

# HEART FAILURE

## HISTORY

### Symptoms

- Dyspnea at rest or with exertion
- Chronic cough
- Wheezing
- Weight gain
- Fatigue

### Symptoms worse at night (pulmonary congestion)

- Orthopnea
- Paroxysmal nocturnal dyspnea
- Nocturia (greater perfusion of renal vasculature)

### Symptoms localizing right heart failure

- Peripheral edema
- Right upper quadrant pain (liver congestion)
- Anorexia/nausea (edema of the gut or impaired GI perfusion)

### Other

- Chest pain
- Palpitations (could indicate underlying arrhythmia)

### Medical History

- Heart failure
  - Last echo
  - Dry weight
- Valve disease, new or worsening?
- Myocarditis
- Arrhythmia
- Ischemia/prior ischemic workup
- Follow with a cardiologist?
- Family history of heart failure or cardiac disease

### Medications

- Current GDMT therapy
- Diuretic dose
- Missed or changed doses?
- Assess for medication precipitants
  - NSAID use
  - Steroids
  - Calcium channel blockers
  - TZDs
  - Anthracyclines

### Assess for Precipitants

- Dietary/medication adherence or changes
- Uncontrolled hypertension
- Acute infection
- AKI
- Pulmonary embolism
- Toxins, alcohol, cocaine

## PHYSICAL EXAM

### Vitals

- Blood pressure
  - Hypertensive mostly in diastolic heart failure
  - Hypotensive in end-stage CHF due to poor cardiac output
- Elevated weight (fluid retention)
- Tachycardia may be present from increased sympathetic activity
- Increased pulse pressure (may be narrowed due to peripheral vasoconstriction and low stroke volume)

### Cardiac Exam

#### Inspection & Palpation

- Inspect the chest for the location of the PMI (point of maximal impulse) – the normal PMI is palpated at the left 5th intercostal space (L. 5th IS), in the midclavicular line
  - Laterally displaced and/or enlarged PMI may indicate left ventricular hypertrophy

#### Auscultation

- To help determine S1 and S2, you may palpate the right carotid artery while auscultating the chest. S1 falls just before the carotid upstroke, and S2 follows the carotid upstroke
  - Accentuated second heart sound may be heard in pulmonary hypertension

#### Abnormal Cardiac Auscultatory Findings

- Gallops are extra heart sounds (known as S3 and S4), which occur between S2 and S1
  - 3rd heart sound (systolic dysfunction) "S3" indicates ventricular dilation
  - 4th heart sound (hypertension and diastolic dysfunction, HCM) "S4" indicates and atrium contracting against a stiff noncompliant left ventricle
- Murmurs usually indicate valvular pathology – the timing (systolic or diastolic) and intensity
  - Commonly from mitral or tricuspid regurgitation which are often functional from heart failure and not the underlying cause
  - Tricuspid regurgitation is most likely the result of pulmonary venous hypertension

#### Measuring the Jugular Venous Pressure

Done to assess a patient's intravascular volume status

- Identify the right jugular venous pulse and the highest point of pulsation in the right jugular vein
- Extend a straight object from this point and a centimeter ruler vertically from the sternal angle, until they intersect at an exact right angle
- Measure the vertical distance in centimeters above the sternal angle where the object crosses the ruler
- Add 5 cm (the distance from the sternal angle to the center of the right atrium) – this is the jugular venous pressure (JVP)
  - Elevated JVP is indicative of venous congestion

### Pulmonary Exam

#### Auscultation

- "Cardiac asthma" can be characterized as rales (fine-pitched inspiratory crackles), wet crackles, or wheezing

#### Percussion

- Dullness at bases may indicate pleural effusions from fluid overload

\* Evaluate for signs of pulmonary congestion as pulmonary edema may be absent on CXR in chronic heart failure due to lymphatic compensation

### Peripheral Exam

#### Pretibial & Pedal Lower Extremity Pitting Edema

- To test for pedal edema, use two fingers to apply firm pressure on the dorsum of the foot for 2 seconds, then release – assess for pitting visually and by running your hand over the area
- Assess pretibial edema on the anterior shin with the same method
  - Grade 1 =  $\leq 2$  mm indentation that disappears immediately
  - Grade 2 = 2-4 mm indentation that lasts 10-15 seconds
  - Grade 3 = 4-6 mm indentation that can last more than a minute
  - Grade 4 = 6-8 mm indentation that can last up to 2-5 minutes
- Shifting Dullness Test for Ascites
  - With patient supine, percuss epigastric area, then to the left toward the flank, noting where tympany changes to dullness
  - Have patient roll onto their left side. Percuss again starting at the epigastrium and percuss towards the patient's left side, once again noting where tympany changes to dullness
    - If significant ascites is present, this border will shift which may indicate congestion from volume overload status
- Hepatomegaly may indicate hepatic congestion from right-sided heart failure
- Hepatojugular reflux (HJR) is elicited by applying pressure to the abdomen and observing the JVP. Unlike the normal response (transient rise in JVP), the JVP remains elevated in HJR, indicating elevated right atrial pressures.

