SPECIAL ARTICLE

Acute Heart Failure in Adults

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Heart failure (CHF) is one of the most important health problems of our population and surprisingly the only cardiovascular disorder whose prevalence, incidence and mortality is steadily rising in spite of extraordinary advances in the diagnosis and management of other forms of cardiac disease. Management of chronic CHF has been the focus of recently published guidelines by cardiovascular societies both in the United States and Europe. However, no analogous guidelines have so far addressed the management of acute CHF. This presentation aims to review current knowledge regarding the diagnosis and management of acute CHF, to promote a more accurate identification of this clinical disorder and an optimization of the care received by patients afflicted with this condition in our community.

Key words: Acute heart failure, Systolic ventricular dysfunction, Diagnosis, Brain natriuretic peptide, Medical treatment

Congestive heart failure has become a public health problem of major proportions. Recent epidemiologic studies report a prevalence of around 5 million cases and an annual incidence of 550,000 new cases in the United States (1-3). A still higher prevalence is described with advancing age, affecting around 6 to 10% of those 65 years or older. A dramatic rise has also been observed in annual hospitalizations due to CHF, from 550,000 admissions in 1985 to 900,000 admissions in 1995 (4). Estimates indicate that nearly 30 percent of those admissions represent acute, severe decompensation requiring management in intensive care facilities. Cardiology societies such as, the American College of Cardiology, the American Heart Association and the European Society of Cardiology have recently published revised guidelines for the management of chronic CHF in adults (5,6). However, no guidelines have been published addressing the treatment options for acute CHF, in spite of the recognition that emergency room and in-hospital treatment for this complication accounts for the majority of the direct costs related to this disorder.

The aim of this article is to offer practicing physicians a summary of the current approaches in the diagnosis and management of acute CHF, fully aware of the fact that therapy for patients with this heterogeneous clinical syndrome must always be highly individualized.

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Clinical Background

The clinical onset of acute CHF may occur in minutes, hours or few days with symptoms related to pulmonary congestion, low cardiac output or both. Presenting symptoms related to pulmonary congestion prominently include shortness of breath, particularly in the supine position, with minimal effort or at rest. Symptoms associated to an acute decrease in cardiac output include loss of alertness, confusion, lethargy, nausea, vomiting or lack of appetite. The most frequent clinical signs associated to acute CHF include resting tachycardia, tachypnea, pulmonary rales, an S3 gallop and hemodynamic instability with rapid changes in vital signs. The latter has been related to surges in catecholamine levels, which in turn lead to fluctuations in the systolic pressure and narrowing of the pulse pressure. Resting tachycardia has been considered a sign of poor prognosis, as it may be a premonitory sign of malignant ventricular arrhythmias (7). Tachypnea has been related to pulmonary edema and acidosis. A diminution in urine output and increases in serum creatinine and potassium are reported to be signs of poor prognosis (8).

Pathogenesis and Pathophysiology

Common causes of acute CHF in adults are listed in Table 1. As described in the table, acute CHF most commonly occurs in patients with chronic CHF that decompensate for various reasons, including volume overload related to noncompliance with instructions on diet or medications, the utilization of nonsteroidal anti-

inflammatory agents that can interfere with the effects of angiotensin converting enzyme inhibitors or upper respiratory tract infections.

Table1. Common Causes of Acute Heart Failure

Rapid worsening of chronic heart failure
Acute myocardial insult
      Myocardial infarction
      Myocarditis
Toxic or metabolic insult associated to alcohol or cocaine use
Infectious endocarditis
Cardiac arrhythmias
Acute increases in systemic oxygen demand
      Sepsis
      Hyperthyroidism
Post cardiac surgery
      Inadequate revascularization
      Residual effects of cardioplegia
      Prolonged ischemia
      Valvular dysfunction
      Tamponade

Acute myocardial insults such as ischemia or infarction are the most common causes of acute CHF in persons without antecedent history of cardiac decompensation. These processes may result in either dysfunction or loss of myocardial contractile elements with ensuing left ventricular or papillary muscle dysfunction, mitral regurgitation or in more catastrophic instances to rupture of either the ventricular septum or the free left ventricular wall. This latter event often presents as pulseless arrest with preserved electrical activity, and is associated with high mortality. In general, acute CHF secondary to ischemic insults is predominantly related to involvement of the left ventricle however, it could also occur after right ventricular infarction. In this last instance a frequent clinical picture is that of isolated right ventricular dysfunction, bradyarrhythmias, low cardiac output and normal pulmonary venous pressures (9).

