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## Disclaimer
Chronic congestive heart failure is a complex clinical syndrome that can result from any structural or functional cardiac disorder that impairs the ability of the ventricle to fill with or eject blood.

It is a major and growing public health problem. It is the only cardiovascular disease that is increasing in incidence and prevalence, partly because the population is aging, but also because of improved cardiovascular interventions for disease processes that reduce early mortality but may result in cardiac changes that lead to heart failure.

The key manifestations are dyspnea and fatigue, which may limit exercise tolerance, and fluid retention, which may lead to pulmonary congestion and peripheral edema.

Diagnosis is largely clinical; a thorough history and physical examination should be obtained to identify cardiac and noncardiac disorders or behaviors that might cause congestive heart failure or accelerate progression.

The single most useful diagnostic test in the evaluation of patients is the comprehensive 2-dimensional echocardiogram coupled with Doppler flow studies. Measurement of B-type natriuretic peptide can be useful in the evaluation of patients at initial presentation.

Interventions that have a proven beneficial impact on patient survival include ACE inhibitors, angiotensin receptor blockers, beta-blockers, aldosterone antagonists, hydralazine and nitrates, cardiac resynchronization therapy, and implantable cardioverter-defibrillators.

Heart failure is a condition in which the heart is unable to generate a cardiac output sufficient to meet the demands of the body without increasing diastolic pressure. It can result from any cardiac disease that compromises ventricular systolic or diastolic function or both. The term "congestive heart failure" (CHF) is reserved for patients with breathlessness and abnormal sodium and water retention, resulting in edema.

Heart failure comprises a wide range of clinical scenarios, from patients with normal left ventricular ejection fraction (LVEF) >50% to those with reduced myocardial contractility (LVEF <40%).

Based on LVEF, heart failure is defined as follows.[1]

1. Heart failure with reduced ejection fraction (HFrEF): symptoms and signs with LVEF <40%.
2. Heart failure with mid-range ejection fraction (HFmrEF): symptoms and signs with LVEF 40% to 49%.
   Other features include elevated natriuretic peptides (B-type natriuretic peptide [BNP] >35 picograms/mL or N-terminal pro-brain natriuretic peptide [NT-pro-BNP] >125 picograms/mL) and at least one additional criterion: (a) relevant structural heart disease (e.g., left ventricular hypertrophy [LVH] or left atrial enlargement), (b) diastolic dysfunction.
3. Heart failure with preserved ejection fraction (HFpEF): symptoms and signs with LVEF >50%.
   Other features include elevated natriuretic peptides (BNP >35 picograms/mL or NT-pro-BNP >125 picograms/mL) and at least one additional criteria: (a) relevant structural heart disease (e.g., LVH or left atrial enlargement), (b) diastolic dysfunction. See our topic "Heart failure with preserved ejection fraction" for more information on this subtype.
Epidemiology

The prevalence of heart failure in the US is between 1.5% and 1.9%. From 2013 to 2016, an estimated 6.2 million adults ≥20 years of age had heart failure in the US. In 2014 there were 1 million new cases in patients >55 years of age. Heart failure is the primary reason for 12 to 15 million office visits and 6.5 million hospital-days each year. Recurrent hospitalization is a major quality of life and cost issue: for example, from 1990 to 1999, the annual number of hospitalizations increased from approximately 810,000 to over 1 million for primary diagnosis and from 2.4 million to 3.6 million for primary or secondary diagnosis. Patients are particularly prone to readmission, with reported rates as high as 50% within 6 months of discharge.

Worldwide the absolute numbers of people living with heart failure are increasing. The rising prevalence of heart failure is not necessarily linked with an increase in heart failure incidence, as the incidence appears to be stable or decreasing in some countries, in part due to better treatment and reduced mortality of patients with acute myocardial infarctions earlier in life. Heart failure is primarily a condition of older people, and thus the widely recognized "aging of the population" contributes to its increasing prevalence.

The prevalence of heart failure increases with increasing age. Among patients ages 40 to 59 years the prevalence of heart failure is about 1.2% in males and 1.7% in females, whereas among patients ages ≥80 years the prevalence of heart failure is about 12.8% in males and 12.0% in females.

Etiology

There are numerous and varied causes of heart failure.

Common causes of chronic heart failure include:

- Coronary artery disease
- Hypertension
- Valvular disease
- Myocarditis.

Other causes include:

- Infiltrative diseases: amyloidosis, hemochromatosis, sarcoid
- Congenital heart diseases
- Pericardial disease
- Toxin-induced: heroin, alcohol, cocaine, amphetamines, lead, arsenic, cobalt, phosphorus
- Infection: bacterial, fungal, viral (HIV), Borrelia burgdorferi (Lyme disease), parasite (e.g., Trypanosoma cruzi [Chagas disease])
- Endocrine disorders: diabetes mellitus, thyroid disease, hypoparathyroidism with hypocalcemia, pheochromocytoma, acromegaly, growth hormone deficiency
- Systemic collagen vascular diseases: lupus, rheumatoid arthritis, systemic sclerosis, polyarteritis nodosa, hypersensitivity vasculitis, Takayasu syndrome, polymyositis, reactive arthritis
- Chemotherapy-induced: for example, adriamycin, trastuzumab
- Nutritional deficiencies: thiamine, protein, selenium, L-carnitine
- Pregnancy: peripartum cardiomyopathy
- Familial cardiomyopathy
- Tachycardia-induced cardiomyopathy
Chronic congestive heart failure

• Stress cardiomyopathy.

Although Chagas disease is an uncommon cause of congestive heart failure in Europe and North America, it is an important cause of heart failure in Central and South America.[2] [9]

Some of these conditions tend to increase metabolic demand, which may not be matched by a sufficient increase in cardiac output by the failing heart. Tachyarrhythmias also decrease the diastolic ventricular filling time and increase myocardial oxygen demand. Uncontrolled hypertension depresses systolic function by increasing the afterload against which the failing ventricle must pump blood, and may be the first clinical manifestation. It should be emphasized that many of these causes may be completely reversible given appropriate and timely treatment/intervention (e.g., revascularization for stunned or hibernating myocardium; standard therapy for peripartum or hypertensive cardiomyopathy; valvuloplasty or valve replacement for valvular heart disease; standard treatment and adjunctive rate control therapy for tachycardia-induced cardiomyopathy and cardiomyopathy related to sepsis and stress).[2] [10] [11] Other causes, such as scarred myocardium or infiltrative cardiomyopathy, are currently considered irreversible.

Pathophysiology

The understanding of the pathophysiology of heart failure has evolved significantly over the last decades, from the hemodynamic model to the neurohormonal paradigm.[12] Heart failure represents a complex syndrome in which an initial myocardial insult results in the over-expression of multiple peptides with different short- and long-term effects on the cardiovascular system. Neurohormonal activation is recognized to play a pivotal role in the development as well as the progression of heart failure. In the acute phase, neurohormonal activation seems to be beneficial in terms of maintaining adequate cardiac output and peripheral perfusion. Sustained neurohormonal activation, however, eventually results in increased wall stress, dilatation, and ventricular remodeling, which contribute to disease progression in the failing myocardium, which eventually leads to further neurohormonal activation. Left ventricular remodeling is the process by which mechanical, neurohormonal, and possibly genetic factors alter ventricular size, shape, and function. Remodeling occurs in several clinical conditions, including myocardial infarction, cardiomyopathy, hypertension, and valvular heart disease; its hallmarks include hypertrophy, loss of myocytes, and increased interstitial fibrosis. One potential deleterious outcome of remodeling, as the left ventricle dilates and the heart assumes a more globular shape, is the development of mitral regurgitation. Mitral regurgitation results in an increasing volume overload on the overburdened left ventricle that further contributes to remodeling and progression of disease and symptoms.

Classification

American College of Cardiology/American Heart Association stages of heart failure[2]

This staged classification underscores the fact that established risk factors and structural abnormalities are necessary for the development of heart failure, recognizes its progressive nature, and superimposes treatment strategies on the fundamentals of preventive efforts. Heart failure may progress from stage A to stage D in a given patient, but generally does not follow the path in reverse.

• Stage A: patients at high risk of developing heart failure because of the presence of conditions that are strongly associated with the development of heart failure (for example, hypertension, diabetes, or
chronic congestive heart failure); however, such patients have no identified structural or functional abnormalities of the pericardium, myocardium, or cardiac valves and have never shown signs or symptoms of heart failure.

- Stage B: patients who have developed structural heart disease that is strongly associated with the development of heart failure but who have never shown signs or symptoms of heart failure (for example, asymptomatic post-infarction left ventricular dysfunction).
- Stage C: patients who have current or prior symptoms of heart failure associated with underlying structural heart disease.
- Stage D: patients with advanced structural heart disease and marked symptoms of heart failure at rest despite maximal medical therapy and who require specialized interventions (for example, heart transplant or left ventricular assist devices).

Framingham criteria for the diagnosis of CHF[3]

Heart failure is essentially a clinical diagnosis. Clinical criteria for diagnosing heart failure, the Framingham criteria for the diagnosis of CHF, were established before the widespread use of echocardiographic assessment of systolic and diastolic dysfunction. The Framingham clinical criteria, listed below, have been extremely useful for identifying heart failure patients, both in clinical practice and in epidemiologic studies, for more than 40 years. However, because their specificity is greater than their sensitivity, it is recognized that they probably miss mild cases of heart failure. In order to come up with a definite diagnosis of CHF, one needs to have either 2 major criteria or the combination of 1 major and 2 minor criteria.

Major criteria:

- Neck vein distention
- Rales
- Acute pulmonary edema
- S3 gallop
- Increased venous pressure greater than 16 cm of water
- Circulation time greater than 25 seconds
- Hepatojugular reflux
- Cardiomegaly
- Paroxysmal nocturnal dyspnea or orthopnea.

Minor criteria:

- Ankle edema
- Night cough
- Dyspnea on exertion
- Hepatomegaly
- Pleural effusion
- Less than one third maximum vital capacity
- Tachycardia (heart rate >120 bpm).

Major or minor criteria:

- Weight loss greater than 4.5 kg in 5 days in response to treatment
Case history

Case history #1

A 67-year-old woman presents to her primary care physician complaining of increasing shortness of breath, especially when trying to sleep. She has a history of poorly controlled hypertension and hyperlipidemia, and is being treated with a beta-blocker and statin therapy. She does not smoke and drinks alcohol in moderation. On examination, her blood pressure is 160/90 mmHg and heart rate is 126 beats per minute. There is an audible S4 and the jugular venous pressure is elevated 3 cm above normal. There is no edema, but she has fine bilateral mid to lower zone crepitation on lung examination. The ECG shows left ventricular hypertrophy and a transthoracic echocardiogram shows left ventricular hypertrophy, left atrial dilatation, normal left and right ventricular systolic function, with a left ventricular ejection fraction of 60%.

Case history #2

A 60-year-old man presents to the emergency department. He reports being progressively short of breath. He has a history of hypertension, noninsulin-dependent diabetes mellitus, and has been a heavy smoker for more than 40 years. He underwent a successful primary angioplasty for a large acute anterior myocardial infarction 2 months ago. His blood pressure is 75/40 mmHg, his heart rate 110 beats per minute, and his respiratory rate 30. He has elevated neck veins and a prominent S3. His ECG shows sinus tachycardia, and a transthoracic echocardiogram performed in the emergency department reveals impaired left ventricular systolic function, with an ejection fraction of 20%.

Other presentations

Many patients remain asymptomatic for an extended period of time because mild impairment in cardiac function is balanced by compensatory mechanisms. Often, clinical manifestations occur only in the presence of precipitating factors that increase the cardiac workload and tip the balanced state into one of decompensation. Thus, the first symptoms and signs may be those of the underlying precipitating condition, such as atrial flutter or fibrillation, anemia, fever, infection, hyperthyroidism, or even pregnancy. A large pulmonary embolism can also lead to the first presentation of symptoms, or to exacerbation of known chronic CHF, by causing hypoxemia, decreased myocardial oxygen supply, and increased right ventricular afterload. An acute ischemic insult (i.e., an acute coronary syndrome or an myocardial infarction) or the initiation of a negative inotropic medication for another reason (e.g., large doses of beta-blockers and certain calcium channel blockers for hypertension) can acutely depress myocardial contractility and precipitate symptoms in an otherwise compensated patient.
**Approach**

Heart failure is primarily a condition of older people and has a higher prevalence in men at all ages.\[9\] [5]\[76\]

Identification of the condition responsible for the cardiac structural and/or functional abnormalities may be important, because some conditions that lead to left ventricular dysfunction are potentially treatable and/or reversible.\[2\] Efforts to identify a cause frequently allow the detection of coexistent conditions that may contribute to or exacerbate the severity of symptoms. However, it may not be possible to discern the cause of heart failure in many patients presenting with this syndrome, and in others, the underlying condition may not be amenable to treatment.

A number of precipitating factors may lead to impaired cardiac function, potentially leading to an episode of acute heart failure. Detection and treatment of precipitating factors plays an important role in patient management. Precipitating factors include excessive salt intake, lack of adherence (with respect to medication and diet), myocardial infarction, pulmonary embolism, uncontrolled hypertension, cardiac arrhythmias, infection, hypothyroidism, hyperthyroidism, renal dysfunction, and alcohol and drug abuse.\[1\]

**Patient history**

The complexity and variety of potential causative factors means that a multitude of patient historical factors may be relevant. A history of hypertension; diabetes mellitus; dyslipidemia; tobacco use; coronary, valvular, or peripheral vascular disease; rheumatic fever; heart murmur or congenital heart disease; personal or family history of myopathy; mediastinal irradiation; and sleep-disturbed breathing should be enquired about. The drug history should record the past or current use of illicit drugs, alcohol, ephedra, or antineoplastic agents such as anthracyclines, trastuzumab, or high-dose cyclophosphamide, because heart failure may occur years after exposure to doxorubicin or cyclophosphamide. The history and physical evaluation should include specific consideration of noncardiac diseases such as collagen vascular disease, bacterial or parasitic infection, obesity, thyroid excess or deficiency, amyloidosis, and pheochromocytoma.

A detailed family history should be obtained, not only to determine whether there is a familial predisposition to atherosclerotic disease but also to identify relatives with cardiomyopathy, sudden unexplained death, conduction system disease, and skeletal myopathies.

Dyspnea on exertion or at rest is the most common symptom of left-sided heart failure. With increasing failure patient may develop leg edema and abdominal distension due to ascites.

**Physical examination**

Particular attention should be paid to the cardinal signs of heart failure. Their presence (and degree) may depend on severity of heart failure and associated comorbid disease.

General examination may reveal tachycardia and cyanosis. A focused cardiovascular examination may reveal elevated jugular venous pressure, ankle edema, and a displaced apex beat, which suggests cardiomegaly. On auscultation, besides presence of pulmonary rales or crepitation, an S3 gallop may be present, which has prognostic significance.

Clinical manifestations of the underlying etiology of heart failure may be present, for example, macroglossia and neuropathy may point to infiltrative cardiomyopathy like amyloidosis; pallor (which may reflect anemia); irregularly irregular pulse (reflecting atrial fibrillation); systolic murmur of aortic stenosis
and mid diastolic murmur of mitral stenosis; or overt signs of thyrotoxicosis. In patients on dialysis, a large arteriovenous fistula may occasionally be the precipitating factor. However, further discussion of the clinical features of etiologic(al) pathways is beyond the scope of this topic.

**Investigations**

For all patients, initial investigations should include ECG, chest x-ray, transthoracic echocardiogram, and baseline hematology and blood chemistry, including complete blood count, serum electrolytes (including calcium and magnesium), blood urea nitrogen and creatinine, liver function tests, and B-type natriuretic peptide/N-terminal pro-brain natriuretic peptide levels. Anemia and high lymphocyte percentage are strong risk factors and prognostic markers of poor survival. In patients presenting with dyspnea, measurement of natriuretic peptide biomarkers is useful to support a diagnosis or exclude heart failure. However, elevated plasma levels of natriuretic peptides can occur with a wide variety of cardiac and noncardiac causes; therefore, clinical judgment is necessary.[77]

Blood glucose, thyroid function tests, and blood lipids are useful to assess for commonly associated comorbid disease.

Subsequent investigations that help in assessing severity of heart failure and functional status include noninvasive stress imaging (cardiovascular MRI, stress echocardiogram, SPECT, PET), standard exercise stress testing (bicycle or treadmill), coronary angiogram, cardiac CT angiography, cardiopulmonary exercise testing with VO₂ max, 6-minute walking test exercise, left and right heart catheterization, and endomyocardial biopsy. Troponin measurement is helpful in further risk stratification in chronic heart failure, as an elevated level is associated with progressive left ventricular dysfunction and increased mortality.[2] [78] Soluble ST2 and galectin-3 (biomarkers for myocardial fibrosis) are predictive of death and hospitalization in patients with heart failure and are additive to natriuretic peptide in their prognostic value.[2]

Based on clinical history, HIV screening and measurement of iron levels and fasting transferrin saturation to screen for hemochromatosis may also be performed. A cardiac MRI scan is particularly useful in the investigation of myocarditis and infiltrative cardiomyopathy. Multi-slice CT (MSCT) can be used for left ventricular ejection fraction (LVEF) estimation. There appears to be no significant difference in LVEF estimation between MSCT and MRI, and also between MSCT and transthoracic echocardiogram.[79]

MSCT may offer additional benefit as it provides a combined evaluation of LVEF and coronary artery disease.

**History and exam**

**Key diagnostic factors**

**dyspnea (common)**

- The most common symptom of left-sided heart failure. May occur with exertion (New York Heart Association [NYHA] II-III) or, in more severe cases, at rest (NYHA IV). This is considered a minor criterion for the diagnosis of heart failure (Framingham criteria).

**neck vein distention (common)**

- A major Framingham criterion for the diagnosis of heart failure.
S3 gallop (common)
• A major Framingham criterion for the diagnosis of heart failure.

cardiomegaly (common)
• Cardiomegaly is a major Framingham criterion for the diagnosis of heart failure. Left ventricular dilation or hypertrophy are common findings.

hepatojugular reflux (common)
• A major Framingham criterion for the diagnosis of heart failure.

rales (common)
• A major Framingham criterion for the diagnosis of heart failure.

orthopnea and paroxysmal nocturnal dyspnea (uncommon)
• Orthopnea (dyspnea that develops in the recumbent position) usually worsens immediately after lying down, because of a sudden increase in venous return; that is, preload. Paroxysmal nocturnal dyspnea occurs several hours after the patient lies down to sleep; it results from the central redistribution of extravascular fluid that progressively increases the venous return.

nocturia (uncommon)
• Increased frequency of uresis occurs several hours after the patient lies down to sleep; it also results from the central redistribution of extravascular fluid that augments the amount of circulating blood cleared from the kidneys.

