OBJECTIVES:

1. Discuss the new and complex pathophysiology of ADHF which consists of multiple types of heart failure patients with various forms of acute decompensation.
2. Discuss the categorization of ADHF patient types by clinical profile and hemodynamic status and match them to specific therapies.

INTRODUCTION

As the population ages, the prevalence of heart failure increases, as does the number of patients requiring hospitalization for acute decompensation. Between 1992 and 2001, emergency department (ED) visits for acute decompensated heart failure (ADHF) increased by almost 20% and accounted for 3% (10.8 million) of the more than 360 million ED visits made during the decade. Historically, these exacerbations were considered clinical manifestations of the downward spiral of congestive heart failure. These events depicted a pathophysiologic model characterized by systolic dysfunction and low cardiac output which resulted in volume overload and pulmonary congestion. The root cause was felt to be worsening underlying cardiac function, possibly due to dietary indiscretion or medication noncompliance or just progression of disease. As a result, intravenous diuretics were used to rapidly alleviate pulmonary congestion without clinical trial data to support long-term safety, efficacy, or beneficial outcome. In much the same way, vasodilators and inotropes eventually became elements of usual care.

Data from the ADHERE registry have challenged this simple model of ADHF and revealed a more complex and varied pathophysiologic entity—one that consists of multiple types of heart failure patients with various forms of acute decompensation. This new pathophysiologic concept has fostered changes in physicians’ views of therapeutic options and targets. Clinicians are now reconsidering how intravenous diuretics, vasodilators, and inotropes should be administered, which ADHF patients should get them, and the long-term morbidity and mortality implications of their decisions.

Although guidelines about the management of patients with heart failure have been previously disseminated, most pertain to chronic management. ADHF patient types have not been well characterized or matched with specific treatment strategies in prospective randomized studies. Despite the recent publication of new diagnosis and treatment guidelines, there are a lack of evidence and consensus-based treatment...
algorithms that address the therapeutic needs of specific subsets of patients with ADHF suggested by databases such as ADHERE. It does appear however that patient risk stratification\(^8\) and initiation of aggressive treatment in the ED\(^9\) may limit potentially irreversible myocardial toxicity, especially in those with moderate to severe ADHF. This article will focus on therapeutic management, with particular emphasis on identifying ADHF patient types and matching them to specific treatment strategies. Management protocols and algorithms are provided which can be implemented in your institution.

**MANAGEMENT ALGORITHMS**

The algorithm depicted in Figure 1 provides guidance for the diagnostic and prognostic evaluation of the suspected ADHF patient, in addition to recommendations for therapeutic strategies and disposition decisions.\(^{10}\) Using typical historical, physical examination, and diagnostic test features, a clinical profile is defined, identifying patients in whom pulmonary congestion predominate the clinical presentation versus those with more of an element of hypoperfusion. Options for initial management of imminent respiratory failure and cardiogenic shock are described. Patients are then further divided based upon severity of illness (low, moderate, or critical severity) with recommendations for treatment and disposition provided for each group.

A minority of patients (~20%) will have mild exacerbations of ADHF (low severity) and the mainstay of therapy for them may be intravenous diuretics, particularly if they have been noncompliant with diet or medications. Topical or sublingual nitrates may be warranted if moderate hypertension (systolic blood pressure 140-160 mmHg) is present or a history of diastolic dysfunction exists.

Most ADHF visits are of moderate severity (~70%) and typically require a longer duration of therapy which necessitates a hospital stay. More aggressive therapy with loop diuretics plus intravenous vasodilators is warranted, especially if significant hypertension is present. Preliminary data suggest these patients should be aggressively treated with intravenous vasodilators early in the ED course\(^9\) and a substantial number may be appropriate for observation unit management.\(^{11}\) The ideal choice of a specific vasodilator in these cases is contentious but both nitroglycerin and nesiritide are effective in symptomatic and hemodynamic improvement, however, their safety profiles remain controversial.\(^{12-14}\) Other factors, such as the need for titration with nitroglycerin which may require admission to an intensive care unit, and play a role in the choice of a specific agent. Using the guidelines to estimate severity from Figure 1, the majority of patients classified as moderate risk and those at low risk can all be managed in an ED observation unit.

Patients who are critically ill (~10%), with complications of respiratory failure and/or cardiogenic shock are not surprisingly, the most difficult to manage. They typically require advanced airway support (endotracheal intubation or non-invasive ventilation) plus a complex
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A combination of pharmacological therapy (inotropes, diuretics, vasodilators), the choices of which depend upon the patient’s hemodynamic status. These patients are admitted to an intensive care unit and frequently require pulmonary artery catheterization to guide therapy.

