OBJECTIVES

1. Explain the concept of polypharmacy in the treatment of congestive heart failure.
2. Explain the function of a diuretic.
3. Discuss drugs used for the initial management of congestive heart failure: furosemide (Lasix), morphine sulfate, and nitroglycerin (Nitrolingual, NitroQuick, Nitro-Dur).
4. Discuss digoxin (Lanoxin) and its use in the long-term management of congestive heart failure.
5. Discuss the role of angiotensin-converting enzyme inhibitors, beta blockers, and calcium channel blockers in treating patients with congestive heart failure.

INTRODUCTION

Congestive heart failure (CHF) is one of the few cardiovascular disorders that continues to increase in prevalence, especially among the elderly. Currently 5 million people in the United States have heart failure, and 500,000 new cases are diagnosed each year. CHF is predominantly a condition of the elderly, with 6% to 10% of all individuals older than 65 years having symptoms consistent with the disease. Paramedics are often called to assist patients with long-standing disease who are often taking multiple medications. Prehospital care providers must be familiar with the medications used for long-term therapy of CHF, as well as short-term drug therapy for exacerbations of CHF and resultant pulmonary edema.

You are dispatched to assist an elderly woman who is reporting shortness of breath. You arrive at the apartment of a 78-year-old woman who is in moderate respiratory distress. Her legs are swollen, and she reports shortness of breath that has become more severe over the past few days. She coughs when lying down and has been having difficulty sleeping for the past three nights. In fact, she tells you that her breathing has been more comfortable when she has tried to sleep in the chair in the living room. Her blood pressure is 188/92 mm Hg, heart rate is 100 beats/min, and respirations are 20 breaths/min. The patient tells you she is diabetic and hypertensive and has high cholesterol, kidney failure, and CHF. You administer high-flow oxygen with a nonrebreather...
OVERVIEW OF CONGESTIVE HEART FAILURE

Heart failure may be the result of ischemic heart disease, diabetes mellitus, hypertension, or disease of the heart valves. The onset of heart failure may be rather acute after a myocardial infarction or may take years to develop in conditions such as valvular heart disease, hypertension, or diabetes mellitus. Patients with heart failure may have symptoms from accumulation of excess fluid or poor peripheral perfusion and inadequate oxygen delivery to the tissues (Fig. 10-1). Signs of fluid overload include shortness of breath from pulmonary edema, as well as edema of the extremities, especially the lower legs. Poor output of the heart caused by heart failure results in an accumulation or “backing up” of fluid in the lungs, which is known as pulmonary edema. Other patients with heart failure may report only fatigue and weakness from poor delivery of oxygen to the tissues as a result of low cardiac output.

▼ Fig. 10-1 In congestive heart failure, decreased forward cardiac output by a diseased left ventricle results in the accumulation of blood in the pulmonary vasculature, leading to pulmonary edema. Pulmonary edema occurs when fluid accumulates in the alveoli. This fluid widens the gap between the alveoli and capillary membrane, which makes diffusion of oxygen and carbon dioxide less efficient.
The diagnosis of CHF is often suspected in patients with shortness of breath and peripheral edema. Shortness of breath, or dyspnea, can be caused by CHF but can also be the result of chronic obstructive pulmonary disease (COPD). CHF, as well as a variety of other conditions, can produce peripheral edema. CHF is not easily diagnosed by physical examination. Approximately 20% of patients diagnosed with CHF have no symptoms at all, and approximately 42% had only dyspnea on exertion. Children with heart disease can also have heart failure and resultant pulmonary edema.

MANAGEMENT

The American Heart Association provides guidelines for the management of CHF and pulmonary edema. Long-term control of systolic and diastolic hypertension is imperative to control the symptoms seen in CHF. Patients with CHF are often taking medications for the treatment of lipid disorders. Angiotensin-converting enzyme (ACE) inhibitors are a class of medication recommended for patients with a history of atherosclerotic vascular disease, diabetes, and hypertension. ACE inhibitors are discussed later in this chapter. Additionally, physicians often place these patients on medications to control heart rate and treat thyroid disorders. The importance of these recommendations in prehospital management is not in the administration of these medications, but in the effects of polypharmacy (the administration of many drugs at the same time) on the patient with CHF who is unstable. Additionally, although these medications are often used for the treatment of CHF, drugs such as digoxin, nitrates, or ACE inhibitors may be potentially harmful in patients with CHF from valvular heart disease or with diastolic dysfunction.