Other diagnostic factors

tachycardia (heart rate >120 beats per minute) (common)
• A minor Framingham criterion for the diagnosis of heart failure.

chest discomfort (common)
• A symptom of poor coronary perfusion.

hepatomegaly (common)
• A minor Framingham criterion for the diagnosis of heart failure; may cause abdominal discomfort/distention and nausea.

ankle edema (common)
• A minor Framingham criterion for the diagnosis of heart failure.

night cough (common)
• A minor Framingham criterion for the diagnosis of heart failure.

signs of pleural effusion (common)
• A minor Framingham criterion for the diagnosis of heart failure.

fatigue, muscle weakness, or tiredness (common)
• Symptom of poor tissue (muscle) perfusion.
Chronic congestive heart failure

Diagnosis

palpitations, presyncope, or syncope (uncommon)

- This may be the result of frequent ectopic supraventricular or ventricular beats or may reflect paroxysms of atrial flutter/fibrillation; permanent atrial fibrillation may or may not cause palpitations. Syncope may result from fast atrial arrhythmias or ventricular tachycardia.

lethargy/confusion (uncommon)

- Symptom of poor tissue (brain) perfusion.

Risk factors

Strong

myocardial infarction (MI)

- The link between MI and risk of heart failure development is strongly and consistently supported by the literature. MI is a potent risk factor for developing heart failure.[13] [14] [15] [16] [17] [18]

hypertension

- Hypertension has consistently been linked to an increased risk of heart failure in the literature and confers a 2- to 3-fold increase in risk of developing heart failure.[13] [14] [15] [16] [17] [18] [19] Elevated systolic blood pressure, elevated diastolic blood pressure, and elevated pulse pressure have all been associated with increased risk for heart failure.[20] [21] Among the Framingham cohort, a 1 standard deviation (20 mmHg) increase in systolic blood pressure was associated with a 56% increased risk for heart failure, a 1 standard deviation (10 mmHg) increase in diastolic blood pressure was associated with 24% increased risk, and a 1 standard deviation (16 mmHg) increase in pulse pressure was associated with a 55% increase in risk.[20]

diabetes mellitus

- Diabetes mellitus has been associated with a 3- to 5-fold increase in the risk of developing heart failure,[14] [15] [16] [18] [22] [23] with the highest increase in relative risk found among women[14] [18] and people with asymptomatic left ventricular dysfunction.[22] Even a slight increase of 1% in hemoglobin A1C has been linked to a greater than 10% risk of hospitalization for heart failure or death.[24]

dyslipidemia

- Lipid abnormalities have been linked to increased risk for heart failure.[25] [26] [27] Compared with men with ratios of total cholesterol:HDL cholesterol of less than 5, in one study men with ratios of 5 to 9.9 had a 1.5-times greater incidence of heart failure, and men with ratios of greater than 10 had a nearly 5-times greater incidence of heart failure.[25] In the same study, women with ratios greater than 10 had more than 6-times greater incidence of heart failure than women with ratios less than 5.[25] In one clinical trial of patients with coronary artery disease, lipid lowering was associated with a 21% reduction in the risk of developing heart failure.[28]

old age

- Increasing age has been consistently linked to a higher risk of developing heart failure.[3] [13] [14] [15] [16] [17] [29] In the Framingham cohort, the incidence of heart failure increased steadily with increasing age.[14] In a cohort of people over age 65 years, every 5-year incremental increase in age
Chronic congestive heart failure

Diagnosis

was associated with a hazard ratio of 1.37.\[16\] In another study, the incidence rate of heart failure among the oldest people (age >80 years) was double that of the youngest people (age 65 to 69 years).\[29\]

**male**

• Male sex has been consistently linked to a higher risk of developing heart failure.\[3\] \[13\] \[14\] \[15\] \[16\] \[17\] \[18\] \[29\] In the Framingham cohort, women had a one third lower incidence of heart failure than men and male sex was associated with a hazard ratio of 1.34.\[14\] \[16\] \[18\] In other studies the incidence among males is 2 to 4 times that of females.\[13\] \[29\] In the National Health and Nutrition Examination Survey (NHANES I) study, which followed a cohort of 13,643 people for an average of 19 years, being male was associated with a relative risk of heart failure of 1.24.\[30\]

**obesity**

• Excess body weight is now an established risk factor for the development of heart failure. Among a subset of the Framingham cohort, the risk of heart failure increased by 5% for men and 7% for women with each increase of 1 in body mass index; obese subjects (body mass index 30 or above) had a risk of heart failure double that of nonobese subjects.\[31\] Obesity may result in heart failure by inducing hemodynamic and myocardial changes that lead to cardiac dysfunction, or may predispose to heart failure risk factors (e.g., hypertension, obstructive sleep apnea) and other cardiovascular disease risk factors (e.g., diabetes, dyslipidemia).\[32\]

**exposure to cardiotoxic agents**

• Doxorubicin and cyclophosphamide can cause myocardial damage leading to left ventricular dysfunction and heart failure.\[40\] \[41\] These chemotherapeutic agents increase risk for heart failure both during acute treatment and for several months after treatment has ended, with increasing risk with increasing cumulative dose.\[42\] \[43\] In addition, trastuzumab, a recombinant DNA-derived humanized monoclonal antibody used widely in the treatment of breast cancer, is also associated with the development of cardiomyopathy. The antihypertensive medication doxazosin has been linked to an increased risk of heart failure. Thiazolidinediones (a class of drug used for the treatment of diabetes) have been associated with an increased risk of heart failure.

• Mediastinal irradiation can cause direct myocardial damage leading to left ventricular dysfunction and heart failure both during acute treatment and for several years after treatment has ended.

**left ventricular dysfunction**

• Moderate-to-severe asymptomatic left ventricular dysfunction (ejection fraction [EF] <40%) has been associated with a hazard ratio of heart failure of 7.8, while mild asymptomatic left ventricular dysfunction (EF 40% to 50%) has been associated with a hazard ratio of 3.3.\[44\]

**left ventricular hypertrophy**

• Left ventricular hypertrophy, such as in hypertrophic obstructive cardiomyopathy, on electrocardiogram has been associated with a higher risk of heart failure, with highest relative risk among younger people.\[45\]

**renal insufficiency**

• Renal insufficiency, defined by elevated serum creatinine (over 1.5 mg/dL in men and 1.3 mg/dL in women) or reduced creatinine clearance (less than 60 mL/minute), has been linked to increased risk for development of heart failure. Compared with subjects with creatinine of less than 1.1 mg/dL, subjects with creatinine of 1.3 to 1.49 mg/dL had almost double the risk of developing CHF, subjects
Chronic congestive heart failure with creatinine of 1.5 to 1.69 mg/dL had almost triple the risk, and those with creatinine greater than 1.7 mg/dL had almost quadruple the risk.[46] [47]

**valvular heart disease**

- Cardiac valvular abnormality was associated with an odds ratio of heart disease of 2.43 among men and 3.47 among women in a multivariate profile based on the Framingham cohort.[48] Valvular abnormalities create pressure overload (e.g., aortic stenosis, mitral stenosis) or volume overload (e.g., mitral regurgitation), which are initially compensated for by mechanisms such as ventricular hypertrophy or ventricular dilation.[49] Ventricular remodeling alters cardiac contractility and increases the risk of heart failure.

**sleep apnea**

- Sleep-disordered breathing has been linked with increased risk of heart failure in multiple studies.[50] [51] [52]

**elevated homocysteine**

- In the Framingham cohort, elevated plasma homocysteine levels were linked with a roughly three quarter increased risk for developing heart failure.[56]

**cocaine abuse**

- Cocaine abuse has been strongly associated with the development of heart failure.[57] [58] [59]

**family history of heart failure**

- Several polymorphisms have been linked with an increased risk of developing heart failure: for example, a deletion of 4 amino acids in position 322 to 325 of the gene coding for a2C-adrenergic receptors (a2C Del322-325) in sympathetic nerve endings in the heart has been studied as a possible link to the development of heart failure. A second polymorphism that was evaluated as a candidate for developing heart failure is a change in position 389 of the gene for beta1-adrenergic receptors (b1Arg389) on myocytes. In the same study, patients who were homozygous for this deletion had a 10-fold increase in risk of developing heart failure.[60]

**atrial fibrillation**

- Atrial fibrillation increases the risk of thrombo-embolic events (e.g., stroke) and may lead to a worsening of symptoms. Atrial fibrillation may also serve as a predictor of mortality, or lead to tachycardiomyopathy, though evidence is less clear.[1]

**thyroid disorders**

- For example, thyrotoxicosis and hypothyroidism. Thyroid disorders are treatable, but are linked to sinus tachycardia, bradycardia, and atrial tachycardia/flutter/fibrillation.[1]

**anemia**

- Anemia is a strong risk factor and prognostic marker of poor survival. A high prevalence of iron deficiency has been reported in heart failure.[61] Iron deficiency in heart failure is due to gastrointestinal or genitourinary blood loss related to the use of antiplatelet drugs and/or oral anticoagulation, impaired nutrition, malabsorption, and reduced intracellular uptake of iron.[62] [63]
Chronic congestive heart failure

**Diagnosis**

- **elevated tumor necrosis factor-alfa (TNF-alfa) and interleukin-6 (IL-6)**
  - TNF-alfa is a pro-inflammatory cytokine associated with myocyte death and cardiac dysfunction.\[64\]
  - IL-6 is a similar pro-inflammatory cytokine.\[65\]

- **elevated C-reactive protein (CRP)**
  - Among the Framingham cohort, an increase of 5 mg/dL in CRP level was associated with over a 2-fold increase in risk of heart failure.\[65\]
  - People who also had elevated serum IL-6 and TNF-alfa values had a 4-fold increase in risk of heart failure.\[65\]

- **decreased insulin-like growth factor-1 (IGF-1)**
  - IGF-1 has been shown to have positive inotropic effects and to decrease the rate of cellular apoptosis.\[66\] \[67\]
  - IGF-1 has also been tentatively linked to vasodilation, which may improve cardiac emptying.\[68\]
  - Among the Framingham cohort, patients with a serum IGF-1 level below 140 mg/L had double the risk of developing heart failure.\[69\]

- **elevated natriuretic peptides**
  - In the Framingham cohort, increased levels of plasma B-type natriuretic peptide (BNP) and N-terminus of the atrial natriuretic peptide prohormone (N-ANP) were associated with an increased risk of heart failure. BNP levels above the 80th percentile (20 picograms/mL for men and 23.3 picograms/mL for women) were associated with a 3-fold increase in heart failure risk.\[70\]

- **dilation of the left ventricle**
  - The risk-factor-adjusted hazard ratio for heart failure in an asymptomatic population was 1.47 per 1 standard deviation increase in left ventricular end-diastolic diameter and 1.43 per 1 standard deviation increase in left ventricular end-systolic dimension.\[44\]

- **increased left ventricular mass**
  - In one cohort, those who developed heart failure had an initial average left ventricular mass/height of 106 g/m, versus 88 g/m among those who did not develop heart failure.\[44\] \[71\] \[72\]

- **abnormal left ventricular diastolic filling**
  - Alternations in the E to A wave ratio, both low and high, have been associated with heart failure risk, with those with the lowest E to A wave ratio (<0.7) having a relative risk of 1.88 and those with the highest E to A wave ratio (>1.5) having a relative risk of 3.50.\[44\] \[72\]

**Weak**

- **low socioeconomic status**
  - The National Health and Nutrition Examination Survey (NHANES I) study found that low socioeconomic status (as indicated by less than high school education) was associated with a relative risk of heart failure of 1.22 (population attributable risk 8.9%).\[30\]

- **tobacco consumption**
  - In contrast to the strong influence of cocaine abuse on the development of heart failure, the literature on the importance of smoking independent of other factors is conflicting.\[14\] \[30\] \[33\] \[34\]
  - In the Framingham cohort, cigarette smoking was not linked with increased incidence of heart failure except among men over age 64 years.\[14\]
  - In other studies, tobacco use has been associated with a relative
risk of heart failure of 1.59 and of 1.51 (smoking <15 cigarettes a day) to 2.31 (smoking 15 or more cigarettes a day).[30] [33]

**excess alcohol consumption**

- Current data strongly support a relationship between excess alcohol consumption and the development of heart failure.[35] [36] [37] This may be related to both direct myocardial toxicity of alcohol and the higher risk of hypertension development. However, the data also suggest a possible weakly protective effect of moderate alcohol consumption.[38] This may be related to lower risk of diabetes and myocardial infarction, and favorable changes in the lipid profile, platelet function, and blood clotting associated with moderate alcohol intake.

**excess sodium intake**

- The National Health and Nutrition Examination Survey (NHANES) found the relative risk for a 100-mmols/day increase in sodium intake was 1.26.[39]

**excess coffee consumption**

- Consumption of five or more cups of coffee a day has been associated with a relative risk of heart failure of 1.11.[33]

**tachycardia**

- Tachycardia-induced cardiomyopathy has been well described in the literature. Among the Framingham cohort, an increase in heart rate of 10 beats per minute was linked with a greater than 10% increased risk of developing heart failure.[48]

**depression/stress**

- Risk is double among depressed compared with nondepressed older people.[53] [54]

**microalbuminuria**

- Although no link between microalbuminuria and the development of heart failure has been established, microalbuminuria was linked with a 3-fold increased risk of heart failure hospitalization in the Heart Outcomes Prevention Evaluation study.[55]
## Investigations

### 1st test to order

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>transthoracic echocardiogram</td>
<td>• Allows for the accurate determination of biventricular systolic and diastolic function. With systolic heart failure, echo usually demonstrates a dilated left and/or right ventricle with low ejection fraction. With pure diastolic heart failure left ventricular ejection fraction (LVEF) is normal but there is evidence of left ventricular hypertrophy (LVH) and of abnormal diastolic filling patterns on Doppler evaluation. Echocardiogram can also identify valvular, myocardial, or pericardial disease or may reveal evidence of underlying coronary artery disease (regional wall motion/thickness abnormalities). A hypertrophied heart may be due to hypertension, hypertrophic obstructive cardiomyopathy, or infiltrative disease like amyloidosis. It should be performed in every patient presenting with heart failure symptoms.</td>
</tr>
<tr>
<td>ECG</td>
<td>• QRS duration greater than 120 ms should always raise the question of ventricular dyssynchrony.</td>
</tr>
<tr>
<td>CXR</td>
<td>• May reveal pulmonary vascular congestion (vascular redistribution, Kerley B lines), cardiomegaly (increased cardiothoracic ratio), or pleural effusion (usually right-sided but often bilateral).</td>
</tr>
<tr>
<td>B-type natriuretic peptide (BNP)/N-terminal pro-brain natriuretic peptide (NT-pro-BNP) levels</td>
<td>• Elevated plasma BNP levels have been associated with reduced left ventricular ejection fraction,[80] left ventricular hypertrophy, elevated left ventricular filling pressures, and acute myocardial infarction and ischemia, although they can occur in other settings, such as pulmonary embolism and chronic obstructive pulmonary disease.[80] [81] [82] They are sensitive to other biologic factors, such as age, sex, weight, and renal function. Elevated levels lend support to a diagnosis of abnormal ventricular function or hemodynamics causing symptomatic heart failure.[83] [84] [85] A low plasma BNP level (&lt;100 picograms/mL) can rapidly rule out decompensated heart failure and point to a pulmonary cause. A high plasma BNP level (&gt;400 picograms/mL) strongly supports the diagnosis of abnormal ventricular function (i.e., heart failure). Intermediate values (100 to 400 picograms/mL) fall into the so-called &quot;gray zone&quot; and should spur a search for a potential noncardiac cause of dyspnea: for example, COPD. In patients presenting with dyspnea, measurement of natriuretic peptide biomarkers is useful to support a diagnosis or exclude heart failure. However, elevated plasma levels of natriuretic peptides can occur with a wide variety of cardiac and noncardiac causes; therefore, clinical judgment is necessary.[77]</td>
</tr>
<tr>
<td></td>
<td>evidence of underlying coronary artery disease, left ventricular hypertrophy, or atrial enlargement; may be conduction abnormalities and abnormal QRS duration</td>
</tr>
<tr>
<td></td>
<td>abnormal</td>
</tr>
<tr>
<td></td>
<td>elevated</td>
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<tr>
<td>Test</td>
<td>Result</td>
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<tr>
<td>• Trials with this diagnostic marker suggest that its use may reduce both the time to hospital discharge and the cost of treatment. B-type natriuretic peptide levels tend to be less elevated in heart failure with preserved ejection fraction than in heart failure with low ejection fraction and are lower in obese patients. Levels of BNP may be elevated meaningfully in women and in people over 60 years of age who do not have heart failure, and thus BNP levels should be interpreted cautiously in such individuals.</td>
<td>laboratory testing may reveal important heart failure etiologies, the presence of disorders or conditions that can lead to or exacerbate heart failure; laboratory testing could also reveal important modulators of therapy</td>
</tr>
<tr>
<td>CBC</td>
<td>laboratory testing may reveal important heart failure etiologies, the presence of disorders or conditions that can lead to or exacerbate heart failure; laboratory testing could also reveal important modulators of therapy</td>
</tr>
<tr>
<td>• Anemia and high lymphocyte percentage are strong risk factors and prognostic markers of poor survival.</td>
<td>decreased sodium (usually &lt;135 mg/dL), altered potassium</td>
</tr>
<tr>
<td>serum electrolytes (including calcium and magnesium)</td>
<td>decreased sodium (usually &lt;135 mg/dL), altered potassium</td>
</tr>
<tr>
<td>• Baseline electrolytes should be obtained in all patients.</td>
<td>decreased sodium (usually &lt;135 mg/dL), altered potassium</td>
</tr>
<tr>
<td>serum creatinine, BUN</td>
<td>increased in diabetes, normal to elevated</td>
</tr>
<tr>
<td>• Reflects tissue perfusion, fluid status, rules out renal disease.</td>
<td>increased in diabetes, normal to elevated</td>
</tr>
<tr>
<td>blood glucose</td>
<td>increased in diabetes, normal to elevated</td>
</tr>
<tr>
<td>• Screening for diabetes mellitus as a comorbid condition. Diabetes mellitus has been associated with a 3- to 5-fold increase in the risk of developing heart failure.</td>
<td>increased in diabetes, normal to elevated</td>
</tr>
<tr>
<td>serum creatinine, BUN</td>
<td>increased in diabetes, normal to elevated</td>
</tr>
<tr>
<td>LFT</td>
<td>normal to elevated</td>
</tr>
<tr>
<td>• Reflects abdominal congestion.</td>
<td>normal to elevated</td>
</tr>
<tr>
<td>LFT</td>
<td>normal to elevated</td>
</tr>
<tr>
<td>thyroid function tests (especially thyroid-stimulating hormone [TSH])</td>
<td>primary hypothyroidism: elevated TSH, decreased free thyroxine (FT4); hyperthyroidism: decreased TSH, elevated free triiodothyronine, elevated FT4</td>
</tr>
<tr>
<td>• Screening for hypo- or hyperthyroidism. Both can be a primary or contributory cause of heart failure.</td>
<td>primary hypothyroidism: elevated TSH, decreased free thyroxine (FT4); hyperthyroidism: decreased TSH, elevated free triiodothyronine, elevated FT4</td>
</tr>
<tr>
<td>blood lipids</td>
<td>elevated in dyslipidemia, decreased in end-stage heart failure, especially in the presence of cardiac cachexia</td>
</tr>
<tr>
<td>• Screening for dyslipoproteinemias/metabolic syndrome.</td>
<td>elevated in dyslipidemia, decreased in end-stage heart failure, especially in the presence of cardiac cachexia</td>
</tr>
<tr>
<td>serum ferritin</td>
<td>elevated (normal value 10-200 nanograms/mL)</td>
</tr>
<tr>
<td>• For evaluation of cardiomyopathy due to iron overload cardiomyopathy/hemochromatosis.</td>
<td>elevated (normal value 10-200 nanograms/mL)</td>
</tr>
<tr>
<td>transferrin saturation</td>
<td>elevated level of transferrin saturation; complete or almost complete transferrin saturation (normal</td>
</tr>
</tbody>
</table>
### Diagnosis