### Wet vs. Dry

Assess for venous congestion (PCWP) by the presence (wet) of: JVD, rales, wet crackles, dullness at bases (pleural effusions), and LE edema

\* Evaluate for signs of pulmonary congestion as pulmonary edema may be absent on CXR in chronic heart failure due to lymphatic compensation

	Warm	Cold
Dry	Compensated → outpatient management	Low flow state → inotropes, vasodilators
Wet	Congested → diuresis +/- vasodilators	Decompensated → ICU for tailored exam

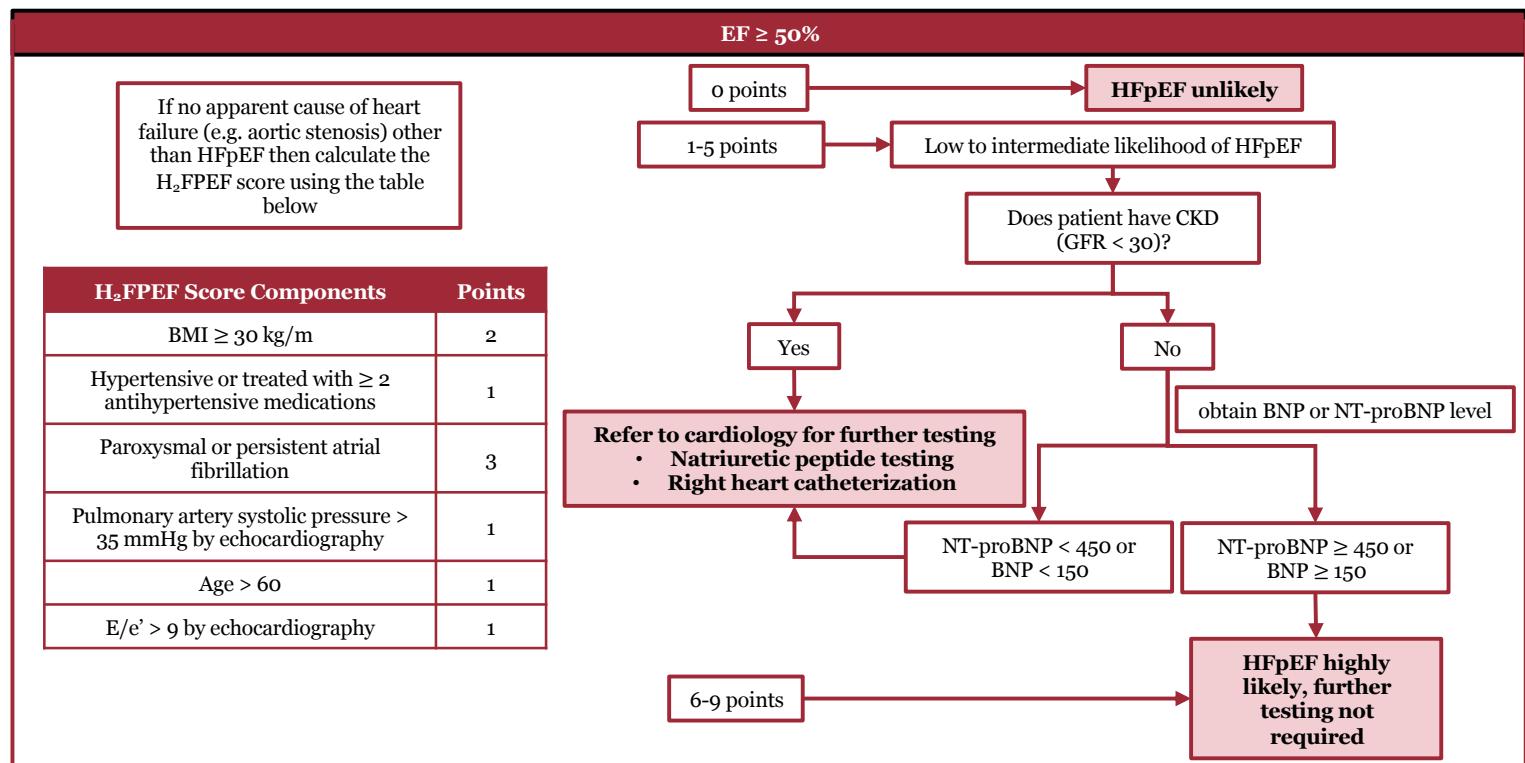
### Warm vs. Cold

Assess for inadequate tissue perfusion (reduced cardiac output) by the presence (cold) of: narrow pulse pressure, altered mental status, and cool extremities

\*Elevated lactate is key in identifying inadequate tissue perfusion

## DIAGNOSIS

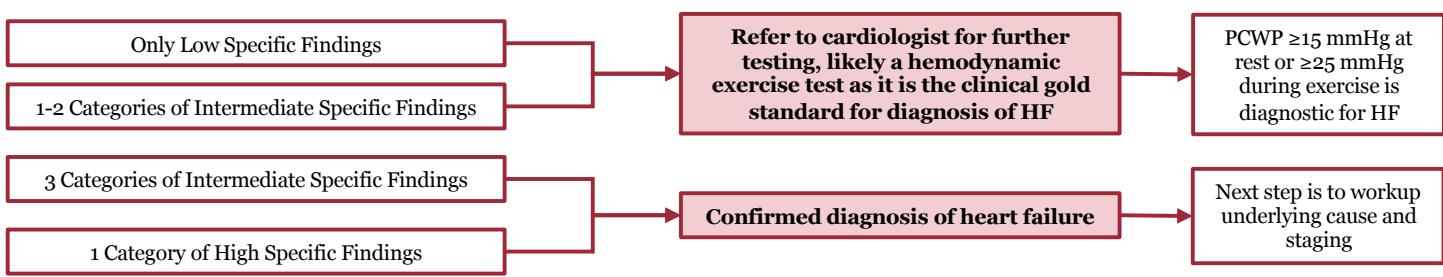
1 or more symptom of HF not caused by a noncardiac condition → TTE



## EF $<$ 50%

Assess the specificity of the findings for heart failure

Clinical Finding Categories	Low Specificity	Intermediate Specificity	High Specificity
<b>Symptoms</b>	DOE, fatigue, weight gain		Orthopnea, PND
<b>Physical Exam</b>	Peripheral edema	Rales (crackles)	JVD, S3, pulsus alternans, laterally displaced PMI
<b>CXR</b>		Cardiomegaly, pleural effusion	Pulmonary edema • Cephalization of pulmonary vessels • Kerley B lines
<b>EKG</b>		AF, LAE, LVH, or pathologic Q waves	