The most common treatment protocols for patients with CHF in the prehospital setting include administration of oxygen, furosemide (Lasix), morphine, and nitroglycerin. The only medication that presents no harmful consequences in this setting is oxygen. Patients with symptoms consistent with CHF or pulmonary edema are treated with sublingual or mucosal nitroglycerin, IV furosemide, and IV morphine or some combination of these drugs.

DRUGS USED FOR IMMEDIATE MANAGEMENT

After the administration of oxygen, one of the principal objectives of drug therapy is reduction of pulmonary edema.

Drugs commonly used for the immediate management of CHF include furosemide, morphine sulfate, and nitroglycerin. Patients with chronic heart failure will typically be taking a diuretic such as furosemide, as well as an ACE inhibitor and a beta blocker.

Furosemide, which is a loop diuretic, is commonly used to reduce pulmonary edema. Diuretics increase urine output, and loop diuretics work by decreasing the absorption of water in the kidneys. This decrease in water absorption increases urine production and decreases intravascular volume. Loop diuretics are more effective than other diuretics in the management of acute and chronic heart failure, as well as life-threatening pulmonary edema. In the management of an adult with CHF, an initial dose of furosemide 40 mg IV push should be administered. Once administered, the diuretic effects of furosemide do not become apparent until approximately 20 minutes later. Because furosemide is not capable of providing immediate relief to the patient with CHF or dyspnea, the provider must rely on other medications for the 20 minutes of treatment.

Nitroglycerin produces vasodilation and dilates veins to a greater magnitude than it does arteries. Venodilation results in less blood returning to the heart, which produces a reduction in cardiac preload. This effect of nitroglycerin provides some early relief before the onset of the diuretic effects of furosemide. Nitroglycerin also reduces cardiac workload in patients with acute symptoms of congestive heart disease, improves blood flow to ischemic myocardium, and decreases myocardial oxygen demand.

In addition to its common uses for the treatment of pain, morphine sulfate is used in patients with CHF and pulmonary edema to relieve pulmonary congestion by venodilation. Morphine also lowers myocardial oxygen demand and reduces anxiety.
Because morphine is a respiratory depressant, paramedics need to be skilled and equipped to support the patient’s airway and respirations in the event of respiratory failure.

Furosemide (Lasix)

**Classification:** Loop diuretic

**Action:** Inhibits the absorption of the sodium and chloride ions and water in the loop of Henle, as well as the convoluted tubule of the nephron. This results in decreased absorption of water and increased production of urine.

**Indications:** Pulmonary edema, CHF, hypertensive emergency.

**Adverse Effects:** Vertigo, dizziness, weakness, orthostatic hypotension, hypokalemia, thrombophlebitis. Patients with anuria, severe renal failure, untreated hepatic coma, increasing azotemia, and electrolyte depletion can develop life-threatening consequences.

**Contraindications:** Known sensitivity to sulfonamides or furosemide.

**Dosage:**

- **Congestive Heart Failure and Pulmonary Edema:**
  - Adult: 40 mg IV, IO administered slowly over a 1- to 2-minute period. If a satisfactory response is not achieved within 1 hour, an additional dose of 80 mg can be given. A maximum single IV dose is 160 to 200 mg.
  - Pediatric: 1 mg/kg IV, IO or IM. If the response is not satisfactory, an additional dose of 2 mg/kg may be administered no sooner than 2 hours after the first dose.

- **Hypertensive Emergency:**
  - Adult: 40 to 80 mg IV, IO.
  - Pediatric: 1 mg/kg IV or IM.