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>transferrin saturation</td>
<td>22% to 46%</td>
</tr>
</tbody>
</table>

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## Other tests to consider

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>noninvasive stress imaging (cardiovascular MRI, stress echocardiogram, SPECT, PET)</strong></td>
<td>• To detect myocardial ischemia and viability when underlying ischemic heart disease is suspected.</td>
</tr>
<tr>
<td></td>
<td>ischemia, scar, viable myocardium</td>
</tr>
<tr>
<td><strong>standard exercise stress testing (bicycle or treadmill)</strong></td>
<td>• Provides an objective assessment of the patient's functional exercise limitation and hemodynamic response to exercise. Test is ordered when exercise-induced arrhythmias or ischemia are suspected. Caution should be taken if there is a high likelihood for aortic stenosis or hypertrophic obstructive cardiomyopathy.</td>
</tr>
<tr>
<td><strong>coronary angiogram</strong></td>
<td>• Provides assessment of coronary stenosis, and is particularly indicated in patients with heart failure and angina, ventricular tachycardia, or cardiac arrest. It is also done in patients with heart failure and ischemia on noninvasive stress test.</td>
</tr>
<tr>
<td><strong>cardiac CT angiography</strong></td>
<td>• Its main use is in patients with heart failure who have low or intermediate pre-test probability of underlying coronary artery disease, or those with equivocal noninvasive stress tests. • In clinical practice it is also useful in patients with a clinical picture of stress/Takotsubo cardiomyopathy, in whom significant proximal coronary artery disease needs to be excluded as a cause of underlying presentation and echocardiogram findings.</td>
</tr>
<tr>
<td><strong>cardiopulmonary exercise testing with VO₂ max</strong></td>
<td>• Provides the most objective assessment of the patient's functional status.</td>
</tr>
<tr>
<td><strong>6-minute walking test exercise</strong></td>
<td>• A patient with heart failure who cannot walk more than 300 m in 6 minutes has a substantially greater annual risk of death than one who can walk 450 m or more.</td>
</tr>
<tr>
<td><strong>right heart catheterization</strong></td>
<td>• Considered in patients intolerant to standard medical therapy, in whom medical therapy has failed to achieve symptomatic relief, before initiation of IV inotrope or inodilator therapy and in candidates for heart transplantation.</td>
</tr>
<tr>
<td>Test</td>
<td>Result</td>
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<td>----------------------------------------------------------------------</td>
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</tr>
<tr>
<td>endomyocardial biopsy</td>
<td>rarely necessary to establish the etiology of heart failure; provides definitive pathologic evidence of cardiac and systemic disease</td>
</tr>
<tr>
<td>• Ordered if acute myocarditis (giant cell or eosinophilic) or primary infiltrative diseases of the heart (amyloidosis, active cardiac sarcoidosis) suspected.</td>
<td></td>
</tr>
<tr>
<td>serum HIV enzyme-linked immunosorbent assay</td>
<td>positive or negative</td>
</tr>
<tr>
<td>• The majority of patients who have cardiomyopathy due to HIV do not present with symptoms of heart failure until other clinical signs of HIV infection are apparent.</td>
<td></td>
</tr>
<tr>
<td>cardiac MRI</td>
<td>myocarditis: subepicardial delayed enhancement in myocardium, high signal in myocardium in T2-weighted imaging; infiltrative cardiomyopathy: amyloid (global subendocardial delayed enhancement); sarcoïd (delayed enhancement); no subendocardial delayed enhancement; constrictive pericarditis: thick pericardium as well as diastolic septal bounce with inspiration</td>
</tr>
<tr>
<td>• Particularly useful in evaluation of conditions like myocarditis, constrictive pericarditis, and infiltrative cardiomyopathy.</td>
<td></td>
</tr>
<tr>
<td>biomarkers</td>
<td>borderline to minimally elevated</td>
</tr>
<tr>
<td>• Troponin is helpful in further risk stratification in chronic heart failure, as elevated level is associated with progressive left ventricular dysfunction and increased mortality.[2] [78]</td>
<td></td>
</tr>
<tr>
<td>• Soluble ST2 and galectin-3 (biomarkers for myocardial fibrosis) are predictive of death and hospitalization in patients with heart failure and are additive to natriuretic peptide in their prognostic value.[2]</td>
<td></td>
</tr>
<tr>
<td>multi-slice computed tomography (MSCT)</td>
<td>quantifies LVEF and coronary artery disease</td>
</tr>
<tr>
<td>• A method for left ventricular ejection fraction (LVEF) estimation. There appears to be no significant difference in LVEF estimation between MSCT and MRI, and also between MSCT and transthoracic echocardiogram.[92]</td>
<td></td>
</tr>
<tr>
<td>• May offer additional benefit as it provides a combined evaluation of LVEF and coronary artery disease.</td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>Differentiating signs / symptoms</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Aging/physical inactivity</td>
<td>• Aging, deconditioning, and/or obesity may cause a reduction in effort tolerance due to dyspnea and/or fatigue, but without the additional major and minor criteria for diagnosing heart failure.</td>
</tr>
<tr>
<td>COPD/pulmonary fibrosis</td>
<td>• Dyspnea may be episodic, with or without environmental triggers, and is usually accompanied by cough, wheezing, sputum, and a history of smoking or industrial exposure.</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>• Patients may present with fever, cough, and productive sputum, with focal signs of consolidation (increased vocal fremitus and bronchial breathing).</td>
</tr>
</tbody>
</table>
| Pulmonary embolism (PE)              | • Sudden onset of chest pain, dyspnea, and hemoptysis, especially after childbirth, are suggestive of PE.[93] Dyspnea with or without chest pain may be present in other conditions associated with venous thrombosis and PE (e.g., cancer, prolonged immobilization, postoperative state). | • ECG is abnormal in the majority of patients with PE and may show a deep S wave in lead I and a deep Q wave and T-wave inversion in lead III (S1-Q3-T3). Other common changes include sinus tachycardia, complete or incomplete right bundle-branch block, and T-wave inversion in the inferior (II, III, aVF) or the anterior leads (V1 to V4). • Normal levels of D-dimers can help to exclude PE, but elevated levels occur in other conditions (e.g., aortic
### Chronic congestive heart failure

#### Diagnosis

<table>
<thead>
<tr>
<th>Condition</th>
<th>Differentiating signs / symptoms</th>
<th>Differentiating tests</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Postpartum cardiomyopathy (PPCM)</strong></td>
<td>• Patients most commonly present with dyspnea, but other frequent complaints include cough, orthopnea, paroxysmal nocturnal dyspnea, hemoptysis, and chest discomfort, which are also common symptoms of PE.</td>
<td>• In the presence of elevated D-dimers (commonplace in pregnancy) and positive risk factors for thromboembolic events, echocardiography will identify the underlying left ventricular systolic dysfunction and point to the diagnosis of PPCM. It usually shows left ventricular enlargement and significant global reduction in ejection fraction. Other findings may include left atrial enlargement, mitral and tricuspid regurgitation, and a small pericardial effusion.</td>
</tr>
<tr>
<td><strong>Cirrhosis</strong></td>
<td>• Typically causes jaundice, fatigue, nausea, peripheral edema, ascites, bruising and prolonged bleeding, gynecomastia, and hematemesis.</td>
<td>• LFTs are abnormal. Ultrasound or CT scan may detect ascites and liver abnormalities. Liver biopsy shows characteristic cirrhotic changes and may reveal the underlying cause.</td>
</tr>
<tr>
<td><strong>Nephrotic syndrome</strong></td>
<td>• Typically causes peripheral edema, fatigue, dyspnea, and loss of appetite.</td>
<td>• Urinalysis shows proteinuria, and serum albumin is reduced. Twenty-four-hour urine collection shows &gt;3.5 g protein. BUN and creatinine clearance may be abnormal in later stages. Serum cholesterol and triglyceride levels may be elevated. Kidney ultrasound</td>
</tr>
<tr>
<td>Condition</td>
<td>Differentiating signs / symptoms</td>
<td>Differentiating tests</td>
</tr>
<tr>
<td>--------------------------</td>
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<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>Chronic congestive heart failure</td>
<td></td>
<td>and biopsy may reveal the underlying cause.</td>
</tr>
<tr>
<td>Pericardial disease</td>
<td>• May present with chest pain, typically worse on lying down, swallowing, or coughing; tachycardia; dyspnea; cough; edema; fatigue; and low-grade fever. Pericardial friction rub may be heard at the left sternal border or apex.</td>
<td>• ECG may show electrical alternans or ST elevation and T wave flattening or inversion. Echocardiography may detect pericardial effusion, tamponade, and pericardial fibrosis. CT scan or MRI may show thickened pericardium. Pericardial biopsy may reveal the underlying cause.</td>
</tr>
<tr>
<td>Venous stasis</td>
<td>• Edema affects lower limbs only, and varicose veins may be present. Skin over the lower legs may be darkened, with ulceration.</td>
<td>• Doppler examination may detect incompetent valves in varicose veins.</td>
</tr>
<tr>
<td>Deep venous thrombosis</td>
<td>• Typically causes pain, swelling, and tenderness of one calf, which becomes red and warm.</td>
<td>• D-dimer test may be positive. Ultrasound scan or contrast venography may detect an area of thrombosis.</td>
</tr>
</tbody>
</table>

**Criteria**

**New York Heart Association (NYHA) classification[94]**

This classification is symptom-based and has primarily been used as shorthand to describe functional limitations. Heart failure symptoms may progress from one class to the next in a given patient, but can also follow the path in reverse; for example, a patient with NYHA class IV symptoms might have quick improvement to class III with diuretic therapy alone.

- **Class I:** Mild. No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitations, or dyspnea.
- **Class II:** Mild. Slight limitation of physical activity. Comfortable at rest, but ordinary physical activity results in fatigue, palpitations, or dyspnea.
- **Class III:** Moderate. Marked limitation of physical activity. Comfortable at rest, but gentle activity causes fatigue, palpitations, or dyspnea.
- **Class IV:** Unable to carry out any physical activity without discomfort. Symptoms of cardiac insufficiency at rest. If any physical activity is undertaken, discomfort is increased.

**Screening**

There is no single test for screening the asymptomatic population. Heart failure is a clinical diagnosis and as such could simply rely on a thorough history and careful physical examination of the population to be tested.
B-type natriuretic peptide (BNP) has recently been used as a screening tool for identifying structural heart disease in the general population. In one study, the sensitivity and specificity of BNP testing for identification of structural heart disease were 61% and 92%, respectively.[95] When sex-specific analyses were performed, sensitivity and specificity were 61% and 91% in men, and 50% and 95% in women, respectively. Although the performance of BNP testing on the basis of these figures might seem suboptimal for the population as a whole, efficacy was improved in subgroups with a high prevalence of heart disease, such as the cohort ages 65 years and older, as well as the cohort having cardiovascular risk factors such as hypertension or diabetes. In another trial, blood N-terminal pro-brain natriuretic peptide concentrations were found to play an important role in stratifying older people into left ventricular dysfunction risk groups. The neurohormone was an independent marker for death or admission for heart failure in the medium term.[96] These results suggest that BNP testing for structural heart disease screening in community-based populations might only be useful for cohorts with a high prevalence of heart disease. The American College of Cardiology/American Heart Association/Heart Failure Society guidelines recommend that for patients at risk of developing heart failure (identified by the presence of hypertension, diabetes mellitus, or known vascular disease), natriuretic peptide biomarker-based screening followed by team-based care, including a cardiovascular specialist optimizing guideline-directed management and therapy, can be useful to prevent the development of left ventricular dysfunction (systolic or diastolic) or new-onset heart failure. However, further studies are needed to determine cost-effectiveness, its impact on quality of life, and mortality rate.[77]
**Approach**

Goals of treatment of chronic CHF are to:

- Alleviate symptoms
- Delay progression
- Reduce mortality.

**General principles of therapy**

- In newly diagnosed patients with CHF, congestion and volume overload should be promptly treated with diuretics, which may be given intravenously in the initial phase. Loop diuretics used for the treatment of heart failure and congestion include furosemide, bumetanide, and torsemide.
- In patients with low left ventricular ejection fraction (LVEF), in addition to diuretics, ACE inhibitors, beta-blockers, and aldosterone antagonists (e.g., spironolactone, eplerenone) should be added.
- In unstable patients, beta-blockers should be initiated only after stabilization, optimization of volume status and discontinuation of inotropes. Beta-blockers should be initiated at a low dose.
- In patients with CHF and reduced LVEF who are hospitalized with exacerbation of heart failure, unless there is evidence of low cardiac output or hemodynamic instability or contraindication, both ACE-inhibitors and beta-blockers should be continued.

**Lifestyle changes**

The success of pharmacologic therapy is strongly related to, and greatly enhanced by, encouraging the patient and his/her family to participate in various complementary nonpharmacologic management strategies. These mainly include lifestyle changes, dietary and nutritional modifications, exercise training, and health maintenance.[99]

**Initial drug treatments**

Diuretics:

- All patients with symptoms and signs of congestion should receive diuretics, irrespective of the LVEF. In patients with reduced LVEF, diuretics should always be used in combination with an ACE inhibitor (or angiotensin-II receptor antagonist), a beta-blocker, and an aldosterone antagonist. Loop diuretics used for the treatment of heart failure and congestion include furosemide, bumetanide, and torsemide. The most commonly used agent appears to be furosemide, but some patients may respond more favorably to another loop diuretic. In resistant cases, loop diuretics should be combined with a thiazide diuretic (e.g., chlorothiazide, hydrochlorothiazide) or a thiazide-like diuretic (e.g., metolazone, indapamide).
- Loop diuretics and thiazide diuretics differ in their pharmacologic actions. Loop diuretics increase excretion of up to 20% to 25% of the filtered load of sodium, enhance free-water clearance, and maintain their efficacy unless renal function is severely impaired. In contrast, thiazide diuretics increase the fractional excretion of sodium to only 5% to 10% of the filtered load, tend to decrease free-water clearance, and lose their effectiveness in patients with impaired renal function (i.e., creatinine clearance less than 40 mL/minute). Consequently, loop diuretics have emerged as the preferred diuretic for use in most patients with heart failure; however, thiazide diuretics may be
Management

preferred in patients with hypertension, heart failure, and mild fluid retention because they confer more persistent antihypertensive effects.

- Careful monitoring of renal function and electrolytes is essential. The minimum dose of diuretic should be used to relieve congestion, keep the patient asymptomatic, and maintain a dry weight.

ACE inhibitors or beta-blockers:

ACE inhibitors

- ACE inhibitors or beta-blockers may be used as first-line treatment. Both are equally important in terms of survival benefit. It has not been shown that starting the ACE inhibitor is better than starting the beta-blocker, but in practice most physicians start an ACE inhibitor first and then add a beta-blocker; the origin of this practice is historical, as the benefits of ACE inhibitors were demonstrated 10 years before those of beta-blockers. Also, most large-scale studies of beta-blockers were conducted using ACE-inhibitor therapy as comparator or standard. If a patient cannot tolerate target doses of both an ACE inhibitor and a beta-blocker when these drugs are co-administered, it is preferable to co-administer lower doses of both drugs than to reach the target dose in one class and not be able to initiate the other.

- ACE inhibitors have been shown to decrease the morbidity and mortality associated with heart failure, and should be given to all patients with left ventricular (LV) dysfunction, symptomatic or otherwise, unless there is a contraindication or prior intolerance to therapy.[2] [98]

Beta-blockers

- Beta-blockers have also been shown to decrease the morbidity and mortality associated with heart failure.[2] [98] They are initiated at low doses and titrated to target dosages.[2] [100] One meta-analysis found that irrespective of pretreatment heart rate, beta-blockers reduced mortality in patients with heart failure with reduced ejection fraction (HFrEF) in sinus rhythm.[101] Achieving a lower heart rate is associated with better prognosis for patients in sinus rhythm but not those with atrial fibrillation. Mortality was lower for patients in sinus rhythm randomized to beta-blockers (hazard ratio: 0.73 vs. placebo; 95% confidence interval [CI] 0.67 to 0.79; P <0.001), regardless of baseline heart rate (interaction P = 0.35). Beta-blockers had no effect on mortality in patients with atrial fibrillation (hazard ratio: 0.96; 95% CI 0.81 to 1.12; P = 0.58) at any heart rate (interaction P = 0.48).[101] However, this was a retrospective analysis and authors commented that background therapy, including devices, may have changed since these trials were conducted and that the heart rate was not measured in a standardized fashion across the trials. In a randomized trial of patients with atrial fibrillation and HFrEF, during a median follow-up of 37 months, beta-blockers were associated with significantly lower all-cause mortality (hazard ratio: 0.721; 95% CI 0.549 to 0.945; P = 0.0180) but not hospitalization (hazard ratio: 0.886; 95% CI 0.715 to 1.100; P = 0.2232).[102] The result of this study supports the evidence-based recommendations for beta-blockers in patients with HFrEF, whether or not they have associated atrial fibrillation.

