. 
Characteristics of HFpEF

- Described as failure of the ventricle to adequately relax and typically denotes a stiffer ventricular wall.
- Inadequate filling of the ventricle results in an inadequate stroke volume.
- Failure of ventricular relaxation also results in elevated end-diastolic pressures with pulmonary edema in left heart failure and peripheral edema in right heart failure.
- Caused by processes that affect cardiac remodeling.
- May be asymptomatic.

Characteristics of HFpEF

- Sensitive to increases in heart rate
- Sudden bouts of tachycardia (caused simply by physiological responses to exertion, fever, or dehydration) can lead to flash edema.
- Pathological tachyarrhythmias (e.g., atrial fibrillation with rapid ventricular response) may result in flash pulmonary edema.
- Diastolic function worsens with age even in individuals without ischemic heart disease.
Characteristics of HFpEF

- Low stroke volume
- Reduced cardiac output despite a normal ejection fraction
- Limited exercise tolerance as a result of elevated left ventricular diastolic and pulmonary venous pressure → reduction in lung compliance → increase in the work of breathing

Epidemiology of HFpEF

- About one third of all patients with congestive heart failure have diastolic heart failure
- Prevalence is highest in patients older than 75 years old
- Mortality rate is about 5-8 % annually as compared to 10-15% among patients with systolic heart failure
- Mortality rate is directly related to age and the presence/absence of coronary disease.
Factors that Exacerbate HFpEF

- Uncontrolled hypertension
- Atrial Fibrillation (AF)
- Non-compliance with or inappropriate discontinuation of medications for heart failure
- Myocardial ischemia
- Anemia
- Renal insufficiency
- Use of nonsteroidal anti-inflammatory drugs (NSAIDS) or thiazolidinediones
- Dietary indiscretion with over-indulgence in salty foods

Diagnosis of HFpEF

- A clinical diagnosis based on the finding of typical symptoms and signs of heart failure in a patient who is shown to have normal left ventricular ejection fraction and no valvular abnormalities on echocardiogram according to the American College of Cardiology (ACC) and the American Heart Association (AHA).
Management Principles for Patients with HFpEF

**Diuretics**—use with caution; aggressive diuresis may result in serious hypotension given the steep curve of the left ventricular diastolic pressure in relation to volume.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Treatment</th>
<th>Daily Dose of Medication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood volume control</td>
<td>Diuretics</td>
<td>3 g of sodium acetate per day</td>
</tr>
<tr>
<td>A</td>
<td>ACE inhibitors</td>
<td>Perindopril 8 mg/day</td>
</tr>
<tr>
<td>B</td>
<td>Angiotensin II receptor blockers</td>
<td>valsartan 160 mg/day</td>
</tr>
<tr>
<td>C</td>
<td>Combination of diuretics and beta blockers</td>
<td>metoprolol 50 mg/day</td>
</tr>
<tr>
<td>D</td>
<td>Calcium-channel blockers</td>
<td>nifedipine 60 mg/day</td>
</tr>
<tr>
<td>E</td>
<td>Rhythm control and modification of atrial fibrillation risk and duration</td>
<td>amiodarone 300 mg/day</td>
</tr>
<tr>
<td>F</td>
<td>Heart failure</td>
<td>imidazole 70-120 mg/day</td>
</tr>
<tr>
<td>G</td>
<td>Beta blockers</td>
<td>bisoprolol 2.5-200 mg/day</td>
</tr>
<tr>
<td>H</td>
<td>Combination therapy</td>
<td>metoprolol 50-100 mg/day</td>
</tr>
<tr>
<td>I</td>
<td>Antihypertensive agents</td>
<td>irbesartan 300 mg/day</td>
</tr>
<tr>
<td>J</td>
<td>Measures with Theoretical Benefit in Diastolic Heart Failure</td>
<td>perindopril 10 mg/day</td>
</tr>
</tbody>
</table>

