

Medical management of decompensated heart failure in adult patients: Part 2: Organ involvement, invasive hemodynamic monitoring, device therapy, and outcomes

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ABSTRACT

Acute decompensated heart failure is a clinical syndrome involving the congestion of vital organs, such as the kidneys, liver, and brain, leading to loss of autoregulation and multiorgan failure. The interaction between organ systems is bi-directional and complex; it cannot be explained by hypoperfusion alone. Despite the multiple signs and symptoms that arise with systemic congestion, there are limitations in the assessment of volume status based only on clinical evaluation. Invasive hemodynamic monitoring is an adjunctive diagnostic and prognostic tool in acute decompensated heart failure when standard therapy fails and/or leads to worsening renal function as well as for the evaluation of advanced therapy options. This review will discuss the use of temporary mechanical circulatory support devices in cardiogenic shock and the expected outcomes for advanced heart failure with the implementation of left ventricular assist devices and cardiac transplantation.

Keywords: acute decompensated heart failure, organ dysfunction, medical management, device therapy

IDENTIFYING END ORGAN INVOLVEMENT IN THE SYSTOLIC HEART FAILURE PATIENT

RENAL IMPAIRMENT

It is known that there is an interaction between renal function and the cardiovascular system. From a heart failure perspective in clinical practice, this is appreciated by initial renal function parameters measured in the serum of a patient and changes in these as medical therapy for heart failure is initiated. Thus, when a patient presents with decompensated heart failure and abnormal renal function, it is important to

distinguish between underlying kidney disease and impaired kidney function precipitated by a collapsing cardiovascular system. Ancillary testing that finds proteinuria, active urine sediment, hematuria, pyuria, or abnormal sized kidneys on radiologic studies usually suggests underlying kidney disease.

Due to the concomitant presence of these diseases the term cardiorenal syndrome (CRS) was initially used broadly for several decades until 2004 when a group of investigators at the National Heart, Lung, and Blood Institute defined the syndrome as a state in which therapy to relieve heart failure (HF) symptoms is limited by further worsening renal function.⁷⁸ Although this seems to be the most common use of the term, some authors argue that it is inaccurate. In 2008, a new definition and classification were proposed by Ronco and colleagues; CRS was defined as a pathophysiologic disorder of the heart and kidneys in which acute

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or chronic dysfunction of one organ may induce acute or chronic dysfunction of the other.⁷⁹ The reduction in GFR was initially thought to result from a reduction in renal blood flow. However, the relationship between heart and kidney is bidirectional; the mechanisms causing CRS seem to be more complex than just reduction of blood flow and include activation of the sympathetic and renin–angiotensin–aldosterone systems, alterations in nitric oxide bioavailability, inflammation, and overproduction of reactive oxygen species.⁷⁹ In these patients a urinary sodium (UNa) below 25 meq/L can occur and is related to activation of the renin–angiotensin–aldosterone and sympathetic nervous systems causing reduced renal perfusion and sodium retention. Heart failure is also a cause of prerenal azotemia, but evidence suggests that worsening renal function due to HF is not solely related to reduced cardiac output. It frequently occurs in patients with elevated right atrial pressures.⁸⁰ Based on the complex heart–kidney interactions and to emphasize the bidirectional nature of dysfunction in these organs, a new classification was created:

1. Type 1 (acute): an abrupt worsening of cardiac function leading to acute kidney injury (e.g., acute cardiogenic shock or decompensated HF).
2. Type 2: chronic abnormalities in cardiac function (e.g., chronic HF) causing progressive chronic kidney disease (CKD).
3. Type 3: an abrupt worsening of renal function (e.g., AKI or glomerulonephritis) causing acute cardiac dysfunction (e.g., HF, arrhythmia, ischemia).
4. Type 4: CKD (e.g., chronic glomerular disease) contributing to decreased cardiac function, cardiac hypertrophy, and/or increased risk of adverse cardiovascular events.
5. Type 5 (secondary): a systemic condition (e.g., sepsis) causing both cardiac and renal dysfunction.⁷⁹