- Although side effects can include bradycardia, worsening of reactive airway disease, and worsening heart failure, these can often be avoided by careful patient selection, dose titration, and close monitoring. Clinical improvement may be delayed and may take 2 to 3 months to become apparent. However, long-term treatment with beta-blockers can lessen the symptoms of heart failure and improve clinical status

Angiotensin-II receptor antagonists:
Angiotensin-II receptor antagonists are considered a reasonable alternative to ACE inhibitors in patients with preserved or decreased LVEF who are intolerant of ACE inhibitors because of cough or angioedema. Experience with these drugs in controlled clinical trials of patients with heart failure is considerably less than that with ACE inhibitors. Nevertheless, valsartan and candesartan have demonstrated benefit by reducing hospitalizations and mortality. In patients with evidence of left ventricular dysfunction early after myocardial infarction, angiotensin-II receptor antagonists may be no more effective than ACE inhibitors and may be no better tolerated. The combination of an ACE inhibitor and an angiotensin-II receptor antagonist may produce more reduction of left ventricular size and may reduce the need for hospitalization more than either agent alone, although whether or not combination therapy further reduces mortality remains unclear. As an alternative to ACE inhibitors, angiotensin-II receptor antagonists should be initiated in patients early post-infarct, but caution should be used in patients in cardiogenic shock or with marginal renal output.

Addition of an angiotensin-II receptor antagonist may be considered in persistently symptomatic patients with heart failure and reduced LVEF who are already being treated with an ACE inhibitor and beta-blockers and in whom an aldosterone antagonist is not indicated or tolerated. Routine combined use of ACE inhibitors with an aldosterone antagonist and an angiotensin-II receptor antagonist is potentially harmful for patients with heart failure and is not recommended. Combined use should be instigated by a specialist and continued only with specialist supervision. Concomitant administration of an ACE inhibitor, a beta-blocker, and an angiotensin-II receptor antagonist should be used with great caution, and perhaps initiated only in the hospital under continuous blood pressure and renal function monitoring because it may provoke life-threatening hypotension and acute renal insufficiency. The CHARM trial showed that this combination may confer added benefit with acceptable risk, but further studies are required. In one study, addition of olmesartan (an angiotensin-II receptor antagonist) to patients with New York Heart Association (NYHA) class II to IV heart failure who had a history of hypertension or who had been treated with antihypertensive medications and were already on ACE inhibitor and beta-blocker therapy did not improve the clinical outcome and led to worsening of renal function. Renin inhibitors (e.g., aliskiren) should also not be combined with ACE inhibitors. In a study of patients with chronic heart failure (NYHA class II to IV, ejection fraction of 35% or less) addition of aliskiren to enalapril compared with enalapril alone led to more adverse events (hypotension and elevated creatinine) without any benefit or difference in primary outcome of death from cardiovascular causes or hospitalization for heart failure.

Angiotensin-II receptor antagonist plus neprilysin inhibitor:

In HFrEF (NYHA class II to IV) and ejection fraction of 40% or less, which was later changed to an ejection fraction of 35% or less, a combination of sacubitril, a neprilysin inhibitor, and valsartan, an angiotensin-II receptor antagonist, was superior to enalapril in reducing mortality and heart failure hospitalization. The drug combination has been approved in the US and in Europe for the treatment
of heart failure. In this study the ejection fraction was 29 ± 6.1% in the sacubitril/valsartan group and 29.4 ± 6.3% in the enalapril group.[112]

Sacubitril/valsartan has been found to improve a patient's physical and social activities compared with enalapril.[113]

Sacubitril/valsartan is recommended as a replacement for an ACE inhibitor in patients who remain symptomatic despite optimal treatment with an ACE inhibitor, a beta-blocker, and a mineralocorticoid-receptor antagonist.[1] It is recommended for patients who fit the profile of the study showing beneficial effects of this combination (i.e., patients in NYHA class II to IV with LVEF of 35% or <35%).[112] The American Heart Association/American College of Cardiology/Heart Failure Society of America guidelines recommend that, in patients with chronic NYHA class II or III who tolerate an ACE inhibitor or angiotensin-II receptor antagonist, these drugs should be replaced by an angiotensin-II receptor antagonist plus neprilysin inhibitor to further reduce morbidity and mortality.[77] Concomitant administration of an angiotensin-II receptor antagonist plus a neprilysin inhibitor with an ACE inhibitor, or within 36 hours of the last dose of an ACE inhibitor, is not recommended.[77]

Treatment with sacubitril/valsartan reduces cardiovascular death by reducing both worsening heart failure and sudden cardiac death.[114]

Hydralazine and nitrates:

The addition of a combination of hydralazine and a nitrate is reasonable for patients with reduced LVEF who are already taking an ACE inhibitor and beta-blocker for symptomatic heart failure and who have persistent symptoms,[2] and has demonstrated benefit in black patients with heart failure.[115] [116] The combined use of hydralazine and isosorbide dinitrate may also be considered as a therapeutic option in patients who are intolerant of ACE inhibitors.[2] This combination may be a useful alternative in patients intolerant to both ACE inhibitors and angiotensin-II receptor antagonists.[2]

A combination of hydralazine and isosorbide dinitrate can be useful to reduce morbidity or mortality in patients with current or prior symptomatic HFrEF who cannot be given an ACE inhibitor or angiotensin-II receptor antagonist because of drug intolerance, hypotension, or renal insufficiency, unless contraindicated.[2] The American College of Cardiology Foundation/American Heart Association guidelines recommend the combination of hydralazine and isosorbide dinitrate to 'reduce morbidity and mortality in patients self-described as African Americans with NYHA class III to IV HFrEF receiving optimal therapy with ACE inhibitors and beta blockers, unless contraindicated'.[2]

Anticoagulants:

At present there is little evidence from long-term studies to recommend antiplatelet therapy or oral anticoagulation in patients with heart failure in sinus rhythm, and antiplatelet agents versus control or anticoagulation for heart failure in sinus rhythm.[117]

- A study comparing warfarin and aspirin in patients with heart failure and sinus rhythm showed no significant difference in the combined outcomes of stroke, intracerebral hemorrhage, and death. Warfarin reduced ischemic stroke at the expense of an increased bleeding risk.[118]
- Although oral anticoagulants are indicated in certain groups of patients with heart failure (e.g., patients with atrial fibrillation), the available data do not support their routine use in heart failure patients who remain in sinus rhythm.[117]
**Digoxin for patients with heart failure**

Digoxin can be beneficial in patients with current or prior symptoms of heart failure or reduced LVEF, especially those with atrial fibrillation. When added to ACE inhibitors, beta-blockers, and diuretics, digoxin can reduce symptoms, prevent hospitalization, control rhythm, and enhance exercise tolerance.[119] Digoxin reduces the composite end point of mortality or hospitalizations in ambulatory patients with chronic heart failure with NYHA class III or IV symptoms, LVEF <25%, or cardiothoracic ratio of >55% and should be considered in these patients.[120]

Digoxin reduces the composite end point of mortality or hospitalizations, but does not reduce all-cause mortality.[120] Digoxin should be used cautiously with plasma level monitoring. One meta-analysis suggests that digoxin use in patients with heart failure is associated with a higher risk of all-cause mortality.[121]

One systematic review and meta-analysis of observational and controlled trial data showed that digoxin has a neutral effect on mortality in randomized trials and reduces hospital admissions.[122]

**Aldosterone antagonists in moderate-to-severe heart failure**

Aldosterone antagonists (also known as mineralocorticoid receptor antagonists) decrease the morbidity and mortality associated with symptomatic chronic heart failure.

Aldosterone antagonists (spironolactone and eplerenone) are recommended in patients with NYHA class II to IV heart failure who have LVEF of 35% or less, unless contraindicated.[2] They are also recommended to reduce mortality and morbidity following acute myocardial infarction in patients with LVEF of 40% or less who develop symptoms of heart failure or have a history of diabetes mellitus, unless contraindicated.[2][123]

Aldosterone antagonists should be initiated after titration of standard medical therapy. Spironolactone and eplerenone can both cause hyperkalemia, and precautions should be taken to minimize the risk. In the EPHESUS trial, the addition of eplerenone to standard care did not increase the risk of hyperkalemia when potassium was regularly monitored.[124]

**Ivabradine**

Ivabradine is approved for use in patients with heart failure and symptoms in spite of drug therapy. The Food and Drug Administration (FDA) has approved it to reduce the risk of hospitalization for worsening heart failure in patients with stable, symptomatic chronic heart failure, with LVEF ≤35%, who are in sinus rhythm with a resting heart rate ≥70 beats per minute and are either on a maximum dose of beta-blockers or have a contraindication to beta-blockers.

In a randomized, double-blind, placebo-controlled trial, addition of ivabradine to standard background therapy in patients with stable coronary artery disease without clinical heart failure (no evidence of left ventricular systolic dysfunction in the overall study population, mean ejection fraction was 56.4%) did not improve the outcome. In the subgroup analysis of this study, ivabradine was associated with an increase in the incidence of the primary end point (death from cardiovascular causes or nonfatal myocardial infarction) among patients who had angina of Canadian Cardiovascular Society class II or higher but not among patients without angina or those who had angina of class I. Ivabradine was associated with an increased incidence of bradycardia, QT prolongation, and atrial fibrillation.[123]
**Vasopressin antagonists**

Use of vasopressin antagonists such as tolvaptan can be considered for patients with symptomatic or severe hyponatremia (<130 mmol/L) and persistent congestion despite standard therapy, to correct hyponatremia and related symptoms.[2] [97]

**Heart transplant and medical devices**

Cardiac transplantation is currently the only established surgical approach, but it is available to fewer than 2500 patients in the US each year.[125] [126] [127] Current indications for cardiac transplantation focus on the identification of patients with severe functional impairment, dependence on intravenous inotropic agents, recurrent life-threatening ventricular arrhythmias, or angina that is refractory to all currently available treatments.[2] [126] [127] [128]

Implantable cardioverter-defibrillators (ICDs) have been shown to decrease mortality in patients with heart failure, both ischemic and nonischemic. The SCD-Heft trial enrolled patients who had left ventricular dysfunction and no prior history of syncope or sustained ventricular tachycardia, and included patients with a prior myocardial infarction and no prior coronary artery disease. Use of ICDs led to a 23% relative mortality risk reduction at 5 years.[129]

An ICD is recommended in the following situations:[2]

1. For primary prevention of sudden cardiac death in selected patients with both nonischemic and ischemic heart failure, at least 40 days post myocardial infarction, LVEF <35%, New York Heart Association (NYHA) class II or III symptoms on guideline-directed medical therapy, and expected to live for >1 year, or LVEF <30%, NYHA class I, on guideline-directed medical therapy, and expected to live for >1 year
2. As secondary prevention to prolong survival in patients with current or prior symptoms of heart failure and reduced LVEF who have a history of cardiac arrest, ventricular fibrillation, or hemodynamically destabilizing ventricular tachycardia.

It has been estimated that one quarter to one third of patients with heart failure have left bundle-branch block: that is, manifest a QRS duration greater than 120 milliseconds (ms).[130] Patients with heart failure who have left bundle-branch block, known as ventricular dyssynchrony, have a poorer prognosis than those without left bundle-branch block.[2] Studies have shown that, in these patients, cardiac resynchronization therapy (CRT) decreases hospitalization and, when combined with an ICD, significantly reduces mortality.[131] [132] [133] [134] [135] [136] In patients who have conduction delay and left ventricular dysfunction, biventricular pacemakers have been shown to improve exercise tolerance and quality of life while decreasing morbidity and mortality.[131] [132] [133] [134] [136] [137] [138] [139] The CARE-HF study randomized patients with a widened QRS, LVEF of 35% or less, and persistent moderate or severe symptoms of heart failure despite pharmacologic therapy, to implantation of a CRT device or not.[140] The main study observed substantial benefits on morbidity and mortality that persisted or increased with longer follow-up.[141] [142] [143] [144] [145] [146] [147] [148] [149] [150] [151] Reduction in mortality was due to fewer deaths from heart failure and from reduced sudden death.[141]

Long-term data from the REVERSE study suggest that improvements in left ventricular function and remodeling can be sustained for over 5 years.[152] [153]

According to the American College of Cardiology Foundation/American Heart Association guidelines, the recommendations for the use of CRT devices in heart failure are as follows.[2]
1. CRT is indicated in patients who have LVEF of 35% or less; sinus rhythm; left bundle-branch block (LBBB) with a QRS duration of 150 ms or greater; NYHA class II, III, or ambulatory IV symptoms on guideline-directed medical therapy.

2. CRT can be useful in patients who have LVEF of 35% or less; sinus rhythm; a non-LBBB with a QRS duration of 150 ms or greater; NYHA class III/ambulatory IV symptoms on guideline-directed medical therapy.

3. CRT can be useful in patients who have LVEF of 35% or less; sinus rhythm; LBBB with a QRS duration of 120 to 149 ms; NYHA class II, III, or ambulatory IV symptoms on guideline-directed medical therapy.

4. CRT can be useful in patients with atrial fibrillation and LVEF of 35% or less on guideline-directed medical therapy if (a) the patient requires pacing or otherwise meets the CRT criteria; and (b) atrioventricular nodal ablation or pharmacological rate control will allow near 100% ventricular pacing with CRT.

5. CRT can be useful for patients on guideline-directed medical therapy who have LVEF of 35% or less and are undergoing device implantation with anticipated requirement for significant (>40%) ventricular pacing.

American Heart Association guidance outlines the indication and evidence behind the use of mechanical circulatory support in patients with heart failure. Mechanical circulatory support, which includes ventricular assist devices, helps to maintain sufficient end organ perfusion by unloading the heart and is considered in carefully selected patients who have end-stage heart failure, despite optimal medical and device therapy, and in whom definite management (e.g., cardiac transplantation) or cardiac recovery is anticipated.

Currently in the US, the accepted indications for implantation of a durable left ventricular assist device (LVAD) are bridge to transplantation and destination therapy (permanent pump implantation in patients not eligible for cardiac transplantation). In clinical practice, another indication for LVAD is to provide a bridge to decisions about future care.

The European Society of Cardiology has outlined the various indications for mechanical circulatory support:

- Bridge to decision/bridge to bridge: use of short-term support (e.g., extracorporeal life support [ECLS] or extracorporeal membrane oxygenation [ECMO]) in patients with cardiogenic shock until hemodynamics and end-organ perfusion are stabilized, contraindications for long-term support are excluded, and therapeutic options including long-term VAD therapy or heart transplant can be evaluated.

- Bridge to candidacy: use of support (usually LVAD) to make ineligible patient eligible for heart transplant.

- Bridge to transplantation: use of LVAD or biventricular assist device to keep high risk transplant candidate alive until donor organ becomes available.

- Bridge to recovery: use of support (usually LVAD) to keep the patient alive until cardiac function recovers sufficiently to remove it.

- Destination therapy: long-term use of LVAD as alternative to heart transplant.

Some of the absolute contraindications for providing durable mechanical support include irreversible hepatic, renal and neurological disease, medical nonadherence, and severe psychosocial limitations.

Please see our topic on Acute heart failure for more information.
### Treatment algorithm overview

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer

<table>
<thead>
<tr>
<th>Acute</th>
<th>(\text{tolerance to ACE inhibitors})</th>
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<tbody>
<tr>
<td>1st</td>
<td>ACE inhibitor or sacubitril/valsartan plus lifestyle changes plus beta-blocker adjunct diuretic adjunct aldosterone antagonist adjunct hydralazine + isosorbide dinitrate adjunct digoxin adjunct ivabradine adjunct vasopressin antagonist</td>
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<tr>
<th>Acute</th>
<th>(\text{intolerance to ACE inhibitors})</th>
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<tbody>
<tr>
<td>1st</td>
<td>beta-blocker + angiotensin-II receptor antagonist plus lifestyle changes adjunct diuretic adjunct aldosterone antagonist adjunct hydralazine + isosorbide dinitrate adjunct digoxin adjunct ivabradine adjunct vasopressin antagonist</td>
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<tr>
<td>2nd</td>
<td>hydralazine + isosorbide dinitrate plus beta-blocker plus lifestyle changes adjunct diuretic adjunct aldosterone antagonist adjunct digoxin adjunct ivabradine adjunct vasopressin antagonist</td>
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### Ongoing refractory to optimal medical treatment

<table>
<thead>
<tr>
<th>LVEF &lt;35%: no left bundle-branch block</th>
<th>1st</th>
<th>implantable cardioverter-defibrillator (ICD)</th>
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<tbody>
<tr>
<td></td>
<td>2nd</td>
<td>mechanical circulatory support</td>
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<tr>
<td></td>
<td>3rd</td>
<td>cardiac transplantation</td>
</tr>
<tr>
<td>LVEF &lt;35%: left bundle-branch block</td>
<td>1st</td>
<td>cardiac resynchronization therapy with biventricular pacemaker (CRT-P)/cardiac resynchronization therapy-defibrillator (CRT-D)</td>
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<tr>
<td></td>
<td>2nd</td>
<td>left ventricular assist device (LVAD)</td>
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<tr>
<td></td>
<td>3rd</td>
<td>cardiac transplantation</td>
</tr>
</tbody>
</table>
Treatment algorithm

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer.
### Acute Tolerance to ACE Inhibitors

**1st ACE Inhibitor or Sacubitril/Valsartan**

**Primary Options**

- **Captopril**: 6.25 to 50 mg orally three times daily

OR

- **Enalapril**: 2.5 to 20 mg orally twice daily

OR

- **Fosinopril**: 5-40 mg orally once daily

OR

- **Lisinopril**: 2.5 to 40 mg orally once daily

OR

- **Perindopril Erbumine**: 2-16 mg orally once daily

OR

- **Quinapril**: 5-20 mg orally twice daily

OR

- **Ramipril**: 1.25 to 10 mg orally once daily

OR

- **Trandolapril**: 1-4 mg orally once daily

OR

- **Sacubitril/Valsartan**: treatment-naive patients: 24 mg (sacubitril)/26 mg (valsartan) orally twice daily initially, increase gradually according to response, maximum 97 mg (sacubitril)/103 mg (valsartan); treatment-experienced: 49 mg (sacubitril)/51 mg (valsartan) orally twice daily initially, increase gradually according to response, maximum 97 mg (sacubitril)/103 mg (valsartan) Patients not taking an ACE inhibitor or angiotensin-II receptor antagonist should be started on a lower dose. Patients who were being treated with an ACE inhibitor or angiotensin-II receptor antagonist should be tapered slowly over 1-2 weeks.
Management

**Acute**

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<td></td>
<td>be started on a higher dose. Allow 36 hours between stopping an ACE inhibitor and starting this drug.</td>
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</table>

» ACE inhibitors have been shown to decrease the morbidity and mortality associated with heart failure, and should be given to all patients with left ventricular dysfunction, both asymptomatic and symptomatic, unless there is a contraindication or prior intolerance to therapy.[2] [98]

» ACE inhibitors should be used with caution in patients in cardiogenic shock, with marginal renal output or hyperkalemia.