Management Goals of HFpEF

- To reverse the consequences of diastolic dysfunction, i.e. venous congestion, exercise intolerance.
- To eliminate or reduce the factor responsible for the diastolic dysfunction.
Symptoms of Heart Failure

The Heart Failure Society of America coined the FACES mnemonic to help identify the main symptoms of heart failure:

- **Fatigue** - Feeling tired and weak
- **Activities limited** - Difficulty doing usual activities like carrying groceries
- **Chest congestion and persistent cough**
- **Edema or ankle swelling** – Swollen ankles, feet, leg and belly
- **Shortness of breath** – Breathless while walking, sitting or lying down flat

Other symptoms of heart failure include:

- Sudden weight gain more than 2 pounds in 1 day or 5 pounds in 1 week
- Bulging of the veins in the neck
- Chest pain
- A racing heartbeat
- Lack of appetite
- Urination at night
### The Reason Behind the Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortness of breath</td>
<td>Blood returning to the heart backs up. This causes fluid to leak into the lungs, making it harder for you to breathe.</td>
</tr>
<tr>
<td>Persistent cough or wheezing</td>
<td>When fluid leaks into the lungs, it often causes a cough the lungs' way of trying to remove the fluid. Some people also have wheezing that mimics asthma.</td>
</tr>
<tr>
<td>Edema</td>
<td>Because the heart isn't pumping effectively, blood and fluid collects around the body. Gravity causes much of this fluid to collect in the feet, ankles, and legs.</td>
</tr>
<tr>
<td>Fatigue, tiredness</td>
<td>Because the heart isn't pumping out enough blood to the body, blood is rationed out first to the most vital organs; all other organs have to work with a shortage of blood. Without enough oxygen-rich blood, the body tires easily.</td>
</tr>
</tbody>
</table>

### The Reason Behind the Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased heart rate</td>
<td>The heart beats faster so that it can compensate for its weaker pumping ability.</td>
</tr>
<tr>
<td>Weight gain</td>
<td>The buildup of excess fluid can cause sudden increase in weight.</td>
</tr>
<tr>
<td>Lack of appetite</td>
<td>Fluid backs up in the liver, causing the liver to enlarge so the stomach can't expand much. This makes you feel full after eating small amounts of food.</td>
</tr>
<tr>
<td>Nighttime urination</td>
<td>As the blood is pulled away from your kidneys during the day to be used by other organs and tissues, less urine is produced. When you lie down at night, the kidneys get more blood and produce more urine. Some medications used to treat high blood pressure may also increase your urine output.</td>
</tr>
</tbody>
</table>
Algorithm for Management of Heart Failure

Stage A Therapy – At Risk for Development of Heart Failure

<table>
<thead>
<tr>
<th>Goals</th>
<th>Drugs</th>
<th>Additional Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat hypertension</td>
<td>ACE inhibitors or ARBs in appropriate patients for vascular disease and diabetes</td>
<td></td>
</tr>
<tr>
<td>Treat lipid disorders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control metabolic syndrome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encourage regular exercise and healthy eating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encourage smoking cessation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discourage alcohol intake and illicit drug use</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Stage B Therapy – Structural Heart Disease

<table>
<thead>
<tr>
<th>Goals</th>
<th>Drugs</th>
<th>Additional Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>All measures under Stage A</td>
<td>ACE inhibitors or ARBs in appropriate patients</td>
<td>Devices in selective patients: Implantable cardioverter-defibrillators</td>
</tr>
<tr>
<td></td>
<td>Beta blockers in appropriate patients</td>
<td></td>
</tr>
</tbody>
</table>

