Chapter 67
Approach to Left Ventricular Failure in the ICU

67.1 Introduction

Left ventricular failure (LVF) frequently presents in critical care settings and reflects the heart's diminished capacity to sustain effective forward flow, leading to systemic hypoperfusion and pulmonary congestion. Patients may complain of breathlessness during exertion or sleep, and physical assessment might reveal cold limbs, neck vein distension, and lung crackles. A structured ICU strategy for LVF involves not only stabilizing the acute episode but also mitigating modifiable triggers and concurrent diseases to reduce recurrent admissions and improve survival [1–3] [Ref: Algorithm 67.1].

67.2 Definition

Heart failure is a multifaceted clinical syndrome characterized by signs and symptoms arising from structural or functional abnormalities that impair the heart's ability to fill with or eject blood effectively. This does not include asymptomatic structural heart diseases or cardiomyopathies.

67.3 Stages of Heart failure

Heart failure progression is typically categorized to guide therapy:

- Stage A: Individuals at high risk (e.g., with hypertension, diabetes, or a family history) but without structural heart disease or symptoms.

S. B. Mishra et al., *Mastering ICU Care*,
https://doi.org/10.1007/978-981-95-0179-3_67

- Stage B: Patients with cardiac structural changes (e.g., low EF, ventricular hypertrophy) or elevated cardiac biomarkers, yet asymptomatic.
- Stage C: Symptomatic individuals with known heart disease, whether symptoms are new or recurrent.
- Stage D: Refractory heart failure with frequent decompensation requiring advanced support or frequent hospitalization.

Even if a patient with symptomatic heart failure (stage C) becomes asymptomatic with appropriate treatment, they remain classified as having stage C heart failure due to their clinical history.

Stage C heart failure can be further subclassified into the following categories:

- **New-onset (de novo) HF:** First presentation of heart failure symptoms in a patient with no prior history of the condition.
- **Resolution of symptoms:** Patients whose symptoms have improved or resolved with therapy but who still meet criteria for stage C due to underlying structural heart disease.
- **Persistent HF:** Ongoing symptoms despite medical management.
- **Worsening HF:** Clinical deterioration or exacerbation of symptoms in a patient with previously stable heart failure.

Classification of Heart Failure Based on Left Ventricular Ejection Fraction (LVEF):

- **HFrEF (Heart Failure with Reduced Ejection Fraction):** Defined by an LVEF $\leq$40%.
- **HFimpEF (Heart Failure with Improved Ejection Fraction):** Refers to patients with a previously documented LVEF $\leq$40% that has improved to >40% on subsequent evaluation.
- **HFmrEF (Heart Failure with Mildly Reduced Ejection Fraction):** LVEF ranging between 41% and 49%, accompanied by evidence of elevated left ventricular filling pressures—either at rest or during stress—such as increased natriuretic peptide levels or abnormal hemodynamic findings via noninvasive or invasive assessments.
- **HFpEF (Heart Failure with Preserved Ejection Fraction):** Characterized by an LVEF $\geq$50% along with evidence of elevated left ventricular filling pressures, demonstrated through raised natriuretic peptide concentrations or supportive findings from imaging or invasive hemodynamic studies.

67.4 Etiology and Risk Factors

Risk factors: Hypertension, obesity, diabetes, atherosclerotic cardiovascular disease.
Etiology:

Cardiac: Ischemic heart disease and myocardial infarction, hypertension and valvular heart disease, familial or genetic cardiomyopathies; amyloidosis, heart rhythm–related (e.g., tachycardia-mediated, PVCs, RV pacing).

Noncardiac causes: Several extracardiac conditions can lead to or worsen left ventricular failure. These include toxic exposure (e.g., chemotherapeutic or cardiotoxic medications), metabolic and endocrine disorders such as thyroid dysfunction, acromegaly, or pheochromocytoma, and systemic diseases like diabetes or obesity. Inflammatory or infectious myocarditis, substance abuse (notably alcohol, methamphetamines, or cocaine), and stress-induced cardiomyopathy (e.g., Takotsubo) are also implicated abuse (e.g., alcohol, cocaine, methamphetamine), stress cardiomyopathy (Takotsubo).