» If patients have an idiosyncratic reaction, with angioedema, ACE inhibitors should not be rechallenged.

» However, in heart failure with reduced ejection fraction (New York Heart Association [NYHA] class II to IV and ejection fraction of 35% or less) a combination of sacubitril, a neprilysin inhibitor, and valsartan, an angiotensin-II receptor antagonist, is superior to enalapril in reducing mortality and heart failure hospitalization.[112]

   The drug combination has been approved in the US and in Europe for the treatment of heart failure. The American Heart Association/ American College of Cardiology/Heart Failure Society of America guidelines recommend that, in patients with chronic NYHA class II or III who tolerate an ACE inhibitor or angiotensin-II receptor antagonist, these drugs should be replaced by an angiotensin-II receptor antagonist plus neprilysin inhibitor to further reduce morbidity and mortality.[77]

   Concomitant administration of an angiotensin-II receptor antagonist plus neprilysin with an ACE inhibitor, or within 36 hours of the last dose of an ACE inhibitor, is not recommended.[77]

**plus lifestyle changes**

Treatment recommended for ALL patients in selected patient group

» Dietary sodium intake is an easily modifiable factor that complements pharmacologic therapy for heart failure. For stage A and B heart failure (stage A: at high risk for heart failure but without structural heart disease or symptoms of heart failure; stage B: structural heart disease but without signs or symptoms of heart failure), the recommendation is to limit sodium intake to 1.5 g/day. For stage C and D heart failure (stage C: structural heart disease with prior or current symptoms of heart failure; stage D: refractory
Acute heart failure requiring specialized interventions), the recommendation is to limit sodium intake to at least 3 g/day.[2]

» Fluid restriction is mostly used as an in-hospital complementary measure in cases of acute exacerbations. In addition, fluid restriction may be warranted in cases of severe hyponatremia. However, it would be of importance to advise the patient to keep a daily intake/output balance at home. Patients are advised to monitor their weight daily and to immediately contact their healthcare provider if a specified change in weight occurs.

» Heart failure patients need continuous and close monitoring of their health. A variety of programs have been shown to decrease morbidity and rehospitalization in this context, including home nursing, telephone advice/triage, telemedicine services, and specialized heart failure clinic-based care.[157]

» Exercise training has also been shown to be beneficial.[99]

plus beta-blocker

Treatment recommended for ALL patients in selected patient group

Primary options

» carvedilol: 3.125 mg orally (immediate-release) twice daily initially, increase according to response, maximum 50 mg/day (body weight ≤85 kg) or 100 mg/day (body weight >85 kg)

Secondary options

» metoprolol succinate: 12.5 to 200 mg orally (extended-release) once daily

OR

» bisoprolol: 1.25 mg orally once daily initially, increase according to response, maximum 10 mg/day

OR

» nebivolol: 1.25 mg orally once daily initially, increase according to response, maximum 10 mg/day

» All patients with chronic heart failure receive a beta-blocker once established on an ACE inhibitor, unless there is a contraindication based
Chronic congestive heart failure

Management

**Acute**

on bradycardia, reactive airway disease, and unstable or low-output heart failure.\[2\] [98]

» Carvedilol seems superior to metoprolol,\[158\] although there is no evidence of superiority to other beta-blockers. In the SENIORS study, nebivolol, a cardioselective beta-blocker with nitric oxide-mediated vasodilating properties, was found to be an effective and well-tolerated treatment for heart failure in patients ages 70 years or more.\[159\] Data suggest that initiation with moderate doses of nebivolol is not associated with the adverse hemodynamic effects usually observed with other beta-blockers in patients with heart failure; therefore, a long up-titration period may not be necessary with nebivolol.\[160\]

» Beta-blockers have been shown to decrease the morbidity and mortality associated with heart failure.\[2\] [98] They are initiated at low doses and titrated to target dosages.\[2\] [100] One meta-analysis found that irrespective of pretreatment heart rate, beta-blockers reduced mortality in patients with heart failure with reduced ejection fraction in sinus rhythm.\[101\]

adjunct diuretic

Treatment recommended for SOME patients in selected patient group

**Primary options**

<table>
<thead>
<tr>
<th>Adjunct diuretic</th>
<th>Primary options</th>
</tr>
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<tbody>
<tr>
<td>furosemide</td>
<td>20-80 mg/dose orally initially, increase by 20-40 mg/dose increments every 6-8 hours according to response, maximum 600 mg/day</td>
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<td>OR</td>
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<tr>
<td>bumetanide</td>
<td>0.5 to 1 mg orally once or twice daily initially, increase according to response, maximum 10 mg/day</td>
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<td>OR</td>
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<tr>
<td>torsemide</td>
<td>10-20 mg orally once daily initially, increase according to response, maximum 200 mg/day</td>
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<tr>
<td>chlorothiazide</td>
<td>250-500 mg orally once or twice daily, maximum 1000 mg/day</td>
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### Acute

- **hydrochlorothiazide**: 25 mg orally once or twice daily, increase according to response, maximum 200 mg/day

OR

- **indapamide**: 2.5 to 5 mg orally once daily

OR

- **metolazone**: 2.5 to 20 mg orally once daily

**Secondary options**

- **amiloride**: 5-20 mg orally once daily

OR

- **triamterene**: 50-100 mg orally twice daily initially, increase according to response, maximum 300 mg/day

**Diuretics** should be considered for patients who have evidence of, or a prior history of, fluid retention.[2] They should generally be combined with an ACE inhibitor and a beta-blocker. All patients with symptoms and signs of congestion should receive diuretics, irrespective of the left ventricular ejection fraction (LVEF).

- Loop diuretics used for the treatment of heart failure and congestion include furosemide, bumetanide, and torsemide. The most commonly used agent appears to be furosemide, but some patients may respond more favorably to another loop diuretic. In resistant cases, loop diuretics should be combined with a thiazide diuretic (e.g., chlorothiazide, hydrochlorothiazide) or a thiazide-like diuretic (e.g., metolazone, indapamide). Careful monitoring of renal function and electrolytes is essential in these patients.

- The minimum dose of diuretic should be used to relieve congestion, keep the patient asymptomatic, and maintain a dry weight. In patients with stable congestive heart failure, loop diuretics are the preferred agent. In patients with hypertension and only mild fluid retention, a thiazide diuretic may be considered.

- Diuretics produce symptomatic benefits more rapidly than any other drug for heart failure. They can relieve pulmonary and peripheral edema within hours or days. Few patients with heart failure and fluid retention can maintain sodium balance without the use of diuretic drugs.[161]
Chronic congestive heart failure

Management

**Acute**

- Diuretics alone are unable to maintain the clinical stability of patients with heart failure for long periods of time,[161] but the risk of clinical decompensation can be reduced when they are combined with an ACE inhibitor and a beta-blocker.[162] Diuretics should be used only in combination with an ACE inhibitor (or angiotensin-II receptor antagonist), a beta-blocker, and an aldosterone antagonist in patients with reduced LVEF.

- In intermediate-term studies, diuretics have been shown to improve cardiac function, symptoms, and exercise tolerance in patients with heart failure.[161][163] There have been no long-term studies of diuretic therapy in heart failure, and thus their effects on morbidity and mortality are not known.

- Amiloride and triamterene (potassium-sparing diuretics) should be used with caution with aldosterone antagonists, because of the increased risk of developing hyperkalemia. Close monitoring of serum potassium levels is suggested in this situation.

**adjunct aldosterone antagonist**

Treatment recommended for SOME patients in selected patient group

**Primary options**

- **spironolactone:** 25-100 mg orally once daily

  **OR**

- **eplerenone:** 25-50 mg orally once daily

**Aldosterone antagonists, also known as mineralocorticoid receptor antagonists (e.g., spironolactone and eplerenone), decrease the morbidity and mortality associated with symptomatic chronic heart failure.**

- Aldosterone antagonists are recommended in patients with New York Heart Association class II to IV heart failure who have left ventricular ejection fraction (LVEF) of 35% or less, unless contraindicated.[2] They are also recommended to reduce mortality and morbidity following acute myocardial infarction in patients with LVEF of 40% or less who develop symptoms of heart failure or have a history of diabetes mellitus, unless contraindicated.

- Aldosterone antagonists should be initiated after titration of standard medical therapy. Spironolactone and eplerenone can both cause...
Acute

Management

Chronic congestive heart failure

Acute hyperkalemia, and precautions should be taken to minimize the risk.

» These agents should be used with caution in patients with renal dysfunction and hyperkalemia. They should not be initiated in patients with a serum creatinine greater than 2.5 mg/dL or a serum potassium greater than 5.0 mEq/dL and should be used with caution in patients with serum creatinine less than 2.5 mg/dL plus a serum potassium greater than 5.0 mEq/dL. Patients should discontinue potassium repletion.

» Adherence to intensive monitoring of renal function and potassium levels has been shown to prevent hyperkalemia, which is as likely to occur with eplerenone therapy as it is with spironolactone therapy.

» Amiloride and triamterene (potassium-sparing diuretics) should be used with caution with aldosterone antagonists, because of the increased risk of developing hyperkalemia. Close monitoring of serum potassium levels is suggested in this situation.

adjunct hydralazine + isosorbide dinitrate

Treatment recommended for SOME patients in selected patient group

Primary options

» isosorbide dinitrate: 20-40 mg orally (immediate-release) three times daily -and-
  » hydralazine: 10-100 mg orally three times daily

OR

» isosorbide dinitrate/hydralazine: 20 mg (isosorbide dinitrate)/37.5 mg (hydralazine) orally three times daily, maximum 40 mg (isosorbide dinitrate)/75 mg (hydralazine) three times daily

» A combination of hydralazine and isosorbide dinitrate can be useful to reduce morbidity or mortality in patients with current or prior symptomatic heart failure with reduced ejection fraction (HFrEF) who cannot be given an ACE inhibitor or angiotensin-II receptor antagonist because of drug intolerance, hypotension, or renal insufficiency, unless contraindicated.[2] The American College of Cardiology Foundation/American Heart Association guidelines recommend the combination of hydralazine and
Chronic congestive heart failure

Management

Acute

- isosorbide dinitrate to "reduce morbidity and mortality in patients self-described as African Americans with NYHA class III to IV HFrEF receiving optimal therapy with ACE inhibitors and beta blockers, unless contraindicated."[2]

  » Nitrate therapy may decrease symptoms of dyspnea at night and during exercise and may improve exercise tolerance in patients who have persistent limitations despite optimization of other therapies.[164] [165]

  » Development of nitrate tolerance seems to be minimized by prescription of a nitrate-free interval of at least 10 hours.[2] Carvedilol use has been shown to prevent nitrate tolerance in patients with CHF.[166] [167]

  » Hydralazine may interfere with the biochemical and molecular mechanisms responsible for the development of nitrate tolerance.[168] [169]

  » A combination pill containing 37.5 mg hydralazine and 20 mg isosorbide dinitrate is available, approved specifically for self-identified African-Americans with CHF.

adjunct digoxin

Treatment recommended for SOME patients in selected patient group

Primary options

- digoxin: 0.125 to 0.5 mg orally once daily

  » Digoxin can be beneficial in patients with reduced left ventricular ejection fraction (LVEF), especially those with atrial fibrillation.

  » When added to ACE inhibitors, beta-blockers, and diuretics, digoxin can reduce symptoms, prevent hospitalization, control rhythm, and enhance exercise tolerance.

  » Digoxin reduces the composite end point of mortality or hospitalizations in ambulatory patients with chronic heart failure with New York Heart Association class III or IV symptoms, LVEF <25%, or cardiothoracic ratio of >55% and should be considered in these patients.[120]

  » Digoxin reduces the composite end point of mortality or hospitalizations, but does not reduce all-cause mortality.[120] Digoxin should be used cautiously with plasma level monitoring; one meta-analysis suggests that digoxin use in patients with heart failure is associated with a higher risk of all-cause mortality.[121]
Overt digitalis toxicity is commonly associated with serum digoxin levels >2 nanograms/mL. However, toxicity may occur with lower levels, especially if hypokalemia, hypomagnesemia, or hypothyroidism coexists.\[170\] [171]

Low doses (0.125 mg/day or every other day) should be used initially if the patient is over 70 years old, has impaired renal function, or has a low lean body mass.\[172\]

Higher doses (e.g., 0.375 to 0.5 mg/day) are rarely used or needed.

There is no reason to use loading doses of digoxin to initiate therapy.

**adjunct ivabradine**

Treatment recommended for SOME patients in selected patient group

**Primary options**

- **ivabradine**: 5 mg orally twice daily initially, may increase to 7.5 mg twice daily after 2 weeks if necessary; adjust dose according to heart rate

Ivabradine is approved for use in patients with heart failure and symptoms in spite of drug therapy. The Food and Drug Administration has approved it to reduce the risk of hospitalization for worsening heart failure in patients with stable, symptomatic chronic heart failure, with left ventricular ejection fraction ≤35%, who are in sinus rhythm with a resting heart rate ≥70 beats per minute and are either on a maximum dose of beta-blockers or have a contraindication to beta-blockers.

Its use should be initiated by a specialist cardiologist and only after a stabilization period of 4 weeks on optimized standard therapy.\[173\]

In a randomized, double-blind, placebo-controlled trial, addition of ivabradine to standard background therapy in patients with stable coronary artery disease without clinical heart failure (no evidence of left ventricular systolic dysfunction in the overall study population, mean ejection fraction was 56.4%) did not improve the outcome. In the subgroup analysis of this study, ivabradine was associated with an increase in the incidence of the primary end point (death from cardiovascular causes or nonfatal myocardial infarction) among patients who had angina of Canadian Cardiovascular Society class II or higher but not among patients...
**Acute**

- without angina or those who had angina of class I. Ivabradine was associated with an increased incidence of bradycardia, QT prolongation, and atrial fibrillation.\[123\]

**adjunct vasopressin antagonist**

Treatment recommended for SOME patients in selected patient group

**Primary options**

- **tolvaptan:** 15 mg orally once daily initially, increase gradually according to response, maximum 60 mg/day for up to 30 days

- Considered for patients with symptomatic or severe hyponatremia (<130 mmol/L) and persistent congestion despite standard therapy, to correct hyponatremia and related symptoms.\[2\] \[97\]

**intolerance to ACE inhibitors**

**1st**

**beta-blocker + angiotensin-II receptor antagonist**

**Primary options**

- **carvedilol:** 3.125 mg orally (immediate-release) twice daily initially, increase according to response, maximum 50 mg/day (body weight ≤85 kg) or 100 mg/day (body weight >85 kg)

  --AND--

  - **candesartan cilexetil:** 4-32 mg orally once daily
  - **or**
  - **losartan:** 25-100 mg orally once daily
  - **or**
  - **valsartan:** 40-160 mg orally twice daily

**Secondary options**

- **metoprolol succinate:** 12.5 to 200 mg orally (extended-release) once daily
  - **or**
  - **bisoprolol:** 1.25 mg orally once daily initially, increase according to response, maximum 10 mg/day
  - **or**
  - **nebivolol:** 1.25 mg orally once daily initially, increase according to response, maximum 10 mg/day

  --AND--

  - **candesartan cilexetil:** 4-32 mg orally once daily
  - **or**
  - **losartan:** 25-100 mg orally once daily
Acute

- valsartan: 40-160 mg orally twice daily

- All patients with chronic heart failure receive a beta-blocker, unless there is a contraindication based on bradycardia, reactive airway disease, and unstable or low-output heart failure. [2] [98]

- Carvedilol seems superior to metoprolol, [158] although there is no evidence of superiority to other beta-blockers. In the SENIORS study, nebivolol, a cardioselective beta-blocker with nitric oxide-mediated vasodilating properties, was found to be an effective and well-tolerated treatment for heart failure in patients ages 70 years or more. [159] Data suggest that initiation with moderate doses of nebivolol is not associated with the adverse hemodynamic effects usually observed with other beta-blockers in patients with heart failure; therefore, a long up-titration period may not be necessary with nebivolol. [160]

- Angiotensin-II receptor antagonists should be added instead of ACE inhibitors in all patients who are intolerant of ACE inhibitors because of cough or angioedema. [2] Valsartan and candesartan have demonstrated benefit by reducing hospitalizations and mortality. [104]

- Angiotensin-II receptor antagonists are as likely to produce hypotension, worsening renal function, and hyperkalemia as ACE inhibitors. Although angioedema is much less frequent, there are cases of patients who developed angioedema to both ACE inhibitors and later to angiotensin-II receptor antagonists.

plus lifestyle changes

Treatment recommended for ALL patients in selected patient group

- Dietary sodium intake is an easily modifiable factor that complements pharmacologic therapy for heart failure. Thus the patient and family are advised to follow a daily dietary sodium intake between 2 and 3 g. Further restriction to 1 to 2 g/day may be necessary for patients with advanced symptoms refractory to therapy.

- Fluid restriction is mostly used as an in-hospital complementary measure in cases of acute exacerbations. In addition, fluid restriction may be warranted in cases of severe hyponatremia. However, it would be of importance to advise the patient to keep a daily intake/output balance at home. Patients are advised to monitor their weight daily and to...
Acute

<table>
<thead>
<tr>
<th>Adjunct</th>
<th>Diuretic</th>
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<tr>
<td>Treatment recommended for SOME patients in selected patient group</td>
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</table>

**Primary options**

- **furosemide**: 20-80 mg/dose orally initially, increase by 20-40 mg/dose increments every 6-8 hours according to response, maximum 600 mg/day

**OR**

- **bumetanide**: 0.5 to 1 mg orally once or twice daily initially, increase according to response, maximum 10 mg/day

**OR**

- **torsemide**: 10-20 mg orally once daily initially, increase according to response, maximum 200 mg/day

**OR**

- **chlorothiazide**: 250-500 mg orally once or twice daily, maximum 1000 mg/day

**OR**

- **hydrochlorothiazide**: 25 mg orally once or twice daily, increase according to response, maximum 200 mg/day

**OR**

- **indapamide**: 2.5 to 5 mg orally once daily

**OR**

- **metolazone**: 2.5 to 20 mg orally once daily

Immediately contact their healthcare provider if a specified change in weight occurs.