### Stage C Therapy – Development of Symptoms of Heart Failure

<table>
<thead>
<tr>
<th>Goals</th>
<th>Drugs</th>
<th>Additional Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>All measures under Stage A and Stage B</td>
<td>Routine use of ACE inhibitors</td>
<td>Devices in selective patients: Biventricular pacing, Implantable cardioverter-defibrillators</td>
</tr>
<tr>
<td>Restrict dietary sodium intake</td>
<td>Routine use of Beta blockers</td>
<td></td>
</tr>
<tr>
<td>To prevent and treat myocardial ischemia</td>
<td>Routine use of diuretics for fluid retention</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drugs in selected patients: Aldosterone antagonists, ARBs, Digitalis, hydrolyzing/nitrates</td>
<td></td>
</tr>
</tbody>
</table>
## Stage D Therapy - Refractory Symptoms of Heart Failure at Rest

<table>
<thead>
<tr>
<th>Goals</th>
<th>Drugs</th>
<th>Additional Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>All measures under Stage A, B and C</td>
<td></td>
<td>Compassionate end of life</td>
</tr>
<tr>
<td>Decide appropriate level of care</td>
<td></td>
<td>Extraordinary measures (e.g., chronic inotropes, experimental drugs or surgery, heart transplant, permanent mechanical support (LVAD))</td>
</tr>
</tbody>
</table>

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## Diagnostic Algorithm for Heart Failure

1. **Medical History and Physical Examination**
   - Signs: Shortness of breath, coughing, fatigue, chest pain, swelling, palpitations, fast heart rate, nausea, vomiting, confusion, decreased mental status, skin diaphoresis, arterial hypotension, and elevated jugular venous pressure.
   - Risk factors: Hypertension, diabetes, obesity, smoking, dyslipidemia, and family history.

2. **ECG and Chest X-ray**
   - Consider other causes of symptoms.

3. **Echocardiogram**
   - Consider stress test.
   - Decreased ejection fraction:
     1. Diagnose arrhythmia problems (arterial hypertension, heart failure, CHF, or TIA).
     2. Diagnose non-cardiac problems (protein-induced cardiomyopathy).

4. **Stress Test**

5. **Cardiac MRI**

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*Used with Permission from Systolic and Diastolic Heart Failure Barbara Brown FOCUS Conference*
Physical Exam

- Consists of taking a complete set of vital signs.
- Assess for sudden weight gain.
- Check for edema of abdomen, arms, and legs.
- Check for jugular venous distention (JVD).
- Using a stethoscope, listen to the heart for abnormal or extra heart sounds, a rapid or irregular heart beat, displaced point of maximum impulse and for a murmur.
- Listen for normal S1 and S2 and for abnormal sounds such as S3 or S4, murmurs, clicks, or rubs which could indicate heart pathology.
- Using a stethoscope listen to the lungs for rales or crackles.

Physical Exam - Non Invasive Hemodynamic Assessment

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take vital signs: Assess pulse for rhythm, strength and rate. Assess blood pressure.</td>
<td>Blood pressure is determined by cardiac output, peripheral vascular resistance, circulating blood volume, blood viscosity, and vessel elasticity.</td>
</tr>
<tr>
<td>Precordium: Inspect the anterior chest for heaves and an increase in visible pulsatility.</td>
<td>Heaves indicate ventricular hypertrophy due to an increased workload.</td>
</tr>
<tr>
<td>Palpate the PMI (point of maximum impulse) for a normal 2+ pulse.</td>
<td>A PMI that is displaced down and to the left indicates ventricular hypertrophy which may be due to volume overload. An increase in force and duration of the pulse may indicate an increase in pressure without volume overload.</td>
</tr>
<tr>
<td>Inspect the neck for jugular venous distention (JVD).</td>
<td>Indicates Central Venous Pressure (CVP). Full distention as the patient sits at a 45 degree angle indicates an increase in CVP.</td>
</tr>
<tr>
<td>Auscultate and palpate the carotid arteries to assess arterial blood flow.</td>
<td>A decrease in pulse amplitude indicates a decrease in stroke volume.</td>
</tr>
<tr>
<td>Assess for hepatojugular reflux.</td>
<td>A positive hepatojugular reflex indicates heart failure.</td>
</tr>
<tr>
<td>Palpate the peripheral pulses and check nailbed capillary refill which is normally less than 3 seconds.</td>
<td>Changes in pulses indicate a change in cardiac output and tissue perfusion.</td>
</tr>
</tbody>
</table>
Physical Exam - Jugular Venous Distention

Man with congestive heart failure and marked jugular venous distension

Technique for Measuring Jugular Venous Pressure

Patient reclining with head elevated 45°. Measure elevation of neck veins above the sternal angle.