CONGESTIVE HEPATOPATHY

Liver dysfunction also occurs in HF, and almost every condition that causes right-sided HF can result in hepatic passive congestion, secondary to elevated right ventricular pressures leading to increased central

venous pressure (CVP) and liver reduced blood outflow.⁸¹ Hepatic congestion can be asymptomatic and detected only by abnormal liver tests found at routine laboratory analysis. In the onset of HF there are two forms of liver dysfunction: chronic congestion or volume retention, which is related to increased CVP and associated with total bilirubin elevation, and acute hepatocellular necrosis, which is caused by impaired perfusion and associated with elevation in serum aminotransferases as seen in patients with shock liver.^{82,83} Thus cardio-hepatic syndrome (congestive hepatopathy) shows a predominant cholestatic enzyme pattern (bilirubin, alkaline phosphatase, and γ -glutamyl-transpeptidase); in acute HF, elevated aminotransaminases are characteristic.⁸⁴

When evaluating hemodynamics, an upper safety limit of inferior vena cava (IVC) pressure is about 27 cm H₂O (20.5 mm Hg), which is already significantly elevated, and a pressure of 35 cm H₂O (26.6 mm Hg) in the IVC is probably a critical level for maintaining liver viability.⁸⁵

The increase in CVP eventually leads to atrophy of hepatocytes and perisinusoidal edema, impairing oxygen and nutrient diffusion.⁸⁶ Cholestatic enzymes, but not aminotransaminases, are associated with severity and chronicity of HF, and with tricuspid regurgitation severity.^{84,8} It has been demonstrated that right ventricular end-diastolic diameter, right atrial area, tricuspid regurgitation, TAPSE, portal vein pulsatility index, and left ventricular ejection fraction are significant predictors of total bilirubin elevation.⁸⁸

Allen et al. reported that a total bilirubin level above the upper limit level was a prognostic predictor of cardiovascular death, worsening heart failure, and all cause mortality. They concluded that total bilirubin in combination with other characteristics (blood count, basic metabolic panel, age, recent hospitalization, and New York Heart Association functional class) may provide an important estimation of overall risk of morbidity and mortality in patients with HF.⁸⁹

Ultimately the clinical presentation of congestive hepatopathy consists in signs and symptoms of right-sided HF rather than those of liver disease. Hepatomegaly is present in 95–99% of cases. A mild, dull,

right upper quadrant pain is caused by Glisson's capsule stretching. A pulsatile liver is the result of volume overload in the right atrium, and loss of such pulsatility implies a progression toward fibrosis or cirrhosis and deserves careful examination.⁹⁰ Ascites may be present in up to 25% of the patients and is the result of right-sided HF and not from intrinsic liver dysfunction.⁸³ As a result, liver abnormalities in an HF patient warrant additional testing to evaluate the morphology and liver synthetic function to distinguish between the presence of primary liver disease and/or its involvement due to abnormal hemodynamics.

HEART FAILURE-INDUCED BRAIN INJURY

Recent data have demonstrated that cerebral blood flow (CBF) is compromised in HF, suggesting an association with CNS-related symptoms.⁹¹ Brain hypoperfusion is not only the result of low cardiac output, but cerebral autoregulation is also compromised.⁹² Levels of carbon dioxide levels fluctuate in patients with acute and with chronic HF, being inversely related to left ventricular end-diastolic pressures, causing constriction and dilatation of CNS blood vessels.^{93,94} Georgiadis et al. demonstrated that even though patients with HF had baseline flow-velocities comparable to those of normal controls, their response to the hypercapnic state (which normally causes vasodilation and increased flow) was blunted.⁹²

Brain function abnormalities associated with HF include reduced psychomotor speed, learning and attention deficits, memory dysfunction, reduced executive function, and occasional language alterations.^{95,96} Mechanisms proposed for these changes include a lack of collaterals and watershed phenomena in deep brain structures causing ischemic damage in hypoperfused conditions.⁹⁷

Another aspect that supports the brain injury secondary to heart failure is how cognitive function improves after LVAD implantation and cardiac transplantation.^{98,99} Angiotensin-converting enzyme inhibitors seem to improve cognitive performance not only due to improved cardiac function but because angiotensin-converting enzyme is present in major cerebral arteries, causing an increase in cerebral perfusion.^{100,101}

ROLE FOR INVASIVE HEMODYNAMICS MEASUREMENTS

Invasive hemodynamic monitoring with a pulmonary artery catheter has a specific role in the management of heart failure. Its routine use is not recommended in normotensive patients with acute decompensated heart failure who respond to diuretics and vasodilators. According to the 2013 ACC/AHA guidelines, right heart catheterization is indicated to guide therapy in patients with respiratory distress or clinical evidence of hypoperfusion when there is an unclear understanding of the hemodynamic state based on clinical evaluation (Class I, LOE C).¹⁸ It is also recommended in symptomatic patients who are refractory to standard treatment and who meet the following clinical scenarios: volume status is uncertain by clinical evaluation, persistent and clinically significant hypotension (symptomatic low blood pressure or SBP <90 mm Hg), use of parenteral vasoactive agents, and/or worsening renal function despite treatment. (Class IIa, LOE C). These recommendations are also in accordance with the 2016 ESC guidelines.¹⁰ In addition, invasive hemodynamic monitoring is required for the evaluation of advanced therapy options including mechanical circulatory support (MCS) or cardiac transplantation (Class IIa, LOE C) and is the gold standard for the diagnosis and surveillance of pulmonary artery hypertension.^{18,102}