<b>Serum Natriuretic Peptide</b>		<ul style="list-style-type: none"> <li>• Age <math>&lt;</math> 50: NT-proBNP 125-450 pg/mL or BNP 35-100 pg/mL</li> <li>• Age 50-75: NT-proBNP 450-900 pg/mL or BNP 35-100 pg/ml</li> <li>• Age <math>&gt;</math> 75: NT-proBNP 900-1,800 pg/mL or BNP 35-100 pg/mL</li> </ul>	<ul style="list-style-type: none"> <li>• Age <math>&lt;</math> 50: NT-proBNP <math>&gt;</math> 450 pg/mL or BNP <math>&gt;</math> 100 pg/mL</li> <li>• Age 50-75: NT-proBNP <math>&gt;</math> 900 pg/mL or BNP <math>&gt;</math> 100 pg/ml</li> <li>• Age <math>&gt;</math> 75: NT-proBNP <math>&gt;</math> 1,800 pg/mL or BNP <math>&gt;</math> 100 pg/mL</li> </ul>
<b>Clinical Features</b>	Age $>$ 60	<ul style="list-style-type: none"> <li>• Coronary artery disease</li> <li>• Moderate valvular regurgitation or stenosis</li> </ul>	<ul style="list-style-type: none"> <li>• Severe valvular regurgitation or stenosis</li> </ul>
<b>Echocardiogram</b>		<ul style="list-style-type: none"> <li>• LA volume index <math>&gt;</math> 34 mL/m<sup>2</sup></li> <li>• E/A <math>\geq</math> 0.9 and <math>&lt;</math> 2.1</li> <li>• E/A <math>\leq</math> 0.8 and E <math>&gt;</math> 50 cm/s</li> </ul>	<ul style="list-style-type: none"> <li>• LVEF <math>&lt;</math> 30%</li> <li>• LVEDD <math>&gt;</math> 5.8 cm (men) or <math>&gt;</math> 5.2 cm (women)</li> <li>• E/e' <math>\geq</math> 15</li> <li>• E/A <math>\geq</math> 2.1</li> <li>• IVC <math>&gt;</math> 2.1 with collapse during sniff <math>&lt;</math> 50%</li> </ul>