- Heart failure patients need continuous and close monitoring of their health. A variety of programs have been shown to decrease morbidity and rehospitalization in this context, including home nursing, telephone advice/triage, telemedicine services, and specialized heart failure-clinic-based care.[157]

- Exercise training has also been shown to be beneficial.[99]
Chronic congestive heart failure

Management

Acute

Secondary options

» amiloride: 5-20 mg orally once daily

OR

» triamterene: 50-100 mg orally twice daily initially, increase according to response, maximum 300 mg/day

» Diuretics should be considered for patients who have evidence of, or a prior history of, fluid retention.[2] They should generally be combined with an ACE inhibitor and a beta-blocker. All patients with symptoms and signs of congestion should receive diuretics, irrespective of the left ventricular ejection fraction (LVEF).

» Loop diuretics used for the treatment of heart failure and congestion include furosemide, bumetanide, and torsemide. The most commonly used agent appears to be furosemide, but some patients may respond more favorably to other loop diuretics. In resistant cases, loop diuretics should be combined with a thiazide diuretic (e.g., chlorothiazide, hydrochlorothiazide) or a thiazide-like diuretic (e.g., metolazone, indapamide). Careful monitoring of renal function and electrolytes is essential in these patients.

» The minimum dose of diuretic should be used to relieve congestion, keep the patient asymptomatic, and maintain a dry weight. In patients with stable congestive heart failure, loop diuretics are the preferred agent. In patients with hypertension and only mild fluid retention, a thiazide diuretic may be considered.

» Diuretics produce symptomatic benefits more rapidly than any other drug for heart failure. They can relieve pulmonary and peripheral edema within hours or days. Few patients with heart failure and fluid retention can maintain sodium balance without the use of diuretic drugs.[161]

» Diuretics alone are unable to maintain the clinical stability of patients with heart failure for long periods of time.[161] but the risk of clinical decompensation can be reduced when they are combined with an ACE inhibitor and a beta-blocker.[162] Diuretics should be used only in combination with an ACE inhibitor (or an angiotensin-II receptor antagonist), a beta-blocker, and an aldosterone antagonist in patients with reduced LVEF.
Acute

» In intermediate-term studies, diuretics have been shown to improve cardiac function, symptoms, and exercise tolerance in patients with heart failure.[161][163]

» There have been no long-term studies of diuretic therapy in heart failure; therefore, their effects on morbidity and mortality are not known.

» Amiloride and triamterene (potassium-sparing diuretics) should be used with caution with aldosterone antagonists, because of the increased risk of developing hyperkalemia. Close monitoring of serum potassium levels is suggested in this situation.

adjunct  
aldosterone antagonist

Treatment recommended for SOME patients in selected patient group

Primary options

» spironolactone: 25-100 mg orally once daily

OR

» eplerenone: 25-50 mg orally once daily

Aldosterone antagonists, also known as mineralocorticoid receptor antagonists (e.g., spironolactone and eplerenone), decrease the morbidity and mortality associated with symptomatic chronic heart failure.

Aldosterone antagonists are recommended in patients with New York Heart Association class II to IV heart failure who have left ventricular ejection fraction (LVEF) of 35% or less, unless contraindicated.[2] They are also recommended to reduce mortality and morbidity following acute myocardial infarction in patients with LVEF of 40% or less who develop symptoms of heart failure or have a history of diabetes mellitus, unless contraindicated.[2]

Aldosterone antagonists should be initiated after titration of standard medical therapy. Spironolactone and eplerenone can both cause hyperkalemia, and precautions should be taken to minimize the risk.

These agents should be used with caution in patients with renal dysfunction and hyperkalemia. They should not be initiated in patients with a serum creatinine greater than 2.5 mg/dL or a serum potassium greater than 5.0 mEq/dL and should be used with caution in patients with serum creatinine less than 2.5
Chronic congestive heart failure

Management

Acute

mg/dL plus a serum potassium greater than 5.0 mEq/dL. Patients should discontinue potassium repletion.

» Adherence to intensive monitoring of renal function and potassium levels has been shown to prevent hyperkalemia, which is as likely to occur with eplerenone therapy as it is with spironolactone therapy.

» Amiloride and triamterene (potassium-sparing diuretics) should be used with caution with aldosterone antagonists, because of the increased risk of developing hyperkalemia. Close monitoring of serum potassium levels is suggested in this situation.

adjunct hydralazine + isosorbide dinitrate

Treatment recommended for SOME patients in selected patient group

Primary options

» isosorbide dinitrate: 20-40 mg orally (immediate-release) three times daily

-and-

» hydralazine: 10-100 mg orally three times daily

OR

» isosorbide dinitrate/hydralazine: 20 mg (isosorbide dinitrate)/37.5 mg (hydralazine) orally three times daily, maximum 40 mg (isosorbide dinitrate)/75 mg (hydralazine) three times daily

» The combined use of hydralazine and isosorbide dinitrate may be considered as a therapeutic option in patients who are intolerant of ACE inhibitors and angiotensin-II receptor antagonists. A combination of hydralazine and isosorbide dinitrate can be useful to reduce morbidity or mortality in patients with current or prior symptomatic heart failure with reduced ejection fraction (HFrEF) who cannot be given an ACE inhibitor or angiotensin-II receptor antagonist because of drug intolerance, hypotension, or renal insufficiency, unless contraindicated. The American College of Cardiology Foundation/American Heart Association guidelines recommend the combination of hydralazine and isosorbide dinitrate to "reduce morbidity and mortality in patients self-described as African Americans with NYHA class III to IV HFrEF receiving optimal therapy with ACE inhibitors and beta blockers, unless contraindicated."
Chronic congestive heart failure
Management

**Acute**

» Nitrate therapy may decrease symptoms of dyspnea at night and during exercise and may improve exercise tolerance in patients who have persistent limitations despite optimization of other therapies.[164] [165]

» Development of nitrate tolerance seems to be minimized by prescription of a nitrate-free interval of at least 10 hours.[2] Carvedilol use has been shown to prevent nitrate tolerance in patients with CHF.[166] [167]

» Hydralazine may interfere with the biochemical and molecular mechanisms responsible for the development of nitrate tolerance.[168] [169]

» A combination pill containing 37.5 mg hydralazine and 20 mg isosorbide dinitrate is available, approved specifically for self-identified African-Americans with CHF.

**adjunct digoxin**

Treatment recommended for SOME patients in selected patient group

**Primary options**

» **digoxin**: 0.125 to 0.5 mg orally once daily

» Digoxin can be beneficial in patients with reduced left ventricular ejection fraction (LVEF), especially those with atrial fibrillation.

» When added to ACE inhibitors, beta-blockers, and diuretics, digoxin can reduce symptoms, prevent hospitalization, control rhythm, and enhance exercise tolerance.

» Digoxin reduces the composite end point of mortality or hospitalizations in ambulatory patients with chronic heart failure with New York Heart Association class III or IV symptoms, LVEF <25%, or cardiothoracic ratio of >55% and should be considered in these patients.[120]

» Digoxin reduces the composite end point of mortality or hospitalizations, but does not reduce all-cause mortality.[120] Digoxin should be used cautiously with plasma level monitoring. One meta-analysis suggests that digoxin use in patients with heart failure is associated with a higher risk of all-cause mortality.[121]

» Overt digitalis toxicity is commonly associated with serum digoxin levels greater than 2 nanograms/mL. However, toxicity may occur with lower levels, especially if hypokalemia, hypomagnesemia, or hypothyroidism coexists.[170] [171]
Chronic congestive heart failure

Management

**Acute**

» Low doses (0.125 mg/day or every other day) should be used initially if the patient is over 70 years old, has impaired renal function, or has a low lean body mass.[172]

» Higher doses (e.g., 0.375 to 0.5 mg/day) are rarely used or needed.

» There is no reason to use loading doses of digoxin to initiate therapy.

**adjunct ivabradine**

Treatment recommended for SOME patients in selected patient group

**Primary options**

» **ivabradine:** 5 mg orally twice daily initially, may increase to 7.5 mg twice daily after 2 weeks if necessary; adjust dose according to heart rate

» Ivabradine is approved for use in patients with heart failure and symptoms in spite of drug therapy. The Food and Drug Administration has approved it to reduce the risk of hospitalization for worsening heart failure in patients with stable, symptomatic chronic heart failure, with left ventricular ejection fraction ≤35%, who are in sinus rhythm with a resting heart rate ≥70 beats per minute and are either on a maximum dose of beta-blockers or have a contraindication to beta-blockers.

» Its use should be initiated by a specialist cardiologist and only after a stabilization period of 4 weeks on optimized standard therapy.[173]

» In a randomized, double-blind, placebo-controlled trial, addition of ivabradine to standard background therapy in patients with stable coronary artery disease without clinical heart failure (no evidence of left ventricular systolic dysfunction in the overall study population, mean ejection fraction was 56.4%) did not improve the outcome. In the subgroup analysis of this study, ivabradine was associated with an increase in the incidence of the primary end point (death from cardiovascular causes or nonfatal myocardial infarction) among patients who had angina of Canadian Cardiovascular Society class II or higher but not among patients without angina or those who had angina of class I. Ivabradine was associated with an increased incidence of bradycardia, QT prolongation, and atrial fibrillation.[123]

**adjunct vasopressin antagonist**
### Chronic Congestive Heart Failure

#### Management

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<th>Treatment recommended for SOME patients in selected patient group</th>
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<tr>
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<td><strong>Primary options</strong></td>
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<tr>
<td></td>
<td>» tolvaptan: 15 mg orally once daily initially, increase gradually according to response, maximum 60 mg/day for up to 30 days</td>
</tr>
<tr>
<td></td>
<td>» Considered for patients with symptomatic or severe hyponatremia (&lt;130 mmol/L) and persistent congestion despite standard therapy, to correct hyponatremia and related symptoms.[2] [97]</td>
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<tr>
<td>2nd</td>
<td><strong>Hydralazine + isosorbide dinitrate</strong></td>
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<td><strong>Primary options</strong></td>
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</table>
|       | » isosorbide dinitrate: 20-40 mg orally (immediate-release) three times daily \-and- \  
|       | » hydralazine: 10-100 mg orally three times daily             |
|       | OR                                                            |
|       | » isosorbide dinitrate/hydralazine: 20 mg (isosorbide dinitrate)/37.5 mg (hydralazine) orally three times daily, maximum 40 mg (isosorbide dinitrate)/75 mg (hydralazine) three times daily |
|       | » The combined use of hydralazine and isosorbide dinitrate may be considered as a therapeutic option in patients who are intolerant of ACE inhibitors and angiotensin-II receptor antagonists.\[174\] \[175\] A combination of hydralazine and isosorbide dinitrate can be useful to reduce morbidity or mortality in patients with current or prior symptomatic heart failure with reduced ejection fraction (HFrEF) who cannot be given an ACE inhibitor or angiotensin-II receptor antagonist because of drug intolerance, hypotension, or renal insufficiency, unless contraindicated.\[2\] The American College of Cardiology Foundation/American Heart Association guidelines recommend the combination of hydralazine and isosorbide dinitrate to “reduce morbidity and mortality in patients self-described as African Americans with NYHA class III to IV HFrEF receiving optimal therapy with ACE inhibitors and beta blockers, unless contraindicated.”\[2\] |
|       | » Nitrate therapy may decrease symptoms of dyspnea at night and during exercise and may improve exercise tolerance in patients who have |
### Acute

Chronic congestive heart failure is often difficult to manage because of persistent limitations despite optimization of other therapies. Development of nitrate tolerance seems to be minimized by prescription of a nitrate-free interval of at least 10 hours. Carvedilol use has been shown to prevent nitrate tolerance in patients with CHF. Hydralazine may interfere with the biochemical and molecular mechanisms responsible for the development of nitrate tolerance.

**plus beta-blocker**

Treatment recommended for ALL patients in selected patient group

**Primary options**

- **carvedilol**: 3.125 mg orally (immediate-release) twice daily initially, increase according to response, maximum 50 mg/day (body weight ≤85 kg) or 100 mg/day (body weight >85 kg)

**Secondary options**

- **metoprolol succinate**: 12.5 to 200 mg orally (extended-release) once daily

  OR

- **bisoprolol**: 1.25 mg orally once daily initially, increase according to response, maximum 10 mg/day

  OR

- **nebivolol**: 1.25 mg orally once daily initially, increase according to response, maximum 10 mg/day

All patients with chronic heart failure receive a beta-blocker, unless there is a contraindication based on bradycardia, reactive airway disease, and unstable or low-output heart failure. Carvedilol seems superior to metoprolol, although there is no evidence of superiority to other beta-blockers. In the SENIORS study, nebivolol, a cardioselective beta-blocker with nitric oxide-mediated vasodilating properties, was found to be an effective and well-tolerated treatment for heart failure in patients ages 70 years or more. Data suggest that initiation with moderate doses of nebivolol is not associated with the adverse hemodynamic effects usually observed with other beta-blockers.
### Acute

<table>
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<th>Management</th>
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| in patients with heart failure; therefore, a long up-titration period may not be necessary with nebivolol. [160]  

**plus** lifestyle changes

Treatment recommended for ALL patients in selected patient group

» Dietary sodium intake is an easily modifiable factor that complements pharmacologic therapy for heart failure. Thus the patient and family are advised to follow a daily dietary sodium intake between 2 and 3 g. Further restriction to 1 to 2 g/day may be necessary for patients with advanced symptoms refractory to therapy.

» Fluid restriction is mostly used as an in-hospital complementary measure in cases of acute exacerbations. In addition, fluid restriction may be warranted in cases of severe hyponatremia. However, it would be of importance to advise the patient to keep a daily intake/output balance at home. Patients are advised to monitor their weight daily and to immediately contact their healthcare provider if a specified change in weight occurs.

» Heart failure patients need continuous and close monitoring of their health. A variety of programs have been shown to decrease morbidity and rehospitalization in this context, including home nursing, telephone advice/triage, telemedicine services, and specialized heart failure-clinic-based care. [157]

» Exercise training has also been shown to be beneficial. [99]

**adjunct** diuretic

Treatment recommended for SOME patients in selected patient group

**Primary options**

» **furosemide**: 20-80 mg/dose orally initially, increase by 20-40 mg/dose increments every 6-8 hours according to response, maximum 600 mg/day  

OR

» **bumetanide**: 0.5 to 1 mg orally once or twice daily initially, increase according to response, maximum 10 mg/day  

OR
### Acute

- **torsemide**: 10-20 mg orally once daily initially, increase according to response, maximum 200 mg/day
  
  OR

- **chlorothiazide**: 250-500 mg orally once or twice daily, maximum 1000 mg/day
  
  OR

- **hydrochlorothiazide**: 25 mg orally once or twice daily, increase according to response, maximum 200 mg/day
  
  OR

- **indapamide**: 2.5 to 5 mg orally once daily
  
  OR

- **metolazone**: 2.5 to 20 mg orally once daily

### Secondary options

- **amiloride**: 5-20 mg orally once daily

- **triamterene**: 50-100 mg orally twice daily initially, increase according to response, maximum 300 mg/day

Diuretics should be considered for patients who have evidence of, or a prior history of, fluid retention.[2] They should generally be combined with an ACE inhibitor and a beta-blocker. All patients with symptoms and signs of congestion should receive diuretics, irrespective of the left ventricular ejection fraction (LVEF).

Loop diuretics used for the treatment of heart failure and congestion include furosemide, bumetanide, and torsemide. The most commonly used agent appears to be furosemide, but some patients may respond more favorably to other loop diuretics. In resistant cases, loop diuretics should be combined with a thiazide diuretic (e.g., chlorothiazide, hydrochlorothiazide) or a thiazide-like diuretic (e.g., metolazone, indapamide). Careful monitoring of renal function and electrolytes is essential in these patients.

The minimum dose of diuretic should be used to relieve congestion, keep the patient asymptomatic, and maintain a dry weight. In
patients with stable congestive heart failure, loop diuretics are the preferred agent. In patients with hypertension and only mild fluid retention, a thiazide diuretic may be considered.

Diuretics produce symptomatic benefits more rapidly than any other drug for heart failure. They can relieve pulmonary and peripheral edema within hours or days. Few patients with heart failure and fluid retention can maintain sodium balance without the use of diuretic drugs.[161]

Diuretics alone are unable to maintain the clinical stability of patients with heart failure for long periods of time,[161] but the risk of clinical decompensation can be reduced when they are combined with an ACE inhibitor and a beta-blocker.[162] Diuretics should be used only in combination with an ACE inhibitor (or an angiotensin-II receptor antagonist), a beta-blocker, and an aldosterone antagonist in patients with reduced LVEF.

In intermediate-term studies, diuretics have been shown to improve cardiac function, symptoms, and exercise tolerance in patients with heart failure.[161] [163]

There have been no long-term studies of diuretic therapy in heart failure; therefore, their effects on morbidity and mortality are not known.

Amiloride and triamterene (potassium-sparing diuretics) should be used with caution with aldosterone antagonists, because of the increased risk of developing hyperkalemia. Close monitoring of serum potassium levels is suggested in this situation.

**adjunct aldosterone antagonist**

Treatment recommended for SOME patients in selected patient group

**Primary options**

» **spironolactone**: 25-100 mg orally once daily

**OR**

» **eplerenone**: 25-50 mg orally once daily

Aldosterone antagonists, also known as mineralocorticoid receptor antagonists (e.g., spironolactone and eplerenone), decrease the morbidity and mortality associated with symptomatic chronic heart failure.
### Acute

» Aldosterone antagonists are recommended in patients with New York Heart Association class II to IV heart failure who have left ventricular ejection fraction (LVEF) of 35% or less, unless contraindicated.[2] They are also recommended to reduce mortality and morbidity following acute myocardial infarction in patients with LVEF of 40% or less who develop symptoms of heart failure or have a history of diabetes mellitus, unless contraindicated.[2]

» Aldosterone antagonists should be initiated after titration of standard medical therapy. Spironolactone and eplerenone can both cause hyperkalemia, and precautions should be taken to minimize the risk.

» These agents should be used with caution in patients with renal dysfunction and hyperkalemia. They should not be initiated in patients with a serum creatinine greater than 2.5 mg/dL or a serum potassium greater than 5.0 mEq/dL and should be used with caution in patients with serum creatinine less than 2.5 mg/dL plus a serum potassium greater than 5.0 mEq/dL. Patients should discontinue potassium repletion.

» Adherence to intensive monitoring of renal function and potassium levels has been shown to prevent hyperkalemia, which is as likely to occur with eplerenone therapy as it is with spironolactone therapy.