Add 5 cm to measurement since right atrium is 5 cm below the sternal angle. Normal CVP <= 8 cm H2O.
**Electrophysiology**

- Electrocardiogram (ECG/EKG) is used to identify arrhythmias, ischemic heart disease, right and left ventricular hypertrophy, and presence of conduction delay or abnormalities (e.g. left bundle branch block).

- An ECG may also diagnose acute myocardial ischemia or infarction (if ST depression or elevation are present).

**Blood Tests**

- Electrolytes, measures of renal function, liver function tests, thyroid function tests, a complete blood count, and often C-reactive protein if infection is suspected.

- B-type natriuretic peptide (BNP).

- Cardiac markers (e.g., CKMB, troponin I) if myocardial infarction suspected.

- N-terminal pro-BNP (NTproBNP).
**B-type Natriuretic Peptide**

• **B-type Natriuretic Peptide** (BNP) is a substance secreted from the ventricles of the heart in response to changes in pressure that occur when heart failure develops and worsens.

• BNP in the blood increases when heart failure symptoms worsen, and decreases when the heart failure condition is stable.

• In a recent study reported, BNP accurately detected heart failure 83% of the time and reduced clinical indecision from 43% to 11%.

• BNP are important in diagnosis and assessment of prognosis, in patients with HF.

**B-type Natriuretic Peptide Results**

• BNP levels below 100 pg/mL indicate no heart failure

• BNP levels of 100-300 suggest heart failure is present

• BNP levels above 300 pg/mL indicate mild heart failure

• BNP levels above 600 pg/mL indicate moderate heart failure.

• BNP levels above 900 pg/mL indicate severe heart failure.

Note: The BNP level in a person with heart failure, even someone whose condition is stable, is higher than in a person with normal heart function.
Echocardiography is commonly used to support a clinical diagnosis of heart failure. It uses ultrasound to determine the stroke volume (SV or the amount of blood in the heart that exits the ventricles with each beat), the end-diastolic volume (EDV or the total amount of blood at the end of diastole). It determines the SV in proportion to the EDV, a value known as the "ejection fraction" (EF). It identifies valvular heart disease, assesses the pericardium, and can aid in deciding what treatments will help the patient. It also detects wall motion abnormality seen with myocardial ischemia.

Left: an echocardiogram of a normal heart. Right: an echocardiogram with a thickened left ventricle wall (Left ventricular hypertrophy or LVH), a sign of heart failure.

Abbreviations: LV = left ventricle; RV = right ventricle; LA = left atrium.
Echocardiography – HFrEF

Two-dimensional echocardiogram showing a four-chambers view of the heart in a patient with systolic dysfunction. Left ventricle is dilated.

Abbreviations: LV = left ventricle; RV = right ventricle; RA = right atrium; LA = left atrium)

Echocardiography – HfPEF

Two-dimensional echocardiogram showing a four-chambers view of the heart in a patient with diastolic dysfunction. Left ventricle is hypertrophied.

Abbreviations: LV = left ventricle; RV = right ventricle; RA = right atrium; LA = left atrium)
Echocardiography
HFpEF

• Doppler echocardiography: measures the velocity of intracardiac blood flow.
• Diastolic flow from the left atrium and left ventricle across the mitral valve has two components: the E wave, early diastolic filling and A wave, atrial contraction in late diastole.
• E wave velocity is influenced by both the rate of early diastolic relaxation and the left atrial pressure.
• Alterations in the pattern of E wave velocity reflects the degree of left ventricular diastolic dysfunction and prognosis.