Acute myocarditis represents a less common but serious cause of acute heart failure, which can be erroneously confused with a diffuse pneumonitis or even an acute myocardial infarction, in view of similar electrocardiographic findings. A myocarditis should be kept in mind when evaluating young persons with signs and symptoms suggestive of a diffuse pneumonitis or an acute myocardial infarction, as its adequate recognition and management may favorably alter its clinical course and prognosis (10). Toxic and metabolic insults to the myocardium secondary to alcohol abuse or use of cocaine may also lead to acute heart failure. Acute CHF may also ensue when infectious endocarditis leads to acute aortic or mitral valve or to dysfunction of an artificial valve. Those situations may produce an abrupt development of pulmonary edema, accompanied by tachycardia and hypotension.

Both tachy and bradyarrhythmias may be associated to acute CHF through diminution of the cardiac output. The most common cause of this situation is atrial fibrillation with rapid ventricular response by shortening of diastolic filling time, loss of the atrial contribution to cardiac output and inadequate ventricular filling.

Patients with prior systolic or diastolic ventricular dysfunction may develop acute CHF in the presence of another co-morbid state, like thyrotoxicosis or sepsis that may cause an acute increase in systemic oxygen demand that cannot be met by the failing heart. Various reports have described that cytokines released during sepsis may depress heart function and lead to severe ventricular systolic dysfunction (11). Acute CHF can also occur during or after any cardiac operation as a result of myocardial dysfunction associated with either inadequate revascularization, the residual effects of cardioplegia, prolonged ischemia, valvular dysfunction or cardiac tamponade (12). The severity of the process is usually associated to the preoperative condition of the myocardium and length of the ischemic time on cardiopulmonary bypass.

Diagnostic Work Up

Gathering of basic clinical data is a must when evaluating a patient for acute CHF at the emergency room or upon admission to an acute care facility (CCU, ICU) or a ward bed with telemetry, in order to determine its etiology, the underlying pathophysiologic mechanisms (systolic versus diastolic) and its severity. Such data includes:

1. A comprehensive history and physical examination: searching among others for the presence of ischemic heart disease, systemic hypertension, alcoholism, recent viral syndromes and valvular or congenital heart disease.

2. A twelve-lead electrocardiogram: screening for acute myocardial infarction, ventricular hypertrophy, arrhythmias or conduction defects.

3. Chest film: for assessment of heart size, pulmonary congestion, pneumonia or pleural effusion.

4. Assessment of weight and urine output.

5. Complete blood count, blood urea nitrogen, serum creatinine, serum electrolytes and blood glucose.

Other diagnostic tests such as:

- Cardiac markers: are to be assessed in patients with suspected myocardial ischemia or infarction.

- Arterial blood gases should be determined and closely monitored in patients with severe

respiratory distress or who experience respiratory failure or an abrupt change in mental status.

Treatment should precede or occur simultaneously with the above diagnostic evaluation in patients who present with an episode of acute pulmonary edema or cardiogenic shock. A more conventional diagnostic approach could be followed in less urgent situations.

Additional studies

1. Two-dimensional and Doppler echocardiogram

A two-dimensional and Doppler echocardiographic examination is an invaluable tool in the evaluation of patients with cardiac decompensation, as it offers vital information about cardiac size, thickness and performance. Most patients with symptoms and signs of CHF are found to have a left ventricular ejection fraction less than 40%. The Doppler examination provides unique assessment of valvular function and permits detection of intracardiac shunts and estimation of the pulmonary artery pressure. Doppler investigation of the diastolic mitral flow pattern is particularly useful also in assessing the presence of left ventricular diastolic dysfunction, as it is a well known fact, that as many as 30 to 40% of patients echocardiographically examined for CHF are found to have normal left ventricular systolic function (13). A common example of left ventricular diastolic dysfunction is seen in elderly hypertensive patients with left ventricular hypertrophy who present a clinical picture suggestive of CHF, but whose left ventricular systolic function is normal. Establishing a diagnosis of diastolic heart failure in such patients is crucial, as they may adequately respond to diuretics but could seriously deteriorate if exposed to vasodilator or positive inotropic therapy.

2. B-type natriuretic peptide assay (BNP)

Although, it is generally considered that heart failure is diagnosed at the bedside, it has been recognized for some time that its associated symptoms have limited accuracy. Furthermore, its clinical signs including tachycardia, neck vein distension, pulmonary rales, an S_3 gallop and peripheral edema have been found with a sensitivity of less than 35% and a positive predictive value that ranges from 3% to 61% (14).