Right heart catheterization is an important tool in determining the etiology of shock and has a prognostic utility in patients with heart failure.¹⁰² Hemodynamic parameters are used to tailor therapy in patients who require inotropic support. Despite its role in direct heart failure therapy in the intensive care unit, the Swan-Ganz catheter has not been associated with increased survival and has limitations, including an inability to use it in the outpatient setting and provide frequent measurements, operator dependent errors inherent to the procedure, and pressure variation with respiration.¹⁰²

The Evaluation Study of Congestive Heart Failure and Pulmonary Artery Catheterization Effectiveness (ESCAPE) trial in 2015 was a randomized controlled trial of 433 patients designed to determine if pulmonary artery catheterization (PAC) is safe and

improves clinical outcomes in patients hospitalized with severe symptomatic and recurrent heart failure.¹⁰³ The use of PAC did not affect the primary end point (days alive and out of the hospital during the first 6 months), mortality, or the number of hospitalization days. However, in-hospital adverse events were more common in the PAC group ($p=0.04$). No information was provided on the use of PAC in cardiogenic shock as this patient population was excluded from the trial. The study results support the recommendation that there is no indication for routine PAC use to adjust therapy for decompensated heart failure.¹⁰³ It is an opinion of the authors that it should be considered on a case by case scenario. Similar results were found in a meta-analysis of 13 RCTs ($n=5051$) that showed no changes in mortality or days of hospitalization with the use of a PAC device in critically ill patients.¹⁰⁴

Strategies to prevent heart failure hospitalizations based on clinical assessment alone have not been successful. It has been established that hemodynamic congestion occurs weeks before clinical congestion is evident.¹⁰⁵ For this reason, the role of remote intracardiac and pulmonary artery pressure monitoring has been explored in an effort to decrease hospitalizations for heart failure.¹⁰⁵ According to the ESC Practice Guidelines, remote hemodynamic monitoring is recommended in patients with symptomatic heart failure and a recent heart failure hospitalization (class IIb recommendation).¹⁰ The Hemodynamic-GUIDEd Management of Heart Failure (GUIDE-HF) trial is a prospective study at 140 sites who will enroll NYHA class II-IV patients with HF with an elevated BNP and/or prior HF hospitalization (HFH) to demonstrate the effect of a pulmonary artery pressure sensor (CardioMEMS™ HF System) in HFH, intravenous diuretic visits and all-cause mortality.¹⁰⁵ Ongoing clinical trials are required to determine which groups of heart failure patients will benefit from remote hemodynamic monitoring.

TEMPORARY MECHANICAL CIRCULATORY SUPPORT IN SYSTOLIC HEART FAILURE

There are approximately 6 million adults in the United States with congestive heart failure.¹⁰⁶ The need

for percutaneous ventricular assist devices (VAD) in acute decompensated heart failure has emerged with increased survival from myocardial infarction (MI) and heart failure. Timing of circulatory support is critical for improvements in survival.¹⁰⁷ There is now a role for mechanical circulatory support initiated at earlier heart failure stages, prophylactically in high risk clinical scenarios before shock progresses to end-organ dysfunction and even in some cases of cardiac arrest where spontaneous circulation cannot be achieved by other means.¹⁰⁷

Ventricular assist devices unload the ventricle, and thereby decrease myocardial oxygen consumption, and promote favorable remodeling, and maintain an adequate systemic pressure and cardiac output (CO) for organ perfusion.¹⁰⁷ The following section discusses the use of the different forms of mechanical support, including intra-aortic balloon pump (IABP) and continuous aortic flow augmentation (i.e., Impella). In addition, there is a section on extracorporeal membrane oxygenation (ECMO).