Understanding and addressing modifiable risk factors is crucial in the prevention and management of LVF. Hypertension and coronary artery disease are primary contributors to the development of LVF. Early detection and aggressive management of these conditions can prevent the progression to heart failure.

67.5 Comprehensive Patient Evaluation

1. Patient Presentation.
   - Initial evaluation involves identifying symptoms and signs indicative of LVF, including dyspnea, orthopnea, and paroxysmal nocturnal dyspnea.
   - Physical examination should assess for signs of hypoperfusion (e.g., cold extremities) and congestion (e.g., elevated JVP, pulmonary rales).
2. Immediate Vital Signs and Advanced Diagnostics.
   - Monitor vital signs closely.
   - Perform a bedside echocardiogram to determine left ventricular EF.
   - Utilize advanced imaging modalities like cardiac MRI to assess myocardial fibrosis and viability.
   - Order laboratory tests (complete blood count, urinalysis, serum electrolytes, blood urea nitrogen, serum creatinine, glucose, lipid profile, liver function tests, iron studies, and thyroid function tests), including BNP/NT-proBNP to distinguish acute heart failure from other causes of dyspnea, troponins for myocardial injury. A 12-lead ECG should be obtained. BNP levels are useful for diagnosis or exclusion of HF and to establish prognosis.
3. Assessment of Comorbid Conditions.
   - Evaluate and manage comorbidities such as diabetes, anemia, chronic kidney disease, iron deficiency, and atrial fibrillation, as they significantly affect LVF prognosis.

67.6 Imaging

A chest radiograph serves as a helpful initial investigation to assess for heart enlargement, pulmonary vascular congestion, or interstitial and alveolar fluid accumulation. It can also point toward alternative diagnoses contributing to respiratory symptoms. Despite its utility, transthoracic echocardiography (TTE) is generally the preferred first-line modality for a detailed evaluation of cardiac anatomy and performance. When more information is required, advanced imaging such as cardiac MRI, nuclear techniques like SPECT or radionuclide ventriculography, PET scans, cardiac CT, or coronary angiography may be employed to provide additional structural or perfusion data.

67.7 Management Based on Hemodynamic Status

Effective management of left ventricular failure (LVF) necessitates a clear understanding of the patient's hemodynamic status, which reflects how efficiently the heart is pumping blood and whether there is excess fluid accumulation in the body. Patients are typically classified into four categories based on their signs and symptoms: warm and dry (compensated), warm and wet (congestion), cold and dry (hypoperfusion), and cold and wet (congestion with hypoperfusion). Each category requires specific management strategies to address the underlying issues and improve patient outcomes.

1. Warm and Dry (Compensated)

Warm and dry patients have adequate blood flow to bodily tissues, indicated by warm skin, and no significant fluid buildup in the lungs or tissues. This state suggests that the heart is compensating well despite underlying dysfunction. The primary goal for these patients is to optimize long-term treatment to prevent the progression of heart failure.

Management involves initiating or adjusting Guideline-Directed Medical Therapy (GDMT):

- ACE Inhibitors or ARBs (e.g., lisinopril, enalapril, losartan, valsartan): These agents reduce afterload by dilating blood vessels, ease cardiac workload, and limit disease progression by mitigating adverse remodeling.
- ARNIs (e.g., sacubitril/valsartan): A combination of neprilysin inhibition with ARB action, these drugs enhance natriuretic peptide activity and improve both symptoms and prognosis in HFrEF.
- Beta-Blockers (e.g., metoprolol, carvedilol): These reduce myocardial oxygen demand and blunt the effects of sympathetic overactivity, thereby improving survival and reducing hospitalization rates.
- MRAs (e.g., spironolactone, eplerenone): These inhibit aldosterone, promoting natriuresis while preventing myocardial fibrosis and adverse remodeling.

- SGLT2 Inhibitors (e.g., empagliflozin, dapagliflozin): Initially developed for diabetes, these agents now have proven benefit across heart failure phenotypes by promoting osmotic diuresis and improving cardiovascular outcomes.

2. Warm and Wet (Congestion)

In the warm and wet category, patients have adequate blood flow to tissues but experience excess fluid accumulation, leading to symptoms like shortness of breath and swelling (edema). The primary focus for these patients is to remove excess fluid to relieve symptoms and prevent complications.