Recent information has emerged regarding the effectiveness of assays of B-type natriuretic peptide (BNP) as an adjunctive tool for the diagnosis of CHF. BNP is one of several cardiac neurohormones secreted from the ventricles in response to volume and pressure overload and increased wall stress, which has been found in multiple reports to be very useful in the diagnosis of CHF, when utilized in combination with the basic clinical information (15).

Review of several studies indicate that one of the most important functions of the BNP assay is its capacity to improve clinical decision making, mainly in patients with acute dyspnea and in which a diagnosis of CHF is not totally evident. Some studies have demonstrated that adding the BNP assay to the clinical decision process significantly improves the predictive power of other clinical variables such as the history, physical signs, chest film and other laboratory studies and leads to a reduction in the rate of clinical indecision (16). Consequently, the utilization of the BNP assay together with other clinical data may enhance the accuracy in reaching to an initial diagnosis of a CHF and lessens the possibility of performing unnecessary studies or submitting the patient to erroneous treatment. In the Breathing Not Properly (BNP) study, the BNP assay was found to be the single most accurate predictor of the presence or absence of CHF and its accuracy surpassed that of either the National Health and Nutrition Examination Surveys (NHANES) or the Framingham criteria for CHF. BNP assay levels in that study significantly correlated with the severity of heart failure as assessed by the New York Heart Association functional classification (17).

Based on the potent negative predictive value of BNP levels the following guidelines have been suggested regarding their utilization in diagnosis and therapy of acute CHF (18). The BNP levels described below correspond to the bedside Triage B-type natriuretic fluorescence immunoassay (Biosite Diagnostics Inc.). Equivalent validated levels of similar assays could be employed for the same purpose.

1. A BNP <100 pg/mL, in a patient who presents symptoms and signs suggestive of acute CHF, should instead prompt the consideration of another diagnosis, as CHF would be most unlikely.

2. In a patient with previous chronic CHF and symptoms and signs of acute decompensation, a BNP assay ≥100 pg/mL, would be supportive of the diagnosis of CHF, but the obtained values would require comparison with that patient's "chronic" BNP values, as it is known that some patients could manifest an elevation of the BNP levels without evident CHF symptomatology.

3. In the setting of acute CHF symptomatology, BNP values from 100 to 400 pg/mL, point to the consideration of another cause of dyspnea like cor pulmonale, pulmonary embolism and others.

4. In the setting of acute CHF symptomatology, BNP values ≥400 pg/ mL, point in the direction of acute CHF.

It is important to stress that although the availability of rapid BNP testing has enhanced our skills to diagnose

acute CHF more accurately, the BNP assay should never be used alone, but must always be employed in the context of all the available clinical information.

It is worthwhile to remind that not all patients with elevated BNP levels will have clinically evident CHF. High BNP levels usually indicate underlying cardiac disease, not necessarily symptomatic heart failure, and should prompt additional testing (e.g., an echocardiogram to evaluate left ventricular function). It is similarly important to mention that a low BNP level may be found in patients with clinical evidence of heart failure if measured too early in the decompensated state, when BNP levels have not yet become elevated.

Medical Therapy

Significant progress has occurred regarding both medical and surgical interventions for management of patients with acute cardiac decompensation during the last decade. However, the scope of this presentation is to offer a brief summary of prevailing approaches for the medical treatment of that condition, in particular when related to severe systolic ventricular dysfunction, including: general principles of management, pharmacologic therapy, mechanical assistance and guides for patient disposition.

General principles of management. Adequate management of acute CHF requires a prompt and accurate diagnosis with identification of the underlying cause, the involved pathophysiologic mechanisms, any precipitating factors and the exclusion of other potential causes of acute dyspnea or congestion based on the available basic clinical data plus standard laboratory tests and procedures. The availability of BNP levels greatly improves the diagnostic accuracy. On occasions, such as in the cardiovascular operating room a transesophageal echocardiographic examination may be useful, along with more intensive hemodynamic monitoring, if clinically indicated.

The principal aim of therapy is to establish a prompt and effective therapeutic regime that leads to the relief of symptoms, the control of fluid overload, an increase in cardiac output and a decrease in vascular resistance. That regime should lead to a short hospital stay and the expeditious initiation or re-adjustment of an oral therapeutic program that will slow disease progression and promote patient's long-term survival.

In general, patients with antecedent chronic CHF may be maintained in their prior drug therapy regarding ACE inhibitors or angiotensin receptor antagonists (ARBs), aldosterone antagonists or beta-blockers. However, beta-blockers prescribed less than 2 weeks prior to

decompensation may require discontinuation or dose reduction. A 2-gram sodium diet and 1500 mL fluid restriction is generally indicated.