INTRA-AORTIC BALLOON PUMP

The IABP is the most commonly used hemodynamic support device in the treatment of acute heart failure from MI.¹⁰⁶ The IABP is inserted percutaneously via the femoral artery with the balloon placed in the proximal descending aorta. Inflation of the balloon is synchronized with diastole producing diastolic aortic pressure augmentation that increases coronary artery pressure as well as mean arterial pressure and thus improves coronary, cerebral, and peripheral perfusion.^{106,107} Deflation then occurs before systole to lower aortic end-diastolic and systolic pressures with a resulting reduction in ventricular afterload and myocardial oxygen consumption and improvement in cardiac output (CO).^{106,107}

The Intra-Aortic Balloon Counterpulsation in Acute Myocardial Infarction Complicated by Cardiogenic Shock (IABP-SHOCK II) trial showed no mortality reduction of IABP compared with medical therapy in the setting of AMI complicated by cardiogenic shock (30-day mortality 39.7% with IABP vs. 41.3% with medical therapy, RR with IABP 0.96, 95% CI 0.79-1.17,

$p=0.69$).¹⁰⁸ Moreover, Stretch et al. demonstrated that IABP prior to the use of contemporary mechanical circulatory support was a predictor of mortality and increased costs.^{106,109} The intra-aortic balloon pump is considered a class IIa indication for use during STEMI complicated by cardiogenic shock according to the 2013 ACC/AHA guidelines.¹⁰⁶

IMPELLA

The Impella is a percutaneous VAD placed across the aortic valve that provides non-pulsatile blood flow by unloading the left ventricle (LV) and delivering blood to the ascending aorta through a trans-axial pump.¹⁰⁶ The device works in series with the LV to improve cardiac output. Impella flow is continuous, independent of cardiac rhythm, and offers a different mechanism of circulatory support than the IABP.

Based on the study A Prospective Feasibility Trial Investigating the Use of IMPELLA RECOVER LP 2.5 System in Patients Undergoing High Risk PCI (PROTECT I) trial and A Prospective, Randomized Clinical Trial of Hemodynamic Support With Impella 2.5 Versus Intra-Aortic Balloon Pump in Patients Undergoing High-Risk Percutaneous Coronary Intervention (PROTECT II) trial, Impella 2.5 and Impella Cardiac Power are approved for use in hemodynamically stable patients undergoing elective or urgent high risk PCI (HR-PCI).^{106,110} The PROTECT II study included 452 symptomatic patients with complex multivessel disease or unprotected left main disease and severely depressed LV function. The primary endpoint was a 30-day composite of 11 major adverse events. Results from PROTECT II trial showed that the 30-day incidence of major adverse events was not statistically different for patients with IABP or Impella 2.5 (35.1% with Impella vs. 40.1% with IABP, $p=0.227$). However, a trend for decreased major adverse events was observed in patients with Impella 2.5 vs. IABP (40.6% versus 49.3%, $P=0.066$) in the intention-to-treat population at 90 days.^{106,110} Additionally, the catheter-based ventricular assist device (cVAD) registry is an observational, multicenter, retrospective registry of patients supported with Impella that suggests greater survival with pre-PCI Impella insertion compared with pre-PCI IABP and/or pharmacotherapy alone.^{106,111} The use of Impella in PCI with cardiogenic shock and

in cardiogenic shock with multiorgan failure is a class I indication according to the 2013 ACCF guidelines.¹⁰⁶

According to the U.S. Impella Registry, early circulatory support (pre-PCI) improved hospital survival to discharge in acute MI complicated by cardiogenic shock (65.1% vs. 40.7%; $p=0.003$). Using hemodynamic support at early stage permits more complex revascularization ($p=0.003$).^{107,112} Finally, The Use of Impella RP Support System in Patients With Right Heart Failure (RECOVER RIGHT) study performed to determine Impella RP safety and efficacy, showed a 73% successful survival to either 30 days or to hospital discharge. The FDA has approved the Impella RP for patients with acute right heart failure or decompensation after LVAD implantation, MI, heart transplant, or open-heart surgery.¹⁰⁶

VENO ARTERIAL EXTRACORPOREAL MEMBRANE OXYGENATION

Venoarterial Extracorporeal Membrane Oxygenation (VA-ECMO) is a mechanical cardiopulmonary support used for acute cardiac failure or combined (cardiac and respiratory) failure; veno-venous ECMO is used when respiratory support is needed exclusively.¹⁰⁷ The VA-ECMO works by removing blood from venous system (RA or IVC) and returning it to the arterial side after gas exchange.