Imaging Modalities-Radiographic

• Chest X-rays in the compensated patient may show cardiomegaly.
• Chest X-rays in left ventricular failure may reveal evidence of vascular redistribution.
Pulmonary Congestion

Pulmonary congestion in cardiac failure

Hemodynamic Monitoring for Heart Failure Management

- Managing Pressures in the Heart Failure Patient
- CardioMEMS™ HF System
- CHAMPION Clinical Trial
Worsening Heart Failure Leading to HF Hospitalizations Contributes to Disease Progression

With each subsequent HF-related admission, the patient leaves the hospital with a further decrease in cardiac function.

Graph adapted from: Gheorghiade MD, et al. Am J. Cardiol. 2005


HF Hospitalizations are a Strong Predictor of Mortality¹,²

- Data from the EFFECT study, n = 9138 patients¹
- Data from the Setoguchi et al., n = 14,374 patients²

Studies show each admission decreases a patient’s chance of survival.

How well do our current tools work?

1,000,000 hospitalizations for heart failure
>3,000,000 hospitalizations include heart failure as contributor
25% of patients are readmitted in 30 days 50% in 6 months

- Post hoc analysis of 463 acute decompensated HF patients from DOSE-HF and CARRESS-HF trials showed:
  - 40% of patients are discharged with moderate to severe congestion.\(^1\)
  - Of patients decongested at discharge, 41% had severe or partial re-congestion by 60 days.\(^1\)

1. Lala A, et al. JCF 2013

CardioMEMS™ HF System

The pulmonary artery pressure sensor is implanted via a right heart catheterization procedure via femoral vein approach.

Target location for pulmonary artery pressure sensor
Cardiomems™ HF System

PA Pressure Sensor on Catheter Delivery System

Patient Home Electronics Unit

PA Pressure Database

Physician Access Via Secure Website

CHAMPION Clinical Trial: PA Pressure-guided Therapy Reduces HF Hospitalizations

Patients managed with PA pressure data had significantly fewer HF hospitalizations as compared to the control group.

### Clues for Differentiating Between HFrEF and HFpEF in Patients with Heart Failure

#### Clues from the Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Systolic Dysfunction</th>
<th>Diastolic Dysfunction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>XX</td>
<td>XXX</td>
</tr>
<tr>
<td>Coronary Artery Disease*</td>
<td>XXX</td>
<td>XX</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>XXX</td>
<td>XX</td>
</tr>
<tr>
<td>Valvular heart disease*</td>
<td>XXX</td>
<td>—</td>
</tr>
<tr>
<td><strong>Physical Examination</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third heard sound (S3) gallop*</td>
<td>XXX</td>
<td>X</td>
</tr>
<tr>
<td>Fourth heart sound (S4) gallop</td>
<td>XX</td>
<td>XXX</td>
</tr>
<tr>
<td>Rales</td>
<td>XX</td>
<td>XX</td>
</tr>
<tr>
<td>Jugular venous distention</td>
<td>XX</td>
<td>X</td>
</tr>
<tr>
<td>Edema</td>
<td>XX</td>
<td>X</td>
</tr>
<tr>
<td>Displaced point of maximal impulse*</td>
<td>XX</td>
<td>—</td>
</tr>
<tr>
<td>Mitral regurgitation*</td>
<td>XXX</td>
<td>X</td>
</tr>
</tbody>
</table>

Used with Permission from Systolic and Diastolic Heart Failure Barbara Brown FOCUS Conference