Respiratory care. Supplemental oxygen by nasal cannula or face mask is frequently warranted, with an aim to maintain the arterial oxygen saturation above 92%. Endotracheal intubation and mechanical ventilation could be required when oxygenation fails, or in cases of hypercapnia or extremely altered mental status. In those situations, the ventilator should be adjusted to maximize oxygenation and to minimize hypercapnia.

Stabilization of the hemodynamic status. Clinical assessment of the patients' initial hemodynamic status can be generally used as a guide for therapy. That can be usually determined by observing whether there is pulmonary or systemic congestion (i.e., is the patient "wet" or "dry") or if the patient exhibits a state of hypoperfusion or shock (i.e., is the patient "warm" or "cold")(19,20).

Symptoms such as orthopnea, paroxysmal nocturnal dyspnea and signs like jugular venous distension, pulmonary rales, hepatomegaly and peripheral edema are suggestive of congestion; lethargy, obtundation, a narrow pulse pressure, cold extremities, hyponatremia, hypotension and renal dysfunction (despite clinically evident fluid overload) are suggestive findings of hypoperfusion or shock. More than 90% of patients hospitalized for acute CHF present congestion clinically and thus would have an elevated pulmonary capillary wedge pressure, if catheterized. These patients could have either adequate or reduced perfusion or shock, however. Signs of hypoperfusion or shock occur in a small minority of patients with symptoms and signs of acute CHF (an estimated 5% or less) and are suggested by a systolic pressure < 90 mmHg, altered mental status, cold extremities and prerenal azotemia.

Pulmonary artery catheterization is not always necessary but may be an important tool for assessment of cardiac output in some patients, particularly those with marked hypoperfusion or oliguria or when the ventricular filling pressures are questionable.

Pharmacologic therapy. Broadly speaking, patients with congestion but adequate perfusion are suitable candidates to receive intravenous diuretics, particularly if have a satisfactory renal function; positive inotropic drugs should be employed in patients with signs of marked hypoperfusion or shock, and vasodilator agents could be beneficial in both situations. However, the most appropriate therapeutic strategy for management of the majority of patients hospitalized with acute CHF, those with congestion and reduced perfusion but not in shock, has not been fully defined. The traditional management for these patients has been diuretics and or inotropic agents.

Diuretics. Prompt intravenous administration of diuretics is indicated in all patients with acute CHF, who present symptoms and signs of pulmonary congestion, but whose systemic perfusion is adequate (21). The diuretic agents of choice are the intravenous loop diuretics, such as furosemide, bumetanide and torsemide. The recommended starting dose of these agents is at double the daily oral dose with reassessment every two to four hours. Occasionally, diuretics are required in a continuous intravenous infusion in patients with more than 10 pounds of edematous weight or those with a suboptimal response to bolus diuretic therapy. Addition of thiazide diuretics may benefit some patients that do not respond to adequate intravenous loop diuretics alone.

Use of diuretics requires monitoring of the acid-base status and serum electrolytes as acidosis and alkalosis may further depress myocardial function and low serum potassium or magnesium may give rise to serious complications. However, excessive reduction of the pulmonary capillary wedge pressure may cause postural hypotension, a decrease in stroke volume, an increase in systemic vascular resistance and the activation of the renin-angiotensin-aldosterone system with subsequent sympathetic activation and increased water and sodium retention. Use of diuretics as sole therapeutic agents has been reported to diminish the glomerular filtration rate with further compromise of renal function (22).

Positive inotropic therapy. Although the intravenous positive inotropic agents are widely utilized in the treatment of acute CHF, their definite indication is in patients who present signs of hypoperfusion or cardiogenic shock (23). Recent studies have discouraged the routine utilization of these agents in patients with either acute or chronic heart failure due high mortality, increased risk of hospitalization, aggravation or induction of arrhythmias and other complications (24, 25). Their primary direct hemodynamic effects are to increase cardiac index, decrease systemic vascular resistance and indirectly increasing ventricular filling pressure.

A list of the most frequently used positive inotropic agents is included in Table 2. The most regularly used of those agents are the phosphodiesterase inhibitor milrinone

Table 2. Inotropic Agents Used in the Treatment of Acute Heart Failure

Milrinone
Dobutamine
Dopamine
Epinephrine
Norepinephrine
Vasopressin

and the beta agonist dobutamine, both of which exhibit vasodilatory and positive inotropic effects. Milrinone is predominantly employed for acute exacerbations of chronic heart failure, where the response to dobutamine may not be optimal due to the patient's chronic adrenergic state or to the concomitant chronic use of beta-blockers. As these medications are not vasoconstrictors, they tend not to cause a rise in blood pressure and may even decrease it.