## WORKUP

### Known History of Heart Failure

#### Admission Orders

- Labs
  - Check NT-proBNP
    - ADHF unlikely if NT-proBNP <300 (NPV 98%), likely if >450 (>900 if age >50)
    - Difficult to interpret in CKD/dialysis. May be falsely low in obesity, HFpEF
  - Ferritin: Screen for & treat iron deficiency in all HF pts independent of Hgb  
Dx: ferritin <100 or ferritin <300 + TSat <20%
    - Tx: replete with IV iron
- Medications
  - Avoid: CCB (esp. non-dihydropyridines), NSAIDs, flecainide
- Other Orders
  - Telemetry
  - 2g Na restricted diet
  - Daily standing weights (get the admission weight!)
  - Strict I/Os
  - DVT ppx

### Indications for Hospitalization

- Hypotensive with organ hypoperfusion
- Severely dyspneic or periodic respirations
- Profound fluid retention states
- Substantive renal or hepatic insufficiency
- Hemodynamic instability requiring IV inotropes
- Dysrhythmias requiring IV antidysrhythmic treatment
- Decompensated HF with refractory angina
- Complication after cardiac transplantation including rejection with hemodynamic instability
- Elevated CPK and CPK-MB and/or 12-lead ECG in ED reflecting MI or new necrosis

### New or Unknown History of Heart Failure

#### Admission Orders

- Echocardiography: TTE for all new presentations; obtain thereafter only if concern for clinical/functional change
  - HFrEF (EF ≤40%), HFmrEF ("mid-range" EF 41-49%), HFpEF (EF ≥50%)
- Ischemic Workup
  - FHx of Ischemic Causes of HF
  - ECG
  - TnT
  - Noninvasive or invasive cardiac testing
- Non-Ischemic Workup:
  - FHx of Non-Ischemic Causes of HF
  - Genetic testing
  - Med Hx
  - Alcohol Use Hx
  - Lipid Panel
  - TSH
  - A1c
  - Urine hCG
  - Iron Studies
  - HIV
  - SPEP/SFLC w/ UFC
- Consider: cardiac MRI, ANA, *T. cruzi* serologies, viral panel, antimyosin Ab, tox screen, thiamine/carnitine/selenium, genetic testing, ARVC, sarcoid, PYP scan, cardiac masses, endomyocardial bx (if serologic testing neg, new onset <6mo unexplained HF, unexplained HF <2wks and HDUS, major arrhythmias) to r/o myocarditis
- Consider high-output etiologies: anemia, thyroid dysfxn, liver failure, Paget's, systemic infection, AV shunt

Ischemic Causes of HF	Non-Ischemic Causes of HF
Coronary artery disease (CAD) Myocardial infarction (MI) Chronic myocardial ischemia	Hypertension Valvular heart disease Dilated cardiomyopathy Alcohol-related cardiomyopathy Atrial fibrillation Chemotherapy-induced Peripartum cardiomyopathy Myocarditis Thyroid disease Amyloidosis

## STAGING

ACCF/AHA Stages of HF		NYHA Classes of HF		Treatment
A	At high risk for HF but without structural heart disease or symptoms of heart failure	-	-	-
B	Structural heart disease but without signs or symptoms of HF	I	Only with vigorous activities (sports)	<ul style="list-style-type: none"> <li>• <b>Initiate ACE inhibitor</b></li> <li>• Mild restriction of sodium intake and physical activity</li> <li>• Start a loop diuretic if volume overloaded</li> </ul>
C	Structural heart disease with prior or current symptoms of HF	II	With prolonged or moderate exertion (climbing stairs, carrying heavy packages)	<ul style="list-style-type: none"> <li>• <b>Initiate ACE inhibitor AND loop diuretic</b></li> <li>• Add a beta-blocker if no response</li> </ul>
		III	With activities of daily living (walking across the room, getting dressed)	<ul style="list-style-type: none"> <li>• <b>Initiate ACE inhibitor AND loop diuretic</b></li> <li>• Add a beta-blocker if no response</li> </ul>
D	Refractory HF requiring specialized interventions	IV	At rest *will also be diaphoretic and have cool extremities at rest	<ul style="list-style-type: none"> <li>• <b>Add digoxin (to loop diuretic and ACE inhibitor)</b></li> <li>• Add spironolactone if still symptomatic</li> </ul>