#### Clues from the Evaluation

<table>
<thead>
<tr>
<th></th>
<th>HFrEF</th>
<th>HFpEF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chest Radiograph</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiomegaly*</td>
<td>XXX</td>
<td>X</td>
</tr>
<tr>
<td>Pulmonary congestion</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td><strong>Electrocardiogram</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q wave</td>
<td>XX</td>
<td>X</td>
</tr>
<tr>
<td>Left ventricular hypertrophy*</td>
<td>X</td>
<td>XXX</td>
</tr>
<tr>
<td><strong>Echocardiogram</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased ejection fraction*</td>
<td>XXX</td>
<td>—</td>
</tr>
<tr>
<td>Dilated left ventricle*</td>
<td>XX</td>
<td>—</td>
</tr>
<tr>
<td>Left ventricle hypertrophy*</td>
<td>X</td>
<td>XXX</td>
</tr>
</tbody>
</table>

X = suggestive, the number of Xs reflects the relative weight; — = not suggestive.* and — Particularly helpful in distinguishing systolic from diastolic dysfunction in heart failure.
**Algorithm - Pharmacological Management of Heart Failure**

**Drugs to avoid in heart failure:** NSAIDS, most calcium channel blockers (felodipine and amlodipine are likely safe), thiazolidinediones, most antiarrhythmics.

**Drugs That Reduce Mortality in Heart Failure With Reduced Ejection Fraction**

Drugs that inhibit the renin-angiotensin system have modest effects on survival

*Based on results of SOLVD-Treatment, CHARM-Alternative, COPERNICUS, MERIT-HF, CIBIS II, RALES and EMPHASIS-HF*
Initiation and Management of Angiotension-Converting Enzyme Inhibitor

- Assess patient’s volume status, serum electrolytes, and renal function before initiation of therapy.

- Do not start in patients with symptomatic hypotension, hyperkalemia, or severe renal disease.

- Initiate at a low dose and titrate upward every 2-4 weeks.

- Repeat serum electrolytes and renal status in 1-2 weeks after initiation or with dosage change.

Angiotension-Converting Enzyme Inhibitor (ACEI)

- Contraindications include cardiogenic shock, angioneurotic edema, and hyperkalemia.

- Renal insufficiency is not a contraindication; start low and monitor renal function closely.

- Heart Failure patients with severe renal insufficiency and on dialysis should be treated.

- To promote regression of left ventricular hypertrophy.

- To treat hypertension.
Recommended Beta Blockers and Dosage

<table>
<thead>
<tr>
<th>Drug</th>
<th>Initial Dose</th>
<th>Target Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bisoprolol</td>
<td>1.25 mg PO qd</td>
<td>10 mg PO qd</td>
</tr>
<tr>
<td>Carvedilol</td>
<td>3.125 mg PO bid</td>
<td>25 mg PO bid</td>
</tr>
<tr>
<td>Metoprolol Succinate</td>
<td>25 mg PO qd</td>
<td>200 mg PO qd</td>
</tr>
</tbody>
</table>

- Bisoprolol is not approved for heart failure in the United States by The FDA.
- A maximum dose of Carvedilol 50 mg bid has been administered to patients with mild to moderate heart failure who weigh over 85 kg (187 lb).
- Metoprolol succinate 12.5 mg may be used in severe heart failure (25 mg cut in half)

Contraindications to beta blockers: Symptomatic bradycardia, hypotension (SBP below 80mmHg), signs of peripheral hypoperfusion (e.g., cold, clammy skin, cyanosis, oliguria, impaired mental status), carcinogenic shock, acute pulmonary edema, advanced heart block without pacemaker, reactive airway disease.

Digitalis

- Symptomatic improvement with reduced hospitalizations in patients with mild to moderate heart failure.
- Less effective in women than in men.
- Optimal target level is 0.6 to 0.9, above which there is an increase in mortality.
- Drug interactions with amiodarone.
**Aldosterone Antagonist**

- Use cautiously in patients with creatinine above 1.5 or potassium above 5.
- Avoid potassium and salt substitutes.
- Monitor potassium and creatinine levels.
- Limited study populations (e.g., NYHA class III and IV, post MI with reduced EF, and diabetes mellitus).
- To reduce development of fibrosis.