Management Strategies Include

- Administering intravenous diuretics like furosemide (Lasix) to promote the excretion of excess fluid through increased urine production.
- Implementing sodium restriction to reduce further fluid retention. This approach is particularly important for patients with heart failure with preserved ejection fraction (HFpEF).
- Monitoring fluid balance carefully by tracking fluid intake and output, and conducting daily weight measurements to detect fluid retention early.
- Considering ultrafiltration if diuresis is inadequate. Ultrafiltration mechanically removes excess fluid from the blood when diuretics are insufficient.
- Employing conservative diuretic protocols for patients at risk of kidney dysfunction to prevent worsening renal function. This involves using the lowest effective diuretic dose and closely monitoring kidney function.

3. Cold and Dry (Hypoperfusion)

Patients categorized as Cold and Dry exhibit reduced blood flow to tissues, indicated by cool extremities, but do not have significant fluid overload. The management goal is to improve blood flow to organs while ensuring adequate blood volume.

Management Involves:

- Assessing Volume Status to check for dehydration, as low blood volume can further reduce blood pressure and perfusion.
- Administering a Fluid Bolus if Hypovolemic, which involves giving intravenous fluids to increase blood volume.
- Initiating Inotropic Support if needed with medications like dobutamine or milrinone that strengthen the heart's contractions and improve its ability to pump blood.
- Monitoring for Signs of Ischemia or Arrhythmias because inotropes can increase the heart's oxygen demand, potentially leading to chest pain or irregular heart rhythms. Continuous cardiac monitoring is essential during inotropic therapy.

Key Points highlight the importance of balancing fluid administration to avoid overloading the patient, which could lead to congestion. Frequent assessments are necessary to adjust treatment promptly based on the patient's response.

4. Cold and Wet (Congestion with Hypoperfusion)

The cold and wet category is the most severe, with patients experiencing poor blood flow to tissues and excess fluid accumulation. Aggressive treatment is required to improve heart function and remove excess fluid.

Management Strategies Include:

- Using a combination of inotropes and vasodilators:
  - Inotropes like dobutamine or milrinone enhance the strength of the heart's contractions.
  - Vasodilators such as nitroglycerin or nitroprusside relax blood vessels, reducing resistance and easing the heart's workload.
  - Ensuring adequate blood pressure since vasodilators can lower blood pressure, and excessively low levels can compromise blood flow to vital organs. Medications should be titrated carefully, with close monitoring of blood pressure.
- Considering mechanical circulatory support devices if pharmacological interventions are insufficient:
  - Intra-aortic balloon pump (IABP) assists the heart by increasing blood flow to the coronary arteries and decreasing the heart's workload.
  - Ventricular assist devices (VADs) take over some or all of the heart's pumping function.
  - Extracorporeal membrane oxygenation (ECMO) provides both cardiac and respiratory support by oxygenating the blood outside the body.

Key points stress that urgent intervention is critical to prevent organ damage. A multidisciplinary approach involving cardiologists, intensivists, and surgeons may be necessary to manage these complex cases effectively.

67.8 Advanced Therapies and Mechanical Support

When standard medical treatments are insufficient, advanced therapies can be lifesaving options for patients with severe heart failure. These interventions aim to improve survival rates and quality of life.

67.8.1 Cardiac Resynchronization Therapy (CRT)

Purpose: CRT aims to improve heart efficiency by helping the ventricles beat in sync, enhancing the coordination of heart contractions. A specialized pacemaker sends electrical impulses to both ventricles simultaneously, improving symptoms and potentially increasing survival.

Considerations:
Ideal Candidates: Patients with HFrEF who have a prolonged QRS duration on electrocardiogram (indicating electrical delay) and persistent symptoms despite optimal medical therapy.

67.8.2 Ventricular Assist Devices (VADs)

Purpose: VADs support a failing heart by assisting in pumping blood throughout the body.

Use Cases:
- Bridge to Transplantation: Keeps patients stable while awaiting a heart transplant.
- Destination Therapy: Provides a long-term solution for patients who are not candidates for transplantation.

Function: A VAD is a mechanical pump surgically implanted to take over some or all of the left ventricle's pumping functions.

Considerations:
- Risks: Potential complications include infection, blood clots, and device malfunction.

Lifestyle Impact: Patients must adapt to significant lifestyle changes and require ongoing medical care.