Another algorithm with more patient specific treatment recommendations for management of ADHF in the ED was reported by DiDomenico et al. and is described in Figure 2. The timeline for key elements of these guidelines is depicted in Figure 3 and provides clinicians with specific clinical targets that should be achieved during the ED or observation unit stay. In this strategy, treatment of ADHF is generally based on the presence or absence of volume overload and an assessment of the patient’s cardiac output. On the left side of Figure 2, treatment recommendations are given for patients with ADHF experiencing signs and symptoms of volume overload, manifested by pulmonary congestion. One of the limitations of this algorithm is grouping all patients with pulmonary congestion together, regardless of the etiology.

Figure 1. Algorithm for the early stabilization of acute decompensated heart failure in the emergency department. ADHF, acute decompensated heart failure; BNP, B-type natriuretic peptide; BUN, blood urea nitrogen; CBC, complete blood count; Cr, creatinine; CXR, chest radiograph; ECG, electrocardiogram; ETT, endotracheal tube; ICU, intensive care unit; LVH, left ventricular hypertrophy; NIV, non-invasive ventilation; O2SAT, oxygen saturation; prn, as needed; SBP, systolic blood pressure; SL, sublingual. Adapted from Peacock WF, Allegra J, Ander D, et al. Management of acutely decompensated heart failure in the emergency department. CHF 2003; 9(suppl 1):3-18
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After diagnosis of ADHF, initiate therapy based on presenting signs and symptoms

- **(A) Signs and Symptoms of Volume Overload**
  - Orthopnea/PND
  - Edema
  - Chest x-ray: pulmonary congestion
  - Recent weight gain

- **(B) Signs and Symptoms of Low Cardiac Output**
  - Tachycardia
  - Decreased urine output
  - Cool extremities
  - TBP

- **(C) Mild volume overload**
  - Inadequate response to IV diuretics
  - Pre-noradrenaline
  - Increased oxygen requirements
  - CPAP or BiPAP requirements
  - Fatigue
  - Inpatient disposition unclear
  - Outpatient furosemide dose > 100 mg daily
  - SBP > 80 mm Hg

- **(D) IV Diuretics**
  - IV furosemide
    - On p.o. furosemide at home?
    - Give total dose as IV bolus (max 160 mg)
    - No p.o. furosemide at home?
    - SCr < 2.0 - start with 40 mg IV push
    - SCr > 2.0 - start with 80 mg IV push

- **(E) Moderate-Severe Volume Overload**
  - Inadequate response to IV diuretics + IV vasodilators
  - Inhalation therapy
  - Nitroglycerin 5-10 mcg/min infusion
  - Nitroprusside 2 mcg/kg IV push, then 0.03 mcg/kg/min infusion

- **(F) IV Diuretics + IV Vasodilators**
  - Furosemide
    - If furosemide given previously, double previous IV dose (max = 360 mg)
    - If no furosemide given previously and signs/symptoms of volume overload, give 40-180 mg IV as described above

- **(G) Mild-Moderate**
  - SBP > 90 mm Hg
  - On a β-blocker chronically?

- **(H) Milrinone**
  - 0.375 mcg/kg/min infusion
  - Adjust dose to desired effect

- **(I) Dobutamine**
  - 2.5 mcg/kg/min infusion
  - May also require vasopressors for BP support

- **(J) Very-Low Cardiac Output**
  - Pulmonary artery catheter placed
  - High SVR
  - High PCWP
  - Low CI
  - SBP < 80 mm Hg

**Inadequate Response**
- < 250-500 mL within 2 hours

**Consider Moderate-Severe Volume Overload**

**Consider Very-Low Cardiac Output**

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Figure 2. Acute decompensated heart failure treatment algorithm. ADHF, acute decompensated heart failure; AJR, abdominal jugular reflex; BiPAP, bi-level positive airway pressure; BNP, B-type natriuretic peptide; CI, cardiac index; CPAP, continuous positive airway pressure; DOE, dyspnea on exertion; HJR, hepatojugular reflex; JVD, jugular venous distention; PCWP, pulmonary capillary wedge pressure; PND, paroxysmal nocturnal dyspnea; SBP, systolic blood pressure; SCr, serum creatinine; SOB, shortness of breath; SVR, systemic vascular resistance. Adapted with permission from DiDomenico RJ, Park HY, Southworth MR, et al. Guidelines for acute decompensated heart failure treatment. Ann Pharmacother. 2004;38:649-660.