» Amiloride and triamterene (potassium-sparing diuretics) should be used with caution with aldosterone antagonists, because of the increased risk of developing hyperkalemia. Close monitoring of serum potassium levels is suggested in this situation.

**adjunct** *digoxin*

Treatment recommended for SOME patients in selected patient group

**Primary options**

» *digoxin*: 0.125 to 0.5 mg orally once daily

» Digoxin can be beneficial in patients with reduced left ventricular ejection fraction (LVEF), especially those with atrial fibrillation.

» When added to ACE inhibitors, beta-blockers, and diuretics, digoxin can reduce symptoms, prevent hospitalization, control rhythm, and enhance exercise tolerance.
Acute

» Digoxin reduces the composite end point of mortality or hospitalizations in ambulatory patients with chronic heart failure with New York Heart Association class III or IV symptoms, LVEF <25%, or cardiothoracic ratio of >55% and should be considered in these patients.[120]

» Digoxin reduces the composite end point of mortality or hospitalizations, but does not reduce all-cause mortality.[120] One meta-analysis suggests that digoxin use in patients with heart failure is associated with a higher risk of all-cause mortality.[121]

» Overt digitalis toxicity is commonly associated with serum digoxin levels >2 nanograms/mL. However, toxicity may occur with lower levels, especially if hypokalemia, hypomagnesemia, or hypothyroidism coexists.[170] [171]

» Low doses (0.125 mg/day or every other day) should be used initially if the patient is over 70 years old, has impaired renal function, or has a low lean body mass.[172]

» Higher doses (e.g., 0.375 to 0.5 mg/day) are rarely used or needed.

» There is no reason to use loading doses of digoxin to initiate therapy.

adjunct ivabradine

Treatment recommended for SOME patients in selected patient group

Primary options

» **ivabradine**: 5 mg orally twice daily initially, may increase to 7.5 mg twice daily after 2 weeks if necessary; adjust dose according to heart rate

» Ivabradine is approved for use in patients with heart failure and symptoms in spite of drug therapy. The Food and Drug Administration has approved it to reduce the risk of hospitalization for worsening heart failure in patients with stable, symptomatic chronic heart failure, with left ventricular ejection fraction ≤35%, who are in sinus rhythm with a resting heart rate ≥70 beats per minute and are either on a maximum dose of beta-blockers or have a contraindication to beta-blockers.

» Its use should be initiated by a specialist cardiologist and only after a stabilization period of 4 weeks on optimized standard therapy.[173]
Acute

» In a randomized, double-blind, placebo-controlled trial, addition of ivabradine to standard background therapy in patients with stable coronary artery disease without clinical heart failure (no evidence of left ventricular systolic dysfunction in the overall study population, mean ejection fraction was 56.4%) did not improve the outcome. In the subgroup analysis of this study, ivabradine was associated with an increase in the incidence of the primary end point (death from cardiovascular causes or nonfatal myocardial infarction) among patients who had angina of Canadian Cardiovascular Society class II or higher but not among patients without angina or those who had angina of class I. Ivabradine was associated with an increased incidence of bradycardia, QT prolongation, and atrial fibrillation.[123]

adjunct vasopressin antagonist

Treatment recommended for SOME patients in selected patient group

Primary options

» tolvaptan: 15 mg orally once daily initially, increase gradually according to response, maximum 60 mg/day for up to 30 days

» Considered for patients with symptomatic or severe hyponatremia (<130 mmol/L) and persistent congestion despite standard therapy, to correct hyponatremia and related symptoms.[2] [97]
MANAGEMENT

Ongoing

refractory to optimal medical treatment

- **LVEF <35%: no left bundle-branch block**

1st implantable cardioverter-defibrillator (ICD)

- An ICD is recommended in the following cases:[2]
  - 1) For primary prevention of sudden cardiac death in selected patients with both nonischemic and ischemic heart failure, at least 40 days post myocardial infarction, LVEF <35%, New York Heart Association (NYHA) class II or III symptoms on guideline-directed medical therapy, and expected to live for >1 year, or LVEF <30%, NYHA class I, on guideline-directed medical therapy, and expected to live for >1 year.
  - 2) As secondary prevention to prolong survival in patients with current or prior symptoms of heart failure and reduced left ventricular ejection fraction (LVEF) who have a history of cardiac arrest, ventricular fibrillation, or hemodynamically destabilizing ventricular tachycardia.

- Patients with refractory end-stage disease who already carry an ICD may want to receive information about the option to inactivate defibrillation.

2nd mechanical circulatory support

- Mechanical circulatory support, which includes ventricular assist devices, helps to maintain sufficient end organ perfusion by unloading the heart and is considered in carefully selected patients who have end-stage heart failure, despite optimal medical and device therapy, and in whom definite management (e.g., cardiac transplantation) or cardiac recovery is anticipated.[1] [2]

- Currently in the US, the accepted indications for implantation of a durable left ventricular assist device (LVAD) are bridge to transplantation and destination therapy (permanent pump implantation in patients not eligible for cardiac transplantation).[155] In clinical practice, another indication for LVAD is to provide a bridge to decisions about future care.

- The European Society of Cardiology has outlined the various indications for mechanical circulatory support:[1]

  - 1) Bridge to decision/bridge to bridge: use of short-term support (e.g., extracorporeal life support)
### Chronic Congestive Heart Failure Management

**Ongoing**

Support (ECLS) or extracorporeal membrane oxygenation (ECMO) in patients with cardiogenic shock until hemodynamics and end-organ perfusion are stabilized, contraindications for long-term support are excluded, and therapeutic options including long-term VAD therapy or heart transplant can be evaluated.

- **Bridge to candidacy:** use of support (usually LVAD) to make ineligible patient eligible for heart transplant.
- **Bridge to transplantation:** use of LVAD or biventricular assist device to keep high-risk transplant candidate alive until donor organ becomes available.
- **Bridge to recovery:** use of support (usually LVAD) to keep the patient alive until cardiac function recovers sufficiently to remove it.
- **Destination therapy:** long-term use of LVAD as alternative to heart transplant.

Some of the absolute contraindications for providing durable mechanical support include irreversible hepatic, renal and neurological disease, medical nonadherence, and severe psychosocial limitations.\[156\]

<table>
<thead>
<tr>
<th>Cardiac Transplantation</th>
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<tr>
<td>Cardiac transplantation is an option for refractory end-stage disease. Before a patient is considered to have refractory end-stage disease, the accuracy of the diagnosis should be confirmed, any contributing conditions should be identified, and all conventional medical strategies should have been optimally employed.</td>
</tr>
</tbody>
</table>

**Cardiac Resynchronization Therapy with Biventricular Pacemaker (CRT-P)/Cardiac Resynchronization Therapy-Defibrillator (CRT-D)**

- In patients with left ventricular (LV) systolic dysfunction and dyssynchronous ventricular activation, cardiac pacing provides simultaneous and coordinated electrical activation of both the left and right ventricle. This cardiac resynchronization therapy (CRT) is provided either by a CRT-pacemaker (CRT-P) or by a combined CRT-implantable cardioverter-defibrillator (CRT-D).
- The CRT-P prevents deterioration in LV function by correcting the LV dyssynchrony and the CRT-D prevents sudden cardiac death from ventricular arrhythmias.
Management

Ongoing

> As both CRT-P and CRT-D are indicated in patients with heart failure and low ejection fraction, there is considerable overlap in the indications for the use of these devices.

> Long-term data from the REVERSE study suggest that improvements in left ventricular function and remodeling can be sustained for over 5 years.[152] [153]

> CRT decreases hospitalization and, when combined with an ICD, significantly reduces mortality.[131] [132] [133] [134] [135] [136]

> In patients who have conduction delay and left ventricular dysfunction, biventricular pacemakers have been shown to improve exercise tolerance and quality of life while decreasing morbidity and mortality.[131] [132] [133] [134] [136] [137] [138] [139]

> CRT is indicated in patients with LVEF ≤35%, sinus rhythm, LBBB with QRS ≥150 ms, and NYHA class II, III or ambulatory NYHA IV on guideline-directed medical therapy.[2]

> Recommendations for the use of CRT devices in heart failure are detailed in the 2013 American College of Cardiology/American Heart Association guidelines.[2]

2nd left ventricular assist device (LVAD)

> Mechanical circulatory support, which includes ventricular assist devices, helps to maintain sufficient end organ perfusion by unloading the heart and is considered in carefully selected patients who have end-stage heart failure, despite optimal medical and device therapy, and in whom definite management (e.g., cardiac transplantation) or cardiac recovery is anticipated.[1] [2]

> Currently in the US, the accepted indications for implantation of a durable left ventricular assist device (LVAD) are bridge to transplantation and destination therapy (permanent pump implantation in patients not eligible for cardiac transplantation).[155] In clinical practice, another indication for LVAD is to provide a bridge to decisions about future care.

> The European Society of Cardiology has outlined the various indications for mechanical circulatory support:[1]

> 1) Bridge to decision/bridge to bridge use of short-term support (e.g., extracorporeal life support [ECLS] or extracorporeal membrane
Ongoing

- Ongoing oxygenation [ECMO] in patients with cardiogenic shock until hemodynamics and end-organ perfusion are stabilized, contraindications for long-term support are excluded, and therapeutic options including long-term VAD therapy or heart transplant can be evaluated.

- 2) Bridge to candidacy: use of support (usually LVAD) to make ineligible patient eligible for heart transplant.

- 3) Bridge to transplantation: use of LVAD or biventricular assist device to keep high-risk transplant candidate alive until donor organ becomes available.

- 4) Bridge to recovery: use of support (usually LVAD) to keep the patient alive until cardiac function recovers sufficiently to remove it.

- 5) Destination therapy: long-term use of LVAD as alternative to heart transplant.

- Some of the absolute contraindications for providing durable mechanical support include irreversible hepatic, renal and neurological disease, medical nonadherence, and severe psychosocial limitations.[156]

3rd cardiac transplantation

- Cardiac transplantation is an option for refractory end-stage disease. Before a patient is considered to have refractory end-stage disease, the accuracy of the diagnosis should be confirmed, any contributing conditions should be identified, and all conventional medical strategies should have been optimally employed.
Emerging

Calcium-sensitizing agents

Levosimendan, a novel calcium sensitizer, improves myocardial contractility without causing an increase in myocardial oxygen demand. Its role in acute, decompensated heart failure is more established than in chronic heart failure, but it may reduce overall mortality and length of hospitalization.[176] In the LIDO study, levsimendan improved survival and hemodynamic performance more effectively than dobutamine, in patients with severe, low-output heart failure.[177] The superiority of levsimendan over dobutamine in improving central hemodynamics and left ventricular performance seems in part to be related to its anti-inflammatory and anti-apoptotic effects.[178]

n-3 polyunsaturated fatty acids (n3-PUFA)

The GISSI-HF trial showed that the addition of n3-PUFA produced a small improvement in mortality and hospital admissions in patients with heart failure.[179] However, a 2012 meta-analysis has shown insufficient evidence of a secondary preventive effect of omega-3 fatty acid supplements against overall cardiovascular events among patients with a history of cardiovascular disease.[180] Omega-3 PUFA supplementation is reasonable to use as adjunctive therapy in patients with New York Heart Association class II to IV symptoms and heart failure, unless contraindicated, to reduce mortality and cardiovascular hospitalizations.

Statins

Statins are not beneficial as adjunctive therapy when prescribed solely for treatment of heart failure in the absence of other indications for their use.[2] Statin therapy has been broadly implicated in prevention of adverse cardiovascular events, including new-onset heart failure. Originally designed to lower cholesterol in patients with cardiovascular disease, statins are known to have beneficial effects on inflammation, oxidative stress, and vascular performance. To date, a sufficient body of evidence does not exist to support the primary prescribing of statins for the treatment of heart failure to improve clinical outcomes.[2]

Nonspecific immunomodulation therapy

Inflammatory mediators are proposed to play a role in heart failure development and progression. In the ACCLAIM trial, nonspecific immunomodulation therapy reduced the risk of hospitalization or death, suggesting that this therapy may be of benefit in heart failure patients.[181]

Recombinant human growth hormone

Preliminary studies suggest that recombinant human growth hormone may have beneficial effects in patients with left ventricular dysfunction, although it may produce an increased risk of arrhythmias.[182] [183] Further studies are required to determine the safety and efficacy of this treatment.

Trimetazidine

In a meta-analysis, trimetazidine, which shifts energy production from fatty acid oxidation to glucose oxidation, was shown to have no effect on mortality, but it improves left ventricular ejection fraction (LVEF) and functional class.[184]

Sodium–glucose cotransporter 2 (SGLT2) inhibitors

SGLT2 inhibitors have been investigated for patients with heart failure with and without diabetes. In a phase 3 randomized controlled trial, dapagliflozin was found to reduce the risk of worsening heart failure or death from cardiovascular causes compared with placebo in patients with heart failure and reduced ejection fraction, regardless of whether the patient also had diabetes.[185] The US Food and Drug Administration (FDA) has approved dapagliflozin for adults with heart failure with reduced ejection fraction to reduce the risk of cardiovascular death and hospitalization. In Europe, dapagliflozin and empagliflozin are approved for the treatment of adults with symptomatic chronic heart failure with reduced ejection fraction. Empagliflozin
Chronic congestive heart failure has been granted fast track designation by the FDA for the reduction of risk for cardiovascular death and hospitalization for heart failure in people with chronic heart failure.

**Vericiguat**

The Food and Drug Administration has approved vericiguat, an orally administered soluble guanylate cyclase stimulator, for treatment of chronic heart failure in patients who are hospitalised for heart failure or need outpatient intravenous diuretics. In Europe, vericiguat is approved for the treatment of symptomatic chronic heart failure in adult patients with reduced ejection fraction who are stabilised after a recent decompensation event requiring intravenous therapy.

**Novel implantable devices**

Cardiac contractility modulation (CCM) delivers non-excitatory electrical stimulation to the ventricle during the absolute refractory period to enhance contractile performance without activating extra systolic contractions. CCM works via key calcium regulatory pathways that increase cardiac contractility.[186] The Optimizer Smart system is an implantable pulse generator that delivers CCM therapy and has been approved by the FDA for the treatment of patients with chronic, moderate-to-severe heart failure who are not suited for treatment with other heart failure devices such as cardiac resynchronization therapy to restore a normal timing pattern of the heartbeat. The Barostim Neo System is an implantable device that delivers baroreflex activation therapy (BAT); it has been approved by the FDA for the improvement of symptoms in patients with advanced heart failure who are not suited for treatment with other heart failure devices, such as cardiac resynchronization therapy. In patients with New York Heart Association functional class III heart failure and ejection fraction <35% on chronic stable guideline-directed medical therapy, use of BAT has been shown to improve functional status, quality of life, exercise capacity, and N-terminal pro–brain natriuretic peptide levels.[187]

**Stem-cell therapy**

Some trials of stem-cell therapy in both ischemic and nonischemic heart failure have shown some potential benefit.[188] A systematic review on the use of stem-cell therapy for chronic ischemic heart disease and congestive heart failure suggests that at both short- and long-term follow-up (≥12 months) the use of autologous bone marrow stem-cell treatment reduces all-cause mortality, although the quality of evidence is low.[189]

**Gene therapy**

An attractive strategy for treatment of heart failure is by gene therapy.[190] In a small randomized study of patients (n=56) with heart failure and LVEF <40%, intracoronary delivery of adenovirus 5 encoding adenylyl cyclase 6 (Ad5.hAC6) increased the LVEF at 4 weeks, with no increase in exercise duration.[191] In a larger double-blind placebo-controlled study (n=250), intracoronary infusion of 1 × 1013 DNase-resistant particle of adeno-associated virus 1 (AAV1)/sarcoplasmic endoplasmic reticulum Ca2 - ATPase (SERCA2a) did not improve the clinical course of patients with heart failure and reduced ejection fraction (ejection fraction ≤35%).[192]

**Surgical strategies**

There have been numerous reports of alternate surgical approaches for the treatment of end-stage heart failure.[193] Mitral valve repair or replacement has been shown to improve clinical status in patients who have a clinically important degree of mitral regurgitation that is secondary to left ventricular dilation.[194] However, no controlled studies have evaluated the effects of this procedure on ventricular function, rehospitalizations, or survival. One single-center study designed to assess the effects of mitral valve annuloplasty on mortality in patients with mitral regurgitation and left ventricular systolic dysfunction failed to demonstrate any clear survival benefit.[195] A variant of the aneurysmsectomy procedure is now being developed for the management of patients with ischemic cardiomyopathy, but its role in the management of heart failure remains to be defined.[196] None of the current surgical reconstruction techniques offer “rescue therapy” to patients with critical hemodynamic compromise.
**Intravenous iron**

In patients with iron deficiency and systolic heart failure, treatment with intravenous ferric carboxymaltose has been associated with lower rates of recurrent cardiovascular hospitalizations and mortality.[197]

**Primary prevention**

Heart failure is the final pathway for a wide array of pathophysiologic processes. Interventions that reduce the risk of development of any cardiovascular disease will ultimately reduce the incidence of heart failure.[73] Thus, key public health targets are prevention of development of hypertension, diabetes, dyslipidemia, obesity (i.e., metabolic syndrome) and ischemic heart disease. Lifestyle modifications, such as increasing physical activity, reducing tobacco, alcohol and recreational drug use, and reducing daily salt intake, and proper medical treatment of established diseases such as hypertension, diabetes, and coronary artery disease, are expected to help reduce incident heart failure.[73] [74] [75]

**Patient discussions**

On discharge from the hospital patients should be instructed on:

- Daily home weight monitoring
- Sodium restriction (2 g to 3 g daily) and fluid restriction when necessary
- Tobacco and alcohol discontinuation
- Aggressive control of hypertension and diabetes (e.g., provide patients with blood pressure and HbA1c goal)
- Lipid management (e.g., provide leaflets and show website links for diet, exercise, and healthy lifestyle)
- Regular, symptom-limited exercise
- Routine health-care maintenance.
Monitoring

Patients benefit from frequent formal evaluation in a specialized center or monitoring in a management program.[238] Assessment should be made at each visit of the ability of a patient to perform routine and desired activities of daily living. Assessment should be also made of the fluid status and weight of the patient. Careful history of current use of alcohol, tobacco, illicit drugs, alternative therapies, and chemotherapy drugs, as well as diet and sodium intake, should be obtained at each visit. Repeat measurement of ejection fraction and assessment of the severity of structural remodeling can provide useful information in patients with heart failure who have had a change in clinical status, or who have experienced or recovered from a clinical event, or received treatment that might have had a significant effect on cardiac function. The value of serial measurements of B-type natriuretic peptide to guide therapy for patients is still not well established. Data suggest that natriuretic-guided therapy reduces hospitalization due to heart failure and that in patients younger than 75 years of age, it also provides a survival benefit.[239] However, one randomized trial found that in high-risk patients with heart failure, natriuretic-guided therapy was not more effective than optimal medical therapy alone in improving outcomes.[240] The use of telemonitoring to monitor patients remotely is an emerging strategy, but requires further evaluation.[241] [242] [Evidence A]

Wireless pulmonary hemodynamic monitoring in patients with chronic heart failure results in significant reduction in heart failure hospitalizations.[243]

Structured telephone support and noninvasive home telemonitoring can reduce the risk of mortality and heart failure-related hospitalizations.[244]

Invasive hemodynamic monitoring, however, is not routinely used in clinical practice, but may be of use in individual patients, particularly those with recurrent heart failure.