The Extracorporeal Life Support Organization (ELSO) registry reported 27% survival to hospital discharge with ECMO to support CPR in adults after cardiac arrest; the need for renal replacement therapy increased mortality.¹¹³ More recent studies have shown 49% survival with either mechanical support devices or ECMO in cardiogenic shock. Prolonged CPR was a risk factor for increased mortality.¹¹³ There are no large randomized controlled trials on the use of ECMO. Guidelines recommend ECMO when concomitant hypoxemia and RV failure are present.^{106,107}

DEVICE CHOICE

Percutaneous VADs are used as a bridge to recovery in patients with cardiogenic shock from potentially reversible causes and provide support in high risk

procedures that attempt to avoid cardiogenic shock precipitants¹⁰⁶ They can also be used as a bridge to allow time for risks and benefit assessment for more definite treatments like LVAD or heart transplant, also considered bridge to candidacy.¹⁰⁶

The decision on the device selection should be individualized considering the severity of cardiogenic shock from initial presentation, the degree of mechanical support needed in the setting of left, right or biventricular failure, and the presence of impaired pulmonary function. Several parameters, including circulatory support, ventricular support, and coronary perfusion, help patient selection.¹⁰⁷

The IABP increases coronary perfusion by diastolic augmentation and provides afterload reduction. It offers less systemic support than other devices and depends on the electrical and mechanical function of the heart.¹⁰⁷ The Impella does not affect afterload but decreases preload and increases CO and systemic pressures. According to Sodhi et al., the Impella is more effective than IABP in reducing LV-end diastolic pressure and equally effective in coronary perfusion in the setting of acute decompensated heart failure and shock.¹⁰⁶ Last, ECMO is the most effective in increasing CO as well as maintaining oxygenation and systemic blood pressure. It is superior to IABP and Impella because it has the ability to provide independent left, right, and biventricular support at high blood flow rates and respiratory support if required.¹¹⁴ However, its effect is limited due to increased myocardial oxygen demand as ECMO has two opposing hemodynamic effects.¹⁰⁶ When blood is removed from the venous system, preload decreases and there is a reduction in LV end-diastolic volume and pressure with subsequent reduction in wall stress and work. However, as blood returns to the arterial system, there is an increase in LV afterload which in turn causes higher myocardial oxygen consumption and affects cardiac remodeling and recovery.^{106,115} For this reason, ECMO has been used concomitantly with other mechanical support devices for both preload reduction with Impella and afterload reduction with the IABP.¹⁰⁷ Moazzami et al. showed that the Impella 2.5 serves to unload the LV reducing right atrial pressure, pulmonary capillary wedge pressure, and LV end-diastolic pressure when used with ECMO.^{115,116}

While there are favorable hemodynamic effects associated with mechanical support, there is a lack of evidence that demonstrates a survival benefit of the Impella vs. medical therapy and IABP. Guidelines require randomized controlled trials that evaluate the benefit of hemodynamic support in cardiogenic shock.

EXPECTED OUTCOMES AND DISPOSITION

IS ORGAN RECOVERY A POSSIBILITY?

The clinical course of heart failure is progressive but nonlinear, characterized by worsening quality of life despite increasing levels of care.¹¹⁷ Prognosis in advanced HF is grave, with a 1-year mortality in ambulatory class III–IV patients >25% and exceeding 50% in class IV patients.¹¹⁸ However, a subset of patients with HFrEF shows improvement in EF with or without medical therapy. This cohort of cases, regarded as having heart failure with improved ejection fraction (HFief), has been shown to have 5-year survival rates of 80% to 90%, compared with 65% to 75% in HFrEF patients.¹¹⁹

Patients with HFief share demographic and clinical characteristics that are distinct from other classifications of heart failure. Among patients with recent onset (<6 months) HFrEF, Givertz et al. documented rates of LVEF improvement (to LVEF >50%) of 60–100% among patients with cardiomyopathy due to tachycardia, takotsubo syndrome, and hyperthyroidism.¹²⁰ Punnoose et al. compared patients with HFief and HFrEF and found that patients in the former category were younger and less likely to have coronary disease compared with the latter, but rates of atrial fibrillation, hypertension, and diabetes were similar.³ Genetic factors may also have a role in organ recovery. Activating mutations in the angiotensin-converting enzyme (ACE) or β 1-adrenergic receptor genes have been associated with refractoriness to medical therapy, whereas truncating mutations in the titin-A gene have a higher frequency of LVEF improvement (>10%).^{121,122} Other factors that have been shown to be associated with HFief include female sex, shorter duration of HF, and less severe adverse cardiac remodeling at initial evaluation.¹²³ However, it

is important to note that despite having improved or even normalized LVEF, these patients may continue to have clinical and biochemical evidence of functional impairment.¹²⁴