Figure 3. Timeline for the management of acute decompensated heart failure in the emergency department/observation unit. ADHF, acute decompensated heart failure; CO, cardiac output; ED, emergency department; ICU, intensive care unit; mod-sev, moderate to severe. Adapted with permission from DiDomenico RJ, Park HY, Southworth MR, et al. Guidelines for acute decompensated heart failure treatment. Ann Pharmacother. 2004;38:649-660.
There is no consideration of the patient with severe hypertension and acute pulmonary edema, occasionally referred to as “vascular failure” whose primary therapy should be control of blood pressure with intravenous vasodilators. Nonetheless, it is quite helpful with general management principles.

The right side of the algorithm provides treatment recommendations for patients with signs and symptoms consistent with low cardiac output [B]. Inotropic support is recommended, with specific choice of therapy based upon the degree of hypotension and whether or not a beta-blocker is being used [G]. Patients may require vasopressor support if symptomatic hypotension develops. Patients with low cardiac output who fail to respond to inotropic therapy should be evaluated for the presence of very low cardiac output and may require additional aggressive management [J]. Typically, these patients require admission to an intensive care unit and may require the placement of a pulmonary artery catheter to more accurately assess their hemodynamic status. Patients with very low cardiac output who have sufficient systolic blood pressure (>90 mmHg) may benefit from the addition of intravenous diuretic therapy and/or intravenous vasodilators [F].

The major emphasis of this protocol is managing volume overload which is further divided into mild and moderate-severe groups. Patients with mild volume overload [C] are treated with intravenous diuretic therapy, typically loop diuretics [D]. Dosages for patients previously taking diuretics are guided by the total home daily dose, given as an intravenous bolus. Therapy for patients not taking oral diuretics at home is based upon renal function, and clinicians should exercise caution with diuretic therapy in patients with renal dysfunction to avoid further injury. Success of diuretic therapy is driven by urine output goals, and recommendations for repeat diuretic dosing are described in the algorithm. Again, caution should be exercised with extremely high doses of loop diuretics, because in addition to prerenal azotemia, electrolyte abnormalities (hypokalemia/hypomagnesemia) are common and should be recognized and treated quickly. Standing orders for management of electrolyte disturbances can be quite helpful.

The authors recognized that patients with more severe volume overload are likely to have an inadequate response to intravenous diuretic therapy alone. In these patients the initial pharmacologic regimen should be more aggressive and include both an intravenous diuretic and vasodilator [F]. Nitroglycerin or nesiritide should be used to produce a more rapid response and more effectively relieve the signs and symptoms of congestion in these patients. Again, no specific recommendations are provided as to which vasodilator should be used, but the suggested starting dose of nitroglycerin (5-10 mcg/min) noted should be considerably higher. A corresponding physician order set was developed which can be modified accordingly to accommodate institutional variations in practice. These are a vital part of any management algorithm and are typically necessary to standardize the treatment of ADHF patients.

**ADHF Patient Types**

Other methods of categorizing ADHF patient types have recently been described by a consensus panel of heart failure experts comprised of cardiologists, emergency physicians, hospitalists and pharmacists. These classifications are based more on hemodynamic characteristics rather than clinical symptom profile or severity of disease. While most EDs don’t have the luxury of obtaining hemodynamic parameters such as pulmonary capillary wedge pressure or cardiac output via invasive means, they do have a reliable and easily obtainable parameter—the patient’s blood pressure. Patients can be classified into normotensive, hypertensive, and hypotensive ADHF. The exact pathophysiology, clinical characteristics, and treatment options of each of these patient types has yet to be fully elucidated but some recommendations based upon expert consensus can be suggested.
Normotensive ADHF

These patients are common and may represent nearly half of the ADHF population. Systolic blood pressure is in the range of 90-140 mmHg. Clinical characteristics include dyspnea and peripheral edema, which are the usual complaints and are often gradual in onset (days/weeks). Rales and pulmonary edema on chest radiograph may or may not be present. Treatment of this group is depicted in Figure 4 and is initiated with an intravenous loop diuretic. The patient’s renal function and response to diuretics should be measured and the blood pressure reassessed. If the patient’s BUN is less than 43 mg/dL, creatinine is less than 2.75 mg/dL, blood pressure is normal, and urine output is adequate (>1 liter in 4 hours), the patient is at low risk for mortality. These patients may be admitted to an observation unit or in-hospital floor and re-assessed for symptomatic improvement. However, if the patient is resistant to diuretic therapy and/or has poor renal function, the addition of a vasodilator such as nitroglycerin, nesiritide, or nitroprusside is warranted. Vasodilators reduce systemic vascular resistance and increase cardiac output, which help reduce preload, afterload, and pulmonary congestion. Because some vasodilators require careful titration, admission to the ICU may be appropriate, particularly in patients with renal insufficiency or those with inadequate urine output. If at any point the patient becomes hypotensive, the vasodilator should be discontinued. Evidence of hypoperfusion may warrant initiation of an intravenous inotrope.