## MEDICATIONS

### ACE INHIBITOR/ARBs/ARNIs

#### Initiating

- Renal function should be checked 1–2 weeks after dose initiation or modification
- There must be a 36-hour washout period required before prescribing ARNI if patient currently on ACEI
- In general, ARNI>ARB>ACEI

#### Monitor for:

- Hypotension
- Lightheadedness
- Creatinine and potassium

	ARNI	ARB		
	Sacubitril valsartan	Valsartan	Candesartan	Losartan
Starting Dose	24/26 mg – 49/51 mg BID	20-40 mg BID	4-8 mg daily	25-50 mg daily
Target Dose	97/103 BID	160 mg BID	32 mg daily	150 mg daily
Renal Dose	<30 GFR, half dose	No dose adjustment	CrCl <30: start 4 mg daily, target 15 mg daily	No dose adjustment

- ARNI contraindicated in patients with prior history of angioedema related to previous ACEi/ARB.
- ARNIs are not recommended in patients with severe hepatic impairment (Child–Pugh Class C)

	ACEi			
	Captopril	Enalapril	Lisinopril	Ramipril
Starting Dose	6.25 mg TID	2.5 mg BID	2.5-5 mg daily	1.25 mg daily
Target Dose	50 mg TID	10-20 mg BID	20-40 mg daily	10 mg daily
Renal Dose	CrCl 10-50: dose every 12-24 h, max 50 mg every 12 h CrCl <10: dose every 24 h, max 50 mg every 24 h	CrCl 10-30: start 2.5 mg daily in 1 or 2 divided doses, max dose 20 mg/day CrCl<10: consider alternative, dose 1.25 mg daily or 2.5 mg every other day, max dose 10 mg/day	CrCl 10-30: start 2.5 mg daily CrCl<10: consider alternative agent	GFR 15-30: max dose 5 mg daily GFR<15: consider alternative agent, max dose 5 mg/day in 1-2 divided doses

### BETA- BLOCKERS

#### Initiating

- Doses can be increased every 1–2 days for inpatients or every two weeks for outpatients
- Best when patients are euvolemic
- Dose titration to goal dose is limited by bradycardia and hypotension in some patients

#### Monitor for:

- Bradycardia
- Hypotension
- Lightheadedness

	Non-Selective	Selective ( $\beta$ 1)	
	Carvedilol	Bisoprolol	Metoprolol succinate
Starting Dose	3.125 mg BID	1.25 mg daily	12-25 mg daily
Target Dose	25-30 mg BID	10 mg daily	200 mg daily
Renal Dose	No dose adjustment	No dose adjustment, may need slower titration if CrCl < 20	No dose adjustment

- Preferred in patients with arterial hypertension
- Contraindicated by the manufacturer in the setting of severe hepatic dysfunction
- Can improve insulin sensitivity

- Preferred in patients with chronic obstructive pulmonary disease (COPD) or asthma
- Not contraindicated in hepatic dysfunction but may require slower dose titration to ensure clinical safety
- Better option if hypotension is a concern

### MRA

#### Initiating

- Check renal function at 1 week, 1 month, then every 6 months after initiation or dose adjustment
- Patients should have eGFR>30 l/min/1.73m<sup>2</sup> with < 5 mEq/L at initiation
- **Discontinue if Cr >2.5 in men (>2 in women), GFR <30 and potassium >5**

### SGLT2i

#### Initiating

- Must ensure GFR >30 before initiation of dapagliflozin and >20 for empagliflozin
- **Contraindicated** in patients with type 1 diabetes
- May need to decrease diuretic doses and diabetes regimen when planning to initiate SGLT2 inhibitors

	Eplerenone	Spironolactone
Starting Dose	25 mg daily	12.5-25 mg daily
Target Dose	50 mg daily	25-50 mg daily
Renal Dose	Starting dose and target dose should be halved for GFR 30–60; contraindicated with GFR < 30	

Monitor for:

- Creatinine
- Potassium

	Dapagliflozin Empagliflozin
Starting & Target Dose	10 mg daily

Monitor for:

- Genital yeast infection
- Euthlycemic DKA

## MANAGEMENT

### Early/Acute Management

- ❑ IV loop diuretics 2-2.5x home dose at infusion rate of 20mg/hr

	<b>Furosemide</b>	<b>Torsemide</b>	<b>Bumetanide</b>	<b>Ethacrynic Acid</b>
IV to oral dosing	1:2	1:1	1:1	1:1
PO Equivalent Across Medications	40mg	20mg	1mg	50mg
IV Equivalent Across Medications	20mg	20mg	1mg	50mg

- ❑ Diuretic naïve → IV furosemide 20-40mg 2-3 times daily (20-80 mg) if creatinine clearance is <60
- ❑ Refractory diuresis: metolazone 2.5-5mg (or chlorothiazide 500mg IV) administered 30min before loop diuretic. May need RHC to clarify hemodynamics or inotropes to augment diuresis. Acetazolamide (500mg daily) may also augment successful decongestion.
- ❑ Worsening renal function occurs in ~23% of pts being treated. Mild-mod “Cr bumps” are likely benign hemodynamic changes.
- ❑ Endpoints: target resolution of signs/symptoms of congestion. Daily weights & hemoconcentration are useful adjuncts

- ❑ If acute pulmonary edema, NIPPV may improve mortality and reduce need for intubation
- ❑ Vasodilators: arterial/venous dilation can relieve symptoms
  - ❑ Consider esp. in severe HTN, acute MR, acute AR
  - ❑ Floor: isosorbide dinitrate, hydralazine, nitropaste, captopril; SDU/CCU: TNG, nitroprusside
- ❑ Guideline-Directed Medical Therapy (GDMT): if not in cardiogenic shock or new AKI, continue ACEi/ARB/ARNi and βB during ADHF (but do not newly initiate βB)

### Guideline-Directed Medical Therapy (GDMT)

Many different methods for initiating and sequencing medications in GDMT

- ❑ Traditional Sequencing
  - ❑ Day 1: initiate ACE inhibitors and titrate to maximum tolerable dose
  - ❑ Week 1-2: initiate beta blocker and titrate to maximum tolerable dose
  - ❑ Week 3-4: initiate MRA and titrate to maximum tolerable dose
  - ❑ Week 4-7: switch to ARNi after 36-hour washout period of ACE inhibitor and titrate to maximum tolerable dose
  - ❑ Week 7-36: initiate SGLT2i and titrate to maximum tolerable dose
- ❑ Rapid Sequencing
  - ❑ Day 1: initiate ARNi, beta-blocker, MRA, and SGLT2i,
  - ❑ Titrate beta blocker in 1-2-week intervals
  - ❑ Titrate ARNi and MRA in 3-4-week intervals
- ❑ Rapid Low Dose Approach
  - ❑ Day 1: initiate beta blocker and SGLT2i, increase doses every 1-2 days (every 2 weeks if outpatient)
  - ❑ Week 1-2: Initiate ARNI and titrate to maximum dose
  - ❑ Week 3-4: Initiate MRA and titrate to maximum dose

### Pre-Discharge Optimization

- ❑ Document d/c weight & NT-proBNP
- ❑ Appointment with PCP and/or cardiology
- ❑ Diuretic plan: determine maintenance diuretic dose and provide specific instructions for taking additional rescue doses
- ❑ Observe on maintenance dose and decide if needs K replacement

### TRIALS & STUDIES

#### RALES (1999)

Spironolactone reduces morbidity and mortality in patients with class III or IV heart failure. It is contraindicated in renal failure.

#### CONSENSUS (1987) & SOLVD (1991)

ACE inhibitors reduce mortality, prolong survival, and alleviate symptoms in mild, moderate, and severe CHF.

#### COMET (2003)

Compared two β-blockers in the treatment of CHF and showed that carvedilol led to significant improvement in survival compared with metoprolol.

#### PARADIGM-HF (2014)

(ARNi)—sacubitril-valsartan was found to be superior to enalapril with respect to mortality and hospitalizations in patients with HFrEF.

#### PIONEER-HF (2019)

Sacubitril-valsartan is safe to initiate in patients with acute decompensated HF.

#### DAPA-HF (2019)

Among patients with HFrEF with or without diabetes, initiation of dapagliflozin decreased rates of CV death, worsening HF and all-cause mortality.

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