**Special Considerations:**

- Onset of action for IV, IO administration occurs within 5 minutes and will peak within 30 minutes.
- Furosemide is a diuretic, so the patient will likely have urinary urgency. Be prepared to help the patient void.
- Pregnancy class C

Morphine Sulfate

**Classification:** Opiate agonist, Schedule C-II

**Action:** Binds with opioid receptors. Morphine is capable of inducing hypotension by depression of the vasomotor centers of the brain, as well as release of the chemical histamine. In the management of angina, morphine reduces stimulation of the sympathetic nervous system caused by pain and anxiety. Reduction of sympathetic stimulation reduces heart rate, cardiac work, and myocardial oxygen consumption.

**Indications:** Moderate to severe pain, including chest pain associated with ACS, CHF, pulmonary edema.

**Adverse Effects:** Respiratory depression, hypotension, nausea/vomiting, dizziness, lightheadedness, sedation, diaphoresis, euphoria, dysphoria, worsening of bradycardia and heart block in some patients with acute inferior wall MI, seizures, cardiac arrest, anaphylactoid reactions.

**Contraindications:** Respiratory depression, shock, known sensitivity. Use with caution in hypotension, acute bronchial asthma, respiratory insufficiency, head trauma.

**Dosage:**

- **Pain:**
  - Adult: 2.5 to 15 mg IV, IO, IM, or Sub-Q administered slowly over a period of several minutes. The dose is the same whether administered IV, IO, IM, or Sub-Q.
  - Pediatric:
    - 6 months to 12 years: 0.05 to 0.2 mg/kg IV, IO, IM, or Sub-Q.
    - Younger than 6 months: 0.03 to 0.05 mg/kg IV, IO, IM, or Sub-Q.

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**Morphine Sulfate—cont’d**

Chest Pain Associated with Acute Coronary Syndromes, Congestive Heart Failure, and Pulmonary Edema:

Administer small doses and reevaluate the patient. Large doses may lead to respiratory depression and worsen the patient’s hypoxia.

- **Adult:** 2 to 4 mg slow IV, IO over a 1- to 5-minute period with increments of 2 to 8 mg repeated every 5 to 15 minutes until patient relieved of chest pain.
- **Pediatric:** 0.1 to 0.2 mg/kg/dose IV, IO.

**Special Considerations:**

Monitor vital signs and pulse oximetry closely. Be prepared to support patient’s airway and ventilations.

Overdose should be treated with naloxone.

Pregnancy class C

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**Nitroglycerin (Nitrolingual, NitroQuick, Nitro-Dur)**

**Classification:** Antianginal agent

**Action:** Relaxes vascular smooth muscle, thereby dilating peripheral arteries and veins. This causes pooling of venous blood and decreased venous return to the heart, which decreases preload. Nitroglycerin also reduces left ventricular systolic wall tension, which decreases afterload.

**Indications:** Angina, ongoing ischemic chest discomfort, hypertension, myocardial ischemia associated with cocaine intoxication.

**Adverse Effects:** Headache, hypotension, bradycardia, lightheadedness, flushing, cardiovascular collapse, methemoglobinemia.

**Contraindications:** Hypotension, severe bradycardia or tachycardia, increased ICP, intracranial bleeding, patients taking any medications for erectile dysfunction (such as sildenafil [Viagra], tadalafil [Cialis], or vardenafil [Levitra]), known sensitivity to nitrates. Use with caution in anemia, closed-angle glaucoma, hypotension, postural hypotension, uncorrected hypovolemia.