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**Hypertensive ADHF**

Occasionally referred to as vascular failure, hypertensive ADHF may be the most common type of ADHF patient. Data from the ADHERE registry demonstrate that 50% of patients had a systolic BP greater than 140 mmHg on presentation. Patients with this type of ADHF are more often women, older, and more likely to have diastolic dysfunction with relatively preserved left ventricular function. Severe dyspnea is the predominant complaint although signs of end-organ hypoperfusion (altered mental status) may be present. Acute “flash” pulmonary edema is the hallmark of this syndrome and is usually evident on examination (rales) and chest radiography (pulmonary edema). Symptom onset is generally abrupt versus the gradual onset seen in patients with normotensive ADHF. However, response to therapy is typically just as rapid, in patients who are aggressively treated. Accordingly, the clinical target is blood pressure control with early, aggressive vasodilation, more so than diuresis. This is particularly true when pulmonary congestion is related to fluid maldistribution, rather than an increase in total fluid volume.

Treatment ensues with the immediate use of a topical or sublingual vasodilator, which is easily and rapidly administered, followed by an intravenous diuretic. This typically produces dramatic improvement within minutes. An intravenous vasodilator (nitroglycerin, nesiritide, or nitroprusside) should then be added, and renal function, blood pressure, and the response to therapy should be assessed. If the patient fails to respond accordingly or has other evidence of high risk (elevated BUN or...

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**Figure 5.** Emergency Department Management Pathway for Hypertensive Acute Decompensated Heart Failure.

*Based on clinical experience, if patients have marked improvement, an IV vasodilator may not be needed.
†Nitroglycerin (NTG)/Nitroprusside (NTP) use may require ICU admission regardless of medical status.
ADHF, acute decompensated heart failure; APE, acute pulmonary edema; ED, emergency department; ICU, intensive care unit; IV, intravenous; NES, nesiritide; SBP, systolic blood pressure. Adapted with permission from Kirk JD, Costanza MR. Managing Patients with Acute Decompensated Heart Failure. Clinical Courier December 2006; 23(56).
creatinine, hypotension), admission to the intensive care unit is recommended. If the patient responds adequately to initial therapy, admission to an observation unit or in-hospital floor is appropriate, unless ongoing titration of the vasodilator necessitates intensive care unit admission.

**Hypotensive ADHF**

Patients typically present with evidence of end-organ hypoperfusion (altered mental status, cool extremities, poor urine output) in addition to pulmonary congestion. Patients with a systolic blood pressure <90 mmHg usually have low cardiac output, but can follow a continuum from cardiogenic shock to reasonably well compensated heart failure. Although this is the smallest subgroup of patients with ADHF, accounting for only 3% of the ADHERE population, it is associated with a disproportionately high in-hospital mortality rate, approaching 30%. Admission to the intensive care unit is warranted and many of these patients require pulmonary artery catheterization to guide therapy. Typical hemodynamic parameters include elevated pulmonary capillary wedge pressure, decreased cardiac index and left ventricular ejection fraction, and advanced Killip class of III or IV.

This group is the most challenging to manage, given the myriad clinical profiles, hemodynamic parameters, and complications of therapeutic agents (hypotension, myocardial injury, mortality risk). Guidelines for therapy are likewise difficult to develop given these limitations (Figure 6). Inotropic therapy, which has been associated with poorer outcomes, does increase cardiac output and elevate blood pressure, and therefore may be appropriate in this critically ill population. If there are ongoing signs...
of congestion, the addition of diuretic therapy may also be reasonable but is frequently curtailed due to hypotension. In some cases, vasodilator therapy may be appropriate if blood pressure increases and there are ongoing hemodynamic derangements such as high systemic vascular resistance, elevated pulmonary capillary wedge pressure, low cardiac index, or poor urine output.\textsuperscript{7,15}

**SUMMARY**

Recent data have challenged the historical model of ADHF and revealed a more complex and varied pathophysiologic entity—one that consists of multiple types of heart failure patients with various forms of acute decompensation. Clinicians and investigators are now reconsidering their therapeutic options. Which drugs should be administered to what type of patient, and most importantly, what are the safety implications are two considerations. Although there is a paucity of evidence-based treatment strategies for patients with ADHF, management protocols and algorithms categorized by clinical profile and hemodynamic status are helpful in identifying ADHF patient types and matching them to specific therapies. Utilizing such strategies should improve the consistency of emergent care and hopefully patient outcome.

**REFERENCES**