Other inotropic agents with vasopressors properties, such as dopamine, epinephrine, norepinephrine and vasopressin are in general most useful in patients with low systemic vascular resistance, like patients with concomitant sepsis.

Vasodilators. Vasodilator treatment is particularly indicated in patients with acute CHF who present congestion or significant hypoperfusion. The rationale for utilization of vasodilators in acute CHF rests on the fact that this pathophysiologic state is one of relative vasoconstriction secondary to compensatory neurohormonal activation with liberation of vasopressor substances such as norepinephrine, angiotensin II, aldosterone, endothelin and vasopressin. This neurohormonal activation promotes volume overload, elevation of ventricular filling pressures and the congestion observed (26). The primary hemodynamic effects of vasodilators are to directly decrease ventricular filling pressures and systemic vascular resistance and to indirectly increase cardiac index. Traditionally, intravenous nitroprusside and nitroglycerin have been the vasodilators mostly utilized in patients with CHF, but alternative agents are being preferred at present in view of safer hemodynamic and side effects profile. IV nitroglycerin still remains a choice in patients with acute ischemic processes.

Nesiritide (recombinant B-type natriuretic peptide (BNP), identical to the endogenous BNP produced by the ventricles) and the first FDA-approved IV vasoactive drug for treatment of acute CHF in over a decade, is at present a preferred vasodilator agent over either nitroprusside or nitroglycerin. Nesiritide is a balanced vasodilator that decreases preload and afterload and increases cardiac output, thus improving the symptoms of patients with acute CHF (27). Unlike nitroglycerin and nitroprusside, which exhibit no direct effects on the neurohormonal milieu of heart failure, nesiritide has been found to directly suppress the renin-angiotensin-aldosterone axis and the sympathetic and other counter-regulatory hormonal systems (28).

The Vasodilation in the Management of Acute CHF (VMAC) Trial in which nesiritide was compared with nitroglycerin (the most commonly prescribed IV

vasoactive therapy for CHF at that time) and placebo in patients with decompensated CHF, established the superiority of nesiritide over nitroglycerin regarding improvement of hemodynamic parameters, tachyphylaxis and incidence of other side effects (29). The recommended starting and maintenance doses of nesiritide are: a 2 mg/kg intravenous bolus; followed by a 0.01 mg/kg/min infusion. Reassessment of therapy is to be performed frequently and the drug could be discontinued after 24 hours, if symptoms are resolved and the patients' urine output has improved.

Mechanical assistance. Intraaortic balloon counterpulsation is to be considered in some patients when signs and symptoms of low cardiac output persist in the presence of high filling pressures and threaten organ dysfunction, such as renal or liver failure.

A line of last resort in therapy could be the necessity to install short or long-term mechanical support with a ventricular assist device. This measure might eventually be necessary when all of the above measures fail and before irreversible organ dysfunction occurs, as a bridge to recovery or cardiac transplantation.

After stabilization, the patients are to be maintained in an oral therapeutic regime in agreement with their particular clinical characteristics and any accompanying co-morbid conditions, so as to assure the full resolution of the symptoms prior to hospital discharge. All patients must receive an education session regarding their condition, diet, fluid ingestion, medications, daily weight, allowable activities and exercise. Upon discharge, a comprehensive neurohormonal blockade regime (including ACE inhibitors or ARBs, aldosterone antagonists and cautious use of beta blockers) is to be prescribed aimed at prolonging survival, the enhancement of clinical stability and the reduction of re-hospitalizations or adverse outcomes.

Resumen

La insuficiencia cardíaca es uno de los problemas de salud más importantes de nuestra población. Sorprendentemente, es la única condición cardíaca cuya prevalencia, incidencia y mortalidad sigue en aumento a pesar de los avances significativos ocurridos en años recientes en el diagnóstico y el tratamiento de los demás desórdenes cardiovasculares. Distintas sociedades cardiovasculares tanto en los Estados Unidos como en Europa han publicado recientemente guías para el manejo de la insuficiencia cardiaca crónica. Sin embargo, todavía no se han estructurado guías similares para el manejo de la insuficiencia cardíaca aguda. El objetivo de esta presentación es aportar para la práctica clínica diaria, un repaso actualizado sobre el diagnóstico y el manejo de la insuficiencia cardíaca aguda y el promover una identificación más precisa y un mejor cuidado para los pacientes con esta condición clínica en nuestra comunidad.

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