**Dosage:**

- **Adult:**
  - **Sublingual tablets:** 1 tablet (0.3-0.4 mg) at 5-minute intervals to a maximum of 3 doses.
  - **Translingual spray:** 1 (0.4 mg) spray at 5-minute intervals to a maximum of 3 sprays.
  - **Ointment:** 2% topical (Nitro-Bid ointment): Apply 1 to 2 inches of paste over the chest wall, cover with transparent wrap, and secure with tape.
  - **IV:**
    - **Bolus:** 12.5 to 25 mcg
    - **Infusion:** 5 mcg/min; may increase rate by 5 to 10 mcg/min every 5 to 10 minutes as needed. End points of dose titration for nitroglycerin include a drop in the blood pressure of 10%, relief of chest pain, and return of ST segment to normal on a 12-lead ECG.
  - **Pediatric IV infusion:** The initial pediatric infusion is 0.25 to 0.5 mcg/kg/min IV, IO titrated by 0.5 to 1 mcg/kg/min. Usual required dose is 1 to 3 mcg/kg/min to a maximum dose of 5 mcg/kg/min.

**Special Considerations:**

Administration of nitroglycerin to a patient with right ventricular MI can result in hypotension. Pregnancy class C
DRUGS USED FOR LONG-TERM MANAGEMENT

Common medications used for the long-term management of patients with CHF include digoxin, lisinopril, and metoprolol. Although these medications are not likely to be administered by prehospital providers, many patients with heart disease take some or all of them. Paramedics must be familiar with these medications because patients can experience ill effects from them that the paramedic may need to recognize and treat.

Digoxin is used in patients with CHF to increase myocardial contractility and often to slow the heart rate. Digoxin may also be used in patients with chronic atrial fibrillation. Simply put, digoxin helps the heart beat stronger and slower. When the heart beats fast, less time is available for the ventricle to fill with blood, which means less blood can fill the ventricle; therefore cardiac output is decreased. When the heart rate is slowed, the ventricles are given more time to fill, and cardiac output is increased.

Blood delivering oxygen to the cells of the heart travels through the coronary arteries. When the heart contracts (systole), the coronary arteries are also squeezed; that action prevents oxygen-rich blood from moving forward. The only time that blood can carry oxygen to the heart is between contractions (diastole). By slowing the heart rate, cardiac consumption of oxygen is reduced, and blood flow to the heart is increased. In summary, the benefits of a drug-induced reduction of heart rate include the following:

- Decreased myocardial oxygen consumption
- Improved stroke volume, increasing cardiac output
- Prolonged diastolic coronary blood flow

A rapid heart rate (especially atrial fibrillation) reduces the filling of the heart, leading to decreased cardiac output and blood pressure.

Lisinopril is an ACE inhibitor. When angiotensin is inhibited, production of the most powerful vasoconstrictor in the body (angiotensinogen) halts. As a result, the patient will have a decrease in blood pressure and mild diuresis. ACE inhibitors also reduce cardiac ischemic events, mortality rate, and hospital admissions for individuals with CHF.

Metoprolol, a beta blocker, binds to beta adrenergic receptors and decreases blood pressure and heart rate, which are beneficial to the diseased heart. Metoprolol is a cardioselective beta blocker used to control hypertension and decrease cardiac workload in the patient with CHF. Adding a beta blocker to an ACE inhibitor has been shown to decrease mortality rate and hospital admissions in symptomatic patients with heart failure.³

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**DIGOXIN (LANOXIN)**

**Classification:** Cardiac glycoside

**Action:** Inhibits sodium-potassium-adenosine triphosphatase membrane pump, resulting in an increase in calcium inside the heart muscle cell, which causes an increase in the force of contraction of the heart.

**Indications:** CHF, to control the ventricular rate in chronic AF and atrial flutter, narrow-complex PSVT.

**Adverse Effects:** Headache, weakness, GI disturbances, arrhythmias, nausea/vomiting, diarrhea, vision disturbances.

**Contraindications:** Digitalis allergy, VT and VF, heart block, sick sinus syndrome, tachycardia without heart failure, pulse lower than 50 to 60 beats/min, MI, ischemic heart disease, patients with preexcitation AF or atrial flutter (i.e., a delta wave, characteristic of Wolff-Parkinson-White syndrome, visible during normal sinus rhythm).

**Dosage:** Dosage is individualized.

**Special Considerations:**

Low levels of serum potassium can lead to digoxin toxicity and bradycardia. Conditions such as administration of steroids or diuretics or vomiting and diarrhea can produce low levels of potassium and subsequent digoxin toxicity.