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**Mechanisms of Progression in Heart Failure**

- **Myocardial or vascular stress or injury**
  - Increased activity or response to maladaptive mechanisms
  - Decreased activity or response to adaptive mechanisms

- **Angiotensin receptor blocker** + **Inhibition of nprilysin**

Evolution and progression of heart failure

Aim of the PARADIGM-HF Trial

Prospective comparison of ARNI with ACEI to Determine Impact on Global Mortality and morbidity in Heart Failure trial (PARADIGM-HF)

SPECIFICALLY DESIGNED TO REPLACE CURRENT USE OF ACE INHIBITORS AND ANGIOTENSIN RECEPTOR BLOCKERS AS THE CORNERSTONE OF THE TREATMENT OF HEART FAILURE

LCZ696 400 mg daily

Enalapril 20 mg daily

Angiotensin Neprilysin Inhibition With LCZ696 Doubles Effect on Cardiovascular Death of Current Inhibitors of the Renin-Angiotensin System

- Effect of ARB vs placebo derived from CHARM-Alternative trial
- Effect of ACE inhibitor vs placebo derived from SOLVD-Treatment trial
- Effect of LCZ696 vs ACE inhibitor derived from PARADIGM-HF trial
Entresto® - sacubitril/valsartan

**Literature Review**

**Conclusions**

- Entresto’s dual inhibition was more effective in reducing the risk of death from cardiovascular causes or hospitalization for HF than ACE inhibition with enalapril.
- The only significant side effect was symptomatic hypotension, though this did not increase the rate of discontinuation.


Entresto™ - sacubitril/valsartan

**Summary**

- Entresto™ inhibits neprilysin and angiotensin receptors.
- Indicated to reduce the risk of cardiovascular death and hospitalization for heart failure in patients with chronic heart failure (NYHA Class II-IV) and reduced ejection fraction.
- Initial dose is based on receipt of ACE-I or ARB therapy prior to initiation.
- Avoid use in combination with an ACE-I or in patients with a history of angioedema.
- Most common side effect is hypotension.

Nonpharmacologic Management - Sleep Apnea

- Obstructive sleep apnea (OSA) worsens heart failure (HF).
- All patients with HF should be evaluated for sleep apnea.
- Persons at risk for OSA should undergo polysomnography.
- Periods of hypoxia in OSA worsen hypertension → contributes to systolic and diastolic dysfunction.

Management Goals - Acute Decompensation of Heart Failure

- Immediate goal is to re-establish adequate perfusion and oxygen delivery to end organs.
- Ensure that airway, breathing, and circulation are adequate.
- Immediate treatments involve combination of vasodilators such as nitroglycerin and diuretics (e.g., furosemide), and possibly non invasive positive pressure ventilation (NIPPV).
- Vasodilators (e.g., nitropresside, nitroglycerin, or nesiritide).
- Inotropes (e.g., milrinone, dobutamine).
Recommendations of Management of Concomitant Diseases in Patients with Heart Failure

- Nitrates and beta-blockers in conjunction with diuretics for the treatment of angina in patients with HF.
- Coronary revascularization in patients who have both HF and angina.
- Anticoagulants in patients with HF who have paroxysmal or chronic atrial fibrillation or previous thromboembolic event.
- Control of the ventricular response in patients with HF and atrial fibrillation with a beta-blocker (amiodarone, if BB is contraindicated or not tolerated).
- Beta-adrenergic in patients with HF to reduce the risk of sudden death.