In one study of patients with New York Heart Association class III heart failure, wireless implantable hemodynamic monitoring compared with control led to a significant reduction of heart failure-related hospitalizations.[243]

Exercise training and rehabilitation

- In patients with heart failure, cardiac rehabilitation and exercise training improves exercise tolerance and quality of life with decreased morbidity and mortality.[245] Patients with stable heart failure are therefore encouraged to do regular aerobic exercise and it is recommended that they are enrolled in a multidisciplinary care management program.[246] One consensus paper provides a detailed description of exercise training in heart failure.[247]
Complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>Timeframe</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>pleural effusion</td>
<td>long term</td>
<td>high</td>
</tr>
<tr>
<td>Pleural effusions are a common complication of chronic congestive heart failure.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chronic kidney disease</td>
<td>long term</td>
<td>medium</td>
</tr>
<tr>
<td>A common reason for refractory symptoms is the cardiorenal syndrome, a spectrum of disorders involving the heart and kidneys in which acute or chronic dysfunction in one organ may induce acute or chronic dysfunction in the other organ.[220] These patients show an impaired response to diuretics and ACE inhibitors and are at increased risk of adverse effects during treatment with digoxin.[221] [222] [223] Persistent or progressive renal functional impairment has been associated with a poor prognosis.[224] [225] The symptoms of heart failure in patients with end-stage renal disease may be exacerbated by an increase in loading conditions produced both by anemia and by fistulas implanted to permit dialysis.[226] Most patients will tolerate mild-to-moderate degrees of functional renal impairment without difficulty. However, if the serum creatinine increases to more than 3 mg/dL, the renal insufficiency can severely limit the efficacy and enhance the toxicity of established treatments.[221] [227] Impaired renal function may exclude the therapeutic use of ACE inhibitors and angiotensin-II receptor antagonists. In patients with a serum creatinine greater than 5 mg/dL, hemofiltration or dialysis may be needed to control fluid retention, minimize the risk of uremia, and allow the patient to respond to and tolerate the drugs routinely used for the management of heart failure.[228] [229] [230] [231]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>anemia</td>
<td>long term</td>
<td>medium</td>
</tr>
<tr>
<td>Patients with heart failure frequently have anemia for a variety of reasons, which may worsen heart failure symptoms. Several studies have demonstrated worse outcomes in patients with heart failure and anemia, such as a 1.027 higher risk for mortality associated with a 1% lower hematocrit, after adjustment for other factors.[232] [233] It is unclear whether anemia is the cause of decreased survival or a marker of more severe disease. Several small studies have suggested benefit from use of erythropoietin and iron for treatment of mild anemia in heart failure, although at the cost of increased risk of thromboembolic events.[234] [235] [236] However, a larger study showed no clinical benefit of darbepoietin alfa treatment.[237]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>acute decompensation of chronic heart failure</td>
<td>variable</td>
<td>high</td>
</tr>
<tr>
<td>Despite optimal treatment, many precipitating factors or even new events may cause acute decompensation of a previously stable patient, thus leading to pulmonary edema (backward failure) or cardiogenic shock (forward failure). Common causes include myocardial infarction and its mechanical complications (papillary muscle rupture with new-onset acute mitral regurgitation, ventricular septal defect, and ventricular rupture), arrhythmias, pulmonary embolism, infection, anemia, tamponade, myocarditis, acute renal failure or even increased salt intake, inappropriate drug therapy, or patient noncompliance. Patients with acute decompensation require urgent hemodynamic stabilization and diagnosis of the precipitating cause. Pharmacologic therapy includes intravenous diuretics, intravenous positive inotropic agents, intravenous vasodilators, and intravenous vasopressors. Nonpharmacologic treatment modalities will be necessary: these include oxygenation, balloon counterpulsation, pacing, urgent catheterization or urgent cardiac surgery, or mechanical support with ventricular assist devices.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>acute kidney injury</td>
<td>variable</td>
<td>high</td>
</tr>
</tbody>
</table>
Chronic congestive heart failure

Follow up

Complications | Timeframe | Likelihood
--- | --- | ---
Patients have a high risk of developing acute renal insufficiency at any point of their clinical course as a result of either poor renal perfusion (low cardiac output state) or drug overuse to treat heart failure (diuretics, ACE inhibitors, aldosterone antagonists, angiotensin-II receptor antagonists). In addition, the use of carvedilol requires close monitoring of the renal function as it could contribute, with other agents, to the development of acute renal injury. Inability to maintain adequate renal perfusion on oral therapy may eventually necessitate IV inotropic infusion or urgent ultrafiltration and hemodialysis.

sudden cardiac death | variable | medium
Sudden cardiac death is common in heart failure patients and accounts for approximately 30% to 40% of the deaths among these patients. It can be the consequence of both ventricular fibrillation and electromechanical dissociation, and can occur any time in the course of the disease, even at the asymptomatic patient.
In patients who survive an episode of cardiac arrest, prophylactic insertion of an implantable cardioverter-defibrillator and initiation of appropriate antiarrhythmic therapy is indicated.

Prognosis

The evaluation of a patient would be incomplete without an initial and periodic assessment of short- and long-term prognosis. However, the likelihood of survival can be determined reliably only in populations and not in individual patients. Numerous factors have been used as prognostic indicators including demographics (age, sex, race), symptoms (New York Heart Association [NYHA] classification), comorbidities (hypertension, diabetes, cachexia, anemia, and renal and hepatic dysfunction), and objective clinical parameters (e.g., ejection fraction, left ventricular size, volume, mass and shape, exercise capacity, and serum levels of sodium, norepinephrine, renin, B-type natriuretic peptide, uric acid, angiotensin II, aldosterone, tumor necrosis factor-alfa, endothelin). Multivariate analysis of these variables has helped to identify the most significant predictors of survival, and prognostic models have been developed and validated.[209] [210] [211] [212] [213] [214] [215] [216] However, all existing models to predict the risk of death or need for urgent transplantation have features that may limit their applicability. Hemoglobin A1c was also found to be an independent progressive risk factor for cardiovascular death, hospitalization, and mortality, even in nondiabetic patients.[217]

The most comprehensive prognostic model is the Seattle Heart Failure Model. [The Seattle Heart Failure Model](http://depts.washington.edu/shfm) This model has been implemented as an interactive program that employs the Seattle Heart Failure Score to estimate mean, 1-, 2-, and 5-year survival and the benefit of adding medications and/or devices for an individual patient.[211]

Despite standard medical therapy the survival for patients with end-stage heart failure is poor.

Despite optimal medical therapy including cardiac resynchronization therapy, only 65% of patients in NYHA class 4 are alive at a mean follow-up of 17 months.[218]

The 5-year survival in patients with stage D heart failure is only 20%. [219]
## Diagnostic guidelines

### International

**2017 ACC/AHA/HFSA focused update of the 2013 ACCF/AHA guideline for the management of heart failure**

[https://professional.heart.org/professional/GuidelinesStatements/UCM_316885_Guidelines-Statements.jsp]  
**Published by:** American College of Cardiology; American Heart Association  
**Last published:** 2017

**2017 comprehensive update of the Canadian Cardiovascular Society guidelines for the management of heart failure**

**Published by:** Canadian Cardiovascular Society  
**Last published:** 2017

**2013 ACCF/AHA guideline for the management of heart failure**

[https://professional.heart.org/professional/GuidelinesStatements/UCM_316885_Guidelines-Statements.jsp]  
**Published by:** American College of Cardiology Foundation; American Heart Association  
**Last published:** 2013

**Chronic heart failure in adults: diagnosis and management**

[https://www.nice.org.uk/guidance/ng106]  
**Published by:** National Institute for Health and Care Excellence  
**Last published:** 2018

**2016 ESC guidelines for the diagnosis and treatment of acute and chronic heart failure**

[https://www.escardio.org/Guidelines/Clinical-Practice-Guidelines]  
**Published by:** European Society of Cardiology  
**Last published:** 2016
# Treatment guidelines

## International


**Published by:** Canadian Cardiovascular Society  
**Last published:** 2020

**Home-based cardiac rehabilitation** ([https://professional.heart.org/en/guidelines-and-statements](https://professional.heart.org/en/guidelines-and-statements))  [199]

**Published by:** American Association of Cardiovascular and Pulmonary Rehabilitation, American Heart Association, American College of Cardiology  
**Last published:** 2019

**Device therapy and arrhythmia management in left ventricular assist device recipients** ([https://professional.heart.org/en/guidelines-and-statements](https://professional.heart.org/en/guidelines-and-statements))  [155]

**Published by:** American Heart Association  
**Last published:** 2019


**Published by:** American Heart Association  
**Last published:** 2018

**Physical activity guidelines for Americans** ([https://health.gov/paguidelines](https://health.gov/paguidelines))  [201]

**Published by:** US Department of Health and Human Services  
**Last published:** 2018

**2017 ACC/AHA/HFSA focused update of the 2013 ACCF/AHA guideline for the management of heart failure** ([https://professional.heart.org/professional/GuidelinesStatements/UCM_316885_Guidelines-Statements.jsp](https://professional.heart.org/professional/GuidelinesStatements/UCM_316885_Guidelines-Statements.jsp))  [77]

**Published by:** American College of Cardiology; American Heart Association; Heart Failure Society of America  
**Last published:** 2017

**ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/STS 2017 appropriate use criteria for coronary revascularization in patients with stable ischemic heart disease** ([https://www.acc.org/guidelines#tab4](https://www.acc.org/guidelines#tab4))  [202]

**Published by:** American College of Cardiology; American Association for Thoracic Surgery; American Heart Association; American Society of Echocardiography; American Society of Nuclear Cardiology; Society for Cardiovascular Angiography and Interventions; Society of Cardiovascular Computed Tomography; Society of Thoracic Surgeons  
**Last published:** 2017


**Published by:** Canadian Cardiovascular Society  
**Last published:** 2017
## International

**Heart failure evidence-based nutrition practice guideline** ([https://www.andeal.org/topic.cfm?menu=5289](https://www.andeal.org/topic.cfm?menu=5289)) [203]

**Published by:** Academy of Nutrition and Dietetics  
**Last published:** 2017

**ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/STS 2016 appropriate use criteria for coronary revascularization in patients with acute coronary syndromes** ([https://www.acc.org/guidelines#tab4](https://www.acc.org/guidelines#tab4)) [204]

**Published by:** American College of Cardiology; American Association for Thoracic Surgery; American Heart Association; American Society of Echocardiography; American Society of Nuclear Cardiology; Society for Cardiovascular Angiography and Interventions; Society of Cardiovascular Computed Tomography; Society of Thoracic Surgeons  
**Last published:** 2016

**Chronic heart failure - diagnosis and management** ([https://www2.gov.bc.ca/gov/content/health/practitioner-professional-resources/bc-guidelines/guidelines-by-alphabetical-listing](https://www2.gov.bc.ca/gov/content/health/practitioner-professional-resources/bc-guidelines/guidelines-by-alphabetical-listing)) [205]

**Published by:** British Columbia Medical Association  
**Last published:** 2015


**Published by:** American College of Cardiology Foundation; American Heart Association  
**Last published:** 2013


**Published by:** American College of Cardiology Foundation; American Heart Association  
**Last published:** 2012

**Task force 8: training in heart failure** ([http://www.onlinejacc.org/content/51/3/383](http://www.onlinejacc.org/content/51/3/383)) [207]

**Published by:** Heart Failure Society of America  
**Last published:** 2008

**Chronic heart failure in adults: diagnosis and management** ([https://www.nice.org.uk/guidance/ng106](https://www.nice.org.uk/guidance/ng106)) [98]

**Published by:** National Institute for Health and Care Excellence  
**Last published:** 2018


**Published by:** European Society of Cardiology  
**Last published:** 2018

Published by: European Society of Cardiology

Last published: 2016
Online resources

1. The Seattle Heart Failure Model (http://depts.washington.edu/shfm) (external link)
In people with heart failure, what are the effects of interactive telemedicine?

This table is a summary of the analysis reported in a Cochrane Clinical Answer that focuses on the above important clinical question.

View the full source Cochrane Clinical Answer (https://www.cochranelibrary.com/cca/doi/10.1002/cca.1311/full)

**Evidence A**

*Confidence in the evidence is high or moderate to high where GRADE has been performed and there is no difference in effectiveness between the intervention and comparison for key outcomes.*

**Population:** Adults (mean age 53 to 79 years) with heart failure

**Intervention:** Telemedicine (includes remote monitoring with system for alerting healthcare professionals, automatic clinical review of data, and/or videoconferencing for patient assessment and self-management education and support) with or without usual care

**Comparison:** Usual care (where reported: home nursing visits or pharmacologic treatment)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effectiveness (BMJ rating)†</th>
<th>Confidence in evidence (GRADE)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause mortality at median 6 months’ follow-up</td>
<td>No statistically significant difference</td>
<td>High</td>
</tr>
<tr>
<td>Disease-specific quality of life at median 3 months’ follow-up</td>
<td>Favors intervention</td>
<td>Moderate</td>
</tr>
<tr>
<td>All-cause hospital admissions at median 8 months’ follow-up: monitoring with clinical review of data</td>
<td>Unknown b</td>
<td>Moderate</td>
</tr>
<tr>
<td>All-cause hospital admissions at median 8 months’ follow-up: monitoring with alerts</td>
<td>Unknown c</td>
<td>Moderate</td>
</tr>
<tr>
<td>Heart failure and/or cardiovascular-related admissions at 3-12 months’ follow-up</td>
<td>Unknown d</td>
<td>GRADE assessment not performed for this outcome</td>
</tr>
<tr>
<td>Emergency department and urgent care visits at median 4 months’ follow-up</td>
<td>No statistically significant difference</td>
<td>GRADE assessment not performed for this outcome</td>
</tr>
</tbody>
</table>
# Evidence tables

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Effectiveness (BMJ rating)†</th>
<th>Confidence in evidence (GRADE)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of stay at median 6 months’ follow-up</td>
<td>No statistically significant difference</td>
<td>GRADE assessment not performed for this outcome</td>
</tr>
<tr>
<td>Length of stay related to heart failure at median 6 months’ follow-up</td>
<td>No statistically significant difference</td>
<td>GRADE assessment not performed for this outcome</td>
</tr>
<tr>
<td>Adverse effects</td>
<td>-</td>
<td>None of the studies identified by the review assessed this outcome</td>
</tr>
</tbody>
</table>

**Note**

* The Cochrane Clinical Answer (CCA) notes that there was a reduction in mortality with telemedicine that did not quite meet statistical significance.

* Results reported narratively (2 RCTs with 156 people; 1 favoured telemedicine while the other reported no statistically significant difference between treatment groups).

* Results reported narratively (9 RCTs with 4373 people, all of which reported no statistically significant difference between treatment groups, apart from 1 which favoured telemedicine).

* Results reported narratively (16 studies with 3236 people, 3 of which reported a reduction in heart failure and/or cardiovascular-related admissions with telemedicine, while the other studies reported similar rates of admission between treatment groups).

**Evidence levels**

The Evidence level is an internal rating applied by BMJ Best Practice. See the EBM Toolkit (https://bestpractice.bmj.com/info/evidence-tables/) for details.

**Confidence in evidence**

A - High or moderate to high

B - Moderate or low to moderate

C - Very low or low

**Effectiveness (BMJ rating)**

Based on statistical significance, which demonstrates that the results are unlikely to be due to chance, but which does not necessarily translate to a clinical significance.
‡ Grade certainty ratings

<table>
<thead>
<tr>
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<th>Description</th>
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</thead>
<tbody>
<tr>
<td>High</td>
<td>The authors are very confident that the true effect is similar to the estimated effect.</td>
</tr>
<tr>
<td>Moderate</td>
<td>The authors are moderately confident that the true effect is likely to be close to the estimated effect.</td>
</tr>
<tr>
<td>Low</td>
<td>The authors have limited confidence in the effect estimate and the true effect may be substantially different.</td>
</tr>
<tr>
<td>Very Low</td>
<td>The authors have very little confidence in the effect estimate and the true effect is likely to be substantially different.</td>
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BMJ Best Practice EBM Toolkit: What is GRADE? (https://bestpractice.bmj.com/info/toolkit/learn-ebm/what-is-grade/)
Key articles


Chronic congestive heart failure

References


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<th>References</th>
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75. Trandberg TE, Holme I, Faergeman O, et al. Comparative effect of atorvastatin (80 mg) versus simvastatin (20 to 40 mg) in preventing hospitalizations for heart failure in patients with...


Chronic congestive heart failure


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Please note that recommended formulations and doses may differ between drug databases drug names and brands, drug formularies, or locations. A local drug formulary should always be consulted for full prescribing information.

Treatment recommendations in BMJ Best Practice are specific to patient groups. Care is advised when selecting the integrated drug formulary as some treatment recommendations are for adults only, and external links to a paediatric formulary do not necessarily advocate use in children (and vice-versa). Always check that you have selected the correct drug formulary for your patient.

Where your version of BMJ Best Practice does not integrate with a local drug formulary, you should consult a local pharmaceutical database for comprehensive drug information including contraindications, drug interactions, and alternative dosing before prescribing.

Interpretation of numbers

Regardless of the language in which the content is displayed, numerals are displayed according to the original English-language numerical separator standard. For example 4 digit numbers shall not include a comma nor a decimal point; numbers of 5 or more digits shall include commas; and numbers stated to be less than 1 shall be depicted using decimal points. See Figure 1 below for an explanatory table.

BMJ accepts no responsibility for misinterpretation of numbers which comply with this stated numerical separator standard.

This approach is in line with the guidance of the International Bureau of Weights and Measures Service.

Figure 1 – BMJ Best Practice Numeral Style
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