Pregnancy class C
ANGIOTENSIN-CONVERTING ENZYME INHIBITORS, BETA BLOCKERS, AND CALCIUM CHANNEL BLOCKERS

Angiotensin-Converting Enzyme Inhibitors

Many patients with CHF are prescribed ACE inhibitors. This class of drugs blocks, or antagonizes, the enzyme responsible for the production of the hormone angiotensin II. Angiotensin II is a vasoconstrictor that is 40 times more powerful than norepinephrine. In addition to being a vasoconstrictor, angiotensin II also has positive inotropic and chronotropic properties. Therefore drugs that block the production of angiotensin II (ACE inhibitors) reduce blood pressure, decrease cardiac afterload, reduce heart rate, and reduce the force of contraction of the heart. ACE inhibitors reduce the mortality rate in patients with moderate and severe CHF.

Angiotensin-Converting Enzyme (ACE) Inhibitors: Captopril (Capoten), Enalapril (Vasotec), Lisinopril (Prinivil, Zestril), Ramipril (Altace)

Classification: ACE inhibitors
Action: Blocks the enzyme responsible for the production of angiotensin II, resulting in a decrease in blood pressure.
Indications: Congestive heart failure, hypertension, post-myocardial infarction.
Adverse Effects: Headache, dizziness, fatigue, depression, chest pain, hypotension, palpitations, cough, dyspnea, upper respiratory infection, nausea/vomiting, rash, pruritus, angioedema, renal failure.
Contraindications: Angioedema related to previous treatment with an ACE inhibitor, known sensitivity. Use with caution in aortic stenosis, bilateral renal artery stenosis, hypertrophic obstructive cardiomyopathy, pericardial tamponade, elevated serum potassium levels, acute kidney failure.
Dosage: 
- Adult: Medication is administered orally. Dosage is individualized.
- Pediatric: Medication is administered orally. Dosage is individualized.
Special Considerations: Pregnancy class D

Beta Blockers

Beta blockers are helpful in the long-term management of patients with CHF; however, beta blockers should be avoided in patients who are unstable or have decompensated CHF. In the management of a patient with chronic heart failure, the dose of beta blockers is slowly and progressively increased over a prolonged period.

Metoprolol (Lopressor, Toprol XL)

Classification: Beta adrenergic antagonist, antianginal, antihypertensive, class II antiarrhythmic
Action: Inhibits the strength of the heart’s contractions, as well as heart rate. This results in a decrease in cardiac oxygen consumption. Also saturates the beta receptors and inhibits dilation of bronchial smooth muscle (beta; receptor).
Indications: ACS, hypertension, SVT, atrial flutter, AF, thyrotoxicosis.
Adverse Effects: Tiredness, dizziness, diarrhea, heart block, bradycardia, bronchospasm, drop in blood pressure.
Contraindications: Cardiogenic shock, AV block, bradycardia, known sensitivity. Use with caution in hypotension, chronic lung disease (asthma and COPD).
Dosage: 
- Cardiac Indications:
  - Adult: 5 mg slow IV, IO over a 5-minute period; repeat at 5-minute intervals up to a total of three infusions totaling 15 mg IV, IO.
  - Pediatric: Not recommended for pediatric patients; no studies available.

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Calcium Channel Blockers
Certain calcium channel blockers such as verapamil, diltiazem, and nifedipine should be avoided in patients with CHF because they have been shown to increase morbidity and mortality rates in patients with left ventricular systolic dysfunction from heart failure.

REVIEW QUESTIONS
1. What are some medical conditions that may predispose a patient to develop CHF?
2. What is the function of a diuretic?
3. How is morphine beneficial in the treatment of heart failure?
4. What are the benefits to the heart of preventing tachycardia when treating someone with heart disease?
5. What is the role of digoxin in the treatment of CHF?
6. Explain the effects of ACE inhibitors on the heart.
7. What precautions should be followed in administering beta blockers to a patient with CHF?

REFERENCES

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