Management Goals - Chronic Management

- Goals are to prevent the development of acute decompensated heart failure, to counteract the effects of cardiac remodeling, and to minimize the patient’s symptoms.
- Pharmacologic agents (e.g., oral loop diuretics, beta blockers, ACE inhibitors or ARBs, vasodilators, and in severe cardiomyopathy aldosterone receptor antagonists).
- Behavioral modification (e.g., dietary modifications, exercise as tolerated and smoking cessation).
- To prevent and treat myocardial ischemia (e.g., revascularization via percutaneous techniques or coronary artery bypass grafting (CABG).
- With severe cardiomyopathy, implantation of an automatic implantable cardioverter-defibrillator (AICD).
- A select population may benefit from ventricular resynchronization.
- In select cases, cardiac transplantation can be considered or left ventricular assist device (LVAD).
- Palliative care and hospice in those with Stage D heart failure.
A ventricular assist device (VAD) is an implantable mechanical pump that helps pump blood from the Ventricles to the rest of your body. LVADs are used in people who have Weakened hearts or heart failure.

A left ventricular assist device (LVAD) is implanted under the skin. It pumps blood from the left ventricle of the heart to the body. A control unit and battery pack are worn outside the body and are connected to the LVAD through a port in the skin.

VADs are implanted as a bridge to heart transplant or long-term Treatment For heart failure and not a good candidate for a heart transplant.

Heart Failure Prognosis

- The cardiopulmonary exercise testing (CPX testing) is used to assess prognosis in advanced heart failure patients. CPX testing is usually required prior to heart transplantation as an indicator of prognosis. Cardiopulmonary exercise testing involves measurement of exhaled oxygen and carbon dioxide during exercise. The peak oxygen consumption (VO2 max) is used as an indicator of prognosis. As a general rule, a VO2 max less than 12-14 cc/kg/min indicates a poorer survival and suggests that the patient may be a candidate for a heart transplant. Patients with a VO2 max<10 cc/kg/min have clearly poorer prognosis.
Facts and Comparisons

- Women are less likely than men to have systolic heart failure
- Symptoms of systolic heart failure are less severe in women than in men
- Men have double the risk of developing blood-pumping (systolic) problems compared with women
- In women the pumping chamber wall thickens but the pumping chamber itself doesn't enlarge; in men, the chamber stretches and enlarges but the wall doesn't thicken, leading to reduced blood-pumping function.
- Women usually have better blood-pumping function and a higher ejection fraction
- Women are more likely to have diastolic heart failure, in which the thickened wall can't relax for the chamber to expand and fill with enough blood.
- Women with long-term systolic heart failure are more likely than men to have symptoms such as swollen ankles, elevated jugular venous pressure and shortness of breath resulting from fluid buildup in the lungs.

JCAHO Core Performance Measures for Heart Failure

Performance Measure

HF-1: Discharged patients with heart failure with written instructions or education materials given to the patient or caregiver at discharge or during the hospital stay that address all of the following: activity level, diet, discharge medications, follow-up appointment, weight monitoring, what to do if symptoms worsen.

HF-2: Patients with heart failure with documentation in the hospital record that LV function was assessed before arrival or during hospitalization or that it is planned after discharge.

HF-3: Patients with heart failure with left ventricular systolic dysfunction (LVSD) and without ACE inhibitor contraindications who are prescribed an ACE inhibitor at discharge.

HF-4: Patients with heart failure with a history of smoking cigarettes who are given smoking cessation counseling during the hospital stay.

JCAHO identified standardized, evidence based performance measures "Core Measures" for adult patients admitted with a main diagnosis of HF. The Core Measures support the HF Guidelines defined by the ACC/AHA.

Abbreviations: JCAHO=Joint Commission on Accreditation of Healthcare Organizations; HF= heart failure; LVSD= left ventricular systolic dysfunction; ACE= angiotension converting enzyme.
Thank you!

References

• Systolic and Diastolic Heart Failure Barbara Brown, DNP, MSN, RN, ACNP-C, FNP, FOCUS Conference, The Gaylord Opryland Hotel - Nashville, TN, May 9, 2013 (Used with permission 12/29/15)