67.8.3 Heart Transplantation

Purpose: Heart transplantation is considered for patients with end-stage heart failure unresponsive to all other treatments, offering a chance for extended survival and improved quality of life.

Considerations:
- Eligibility: Patients must meet strict criteria, including overall health status, absence of other significant diseases, and the ability to adhere to lifelong immunosuppressive therapy.

Post-Transplant Care: Requires lifelong medications to prevent organ rejection and frequent medical evaluations to monitor for complications.

67.9 Assess for Reversible Causes

Identifying and treating underlying issues can improve heart function or even reverse heart failure in some cases. Addressing these reversible causes is a critical component of comprehensive heart failure management.

67.9.1 Ischemia (Reduced Blood Flow to the Heart)

Action Steps:
- Diagnosis: Utilize tests such as electrocardiograms (ECG), stress tests, or coronary angiography to detect blockages in the coronary arteries.
- Treatment:
  - Medications: Prescribe anti-anginal drugs and antiplatelet agents to improve blood flow and prevent clot formation.
  - Procedures: Perform angioplasty with stenting or coronary artery bypass grafting (CABG) to restore adequate blood flow to the heart muscle.

67.9.2 Arrhythmias (Abnormal Heart Rhythms)

Action Steps:
- Diagnosis: Continuous ECG monitoring is essential to detect irregular heart rhythms like atrial fibrillation, which can exacerbate heart failure symptoms.
- Treatment:
  - Medications: Use antiarrhythmic drugs to control heart rate and rhythm.
  - Procedures: Consider electrical cardioversion or catheter ablation therapy to restore normal rhythm.

67.9.3 Valvular Disease

Action Steps:
- Diagnosis: Perform echocardiography to assess the structure and function of heart valves.
- Treatment:
  - Medications: Manage symptoms with appropriate pharmacotherapy.
  - Procedures: Surgical repair or replacement of the faulty valve may be necessary. Minimally invasive techniques like trans-catheter aortic valve replacement (TAVR) can be options for select patients.

67.9.4 Infection

Action Steps:
- Diagnosis: Conduct blood tests, imaging studies, and cultures to identify infections such as endocarditis.

- Treatment:
  - Antibiotics: Administer appropriate antimicrobial therapy based on the identified organism.
  - Supportive Care: Manage fever and other systemic symptoms to reduce cardiac workload.

67.10 Monitoring and Fluid Management

Continuous assessment and timely adjustments are crucial for effective heart failure management. Proper monitoring helps in detecting changes early and modifying treatment to prevent deterioration.

67.10.1 Daily Monitoring

Fluid Balance:
- Intake and Output Charts: Keep detailed records of all fluids consumed and excreted to maintain appropriate fluid balance.
- Urine Output: Monitor as an indicator of kidney function and effectiveness of diuretic therapy.

Weight Monitoring:
- Daily Weights: Weigh the patient at the same time each day, preferably in the morning after urination, to detect fluid retention promptly.

Electrolyte Levels:
Regular Blood Tests: Check levels of sodium, potassium, and kidney function markers to identify imbalances that may require intervention.

67.10.2 Adjust Therapy

Based on Clinical Response:
- Symptoms: Monitor for worsening shortness of breath, increased swelling, fatigue, or other signs of heart failure exacerbation.
- Vital Signs: Regularly assess blood pressure, heart rate, and oxygen saturation to guide therapy adjustments.

Based on Laboratory Results:
- Kidney Function: Adjust diuretic doses if there is evidence of renal impairment.

Electrolyte Imbalances: Supplement or modify medications to correct abnormalities.

67.10.3 Fluid Management

Individualized Strategies:
- Fluid Restriction: Limit total daily fluid intake based on the patient's condition and risk of fluid overload.
- Diuretic Adjustments: Modify doses according to the patien's response and kidney function, aiming for optimal fluid removal without causing dehydration.

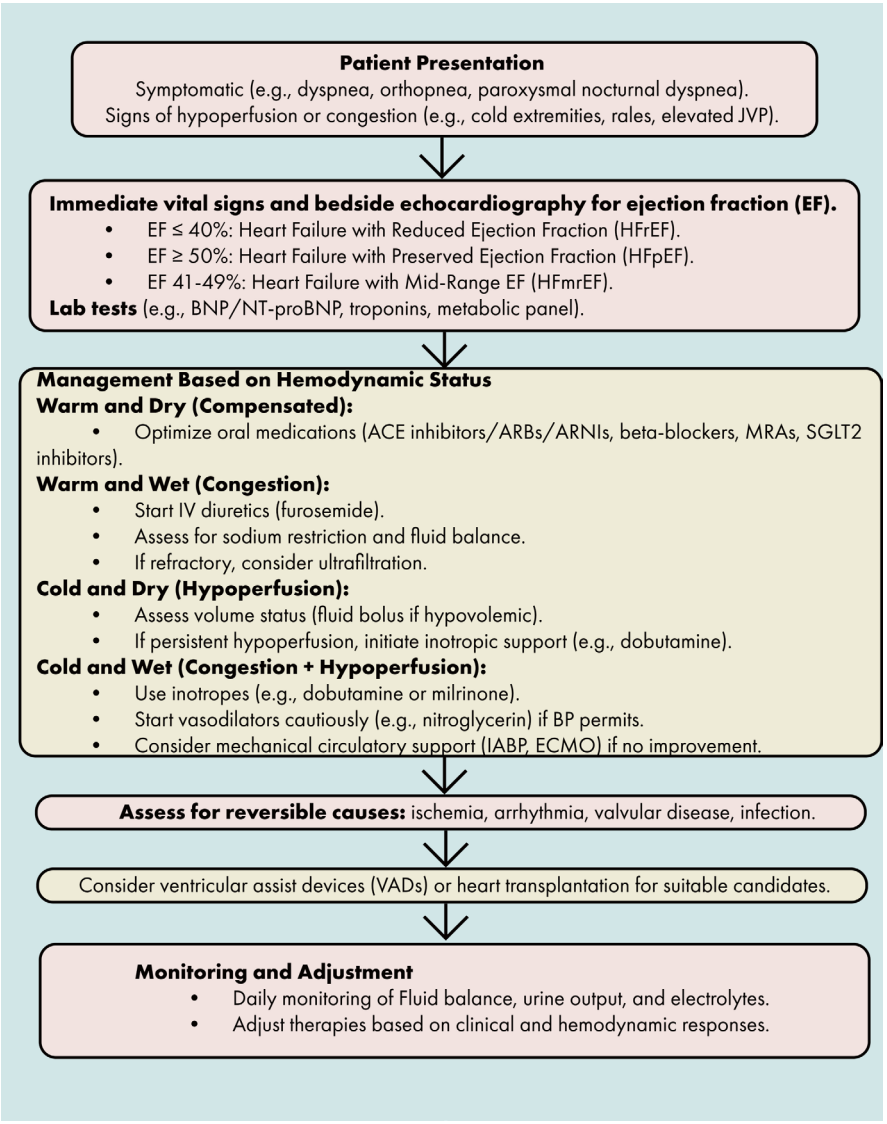
Sodium Restriction:
- Dietary Changes: Educate patients on consuming low-sodium foods and understanding food labels to reduce sodium intake.

Goal: Typically, sodium intake is limited to less than 2000 mg per day to prevent fluid retention.

67.11 Conclusion

A systematic and comprehensive approach to managing left ventricular failure in the ICU is essential for improving patient outcomes. This includes not only acute stabilization but also addressing modifiable risk factors, comorbidities, and implementing evidence-based therapies. Advances in pharmacological treatments and mechanical support devices have expanded the options available for patients with LVF. Ongoing monitoring and adjustment of therapy, along with patient education, play a critical role in the successful management of this complex condition.

Algorithm 67.1: Approach to left ventricular failure in the ICU



Bibliography

1. McDonagh TA, Metra M, Adamo M, Gardner RS, Baumbach A, Bohm M, et al. 202ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. Eur Heart J. 2021;42(36):3599–726.
2. Heidenreich PA, Bozkurt B, Aguilar D, Allen LA, Byun JJ, Colvin MM, et al. AHA/ACC/HFSA guideline for the management of heart failure: a report of the American college of cardiology/American heart association joint committee on clinical practice guidelines. Circulation. 2022;145(18):e895–e1032.
3. McDonagh TA, Metra M, Adamo M, Gardner RS, Baumbach A, Bohm M, et al. Focused Update of the 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. Eur Heart J. 2023;44(37):3627–39.