ADVANCED THERAPY OPTIONS

Developments in advanced heart failure therapeutics in the form of cardiac transplantation and left ventricular assist devices (LVADs) have transformed the prospects for patients with advanced heart disease refractory to optimal medical therapy. The 1-year survival rate following heart transplantation is about 90%, the 5-year rate is about 70%, but only about 20% survive 20 years or longer.¹²⁵ Quality of life after heart transplantation is also generally excellent and patients are frequently able to return to work, regardless of their profession.¹²⁶ The leading cause of death after heart transplantation is malignancy, followed by coronary artery vasculopathy (CAV), then by graft failure. Acute rejection, which used to be one of the main causes of death, now has a low incidence due to current drugs.¹²⁷ Despite its benefits, the process of transplanting a heart is drawn out and expensive, and many eligible patients simply never receive an organ due to the stagnating or decreasing number of suitable donors.

Durable left ventricular assist devices (LVADs) have become the most commonly used surgical therapy for advanced heart failure, and their use is now uncoupled from transplant candidacy.¹²⁸ Historically LVADs were indicated only as a so-called bridge-to-transplantation (BTT) to ensure survival until a donor organ became available.¹²⁹ Since publication of the Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure (REMATCH) trial in 2001 that demonstrated improved survival in advanced HF patients ineligible for transplantation treated with LVAD vs. optimal medical therapy, LVADs have become increasingly approved as a more permanent 'destination therapy' (DT).¹²⁸ With the advent of continuous flow devices, the 1-year survival of patients with LVADs is now in excess of 80%.¹³⁰ The vast majority of modern LVADs are continuous-flow (CF) devices. These pumps may be either centrifugal (HeartWare HVAD, Medtronic; HeartMate III,

St. Jude Medical) or axial-flow (HeartMate II, St. Jude Medical). Modern LVADs are driven electrically via a percutaneous driveline connected to a portable controller and external power source, typically batteries that are replaced every 4–18 h, and last >10 years.¹³¹ Currently, >2500 pumps are implanted in the U.S. every year, and it is clear that a linear increase has taken place since 2006.¹³² Early referral for evaluation in an LVAD or transplant center is essential. Physicians should strongly consider patients who remain in NYHA III despite optimal medical therapy; other factors that may guide decision-making include inability to walk one block, hyponatremia, significant renal dysfunction, frequent HF admissions, or lack of response to CRT.¹³³

ROLE OF PALLIATIVE CARE

Involvement of palliative care early in the course of life-limiting chronic illness has been associated with fewer invasive procedures and interventions at the end of life, decreased length of stay, and shorter admissions to intensive care units.¹³⁴ The WHO recommends that palliative care should be used "early in the course of illness, in conjunction with other therapies that are intended to prolong life," as it "improves the quality of life of patients and their families facing the problem associated with life-threatening illness, through the prevention and relief of suffering."¹³⁵ A cross-sectional study comparing symptomatic HF and cancer patients reported that HF patients may benefit from palliative care as much as cancer patients.¹³⁶ Nevertheless, a national survey of HF specialists in 2004 found that 67% had not referred a single patient to palliative care in the 6 months prior to the survey.¹³⁷ In a study of 600 patients who died from heart disease, 47% of family members said they did not receive adequate information about the disease and its progression, and 63% were unaware of the poor prognosis.¹³⁸

Symptomatic management of heart failure includes loop diuretics to decrease dyspnea and improve exertional capacity and opioids to alleviate dyspnea and pain. Testosterone supplementation therapy has been shown to improve exercise capacity, muscle strength, and peak oxygen consumption

in patients with advanced heart failure regardless of gender.¹³⁹ It is important to screen patients for sleep-disordered breathing and depression, given their high prevalence among HF patients. Continuous ambulatory inotrope infusion should be considered for patients with dyspnea at rest despite maximal medical therapy.¹⁴⁰ Medical devices such as permanent pacemakers and ICDs may no longer be indicated or desired by patients at end-of-life. About 20% of terminal heart failure patients with implantable cardioverter-defibrillators receive painful unnecessary shocks. Discontinuation of such therapies may actually improve quality of life for some patients.¹⁴¹

CONCLUSIONS-PART 2

Advanced heart failure leads to end-organ dysfunction, such as the development of cardiorenal syndrome, congestive hepatopathy, and heart failure-induced brain injury. Decreased blood flow can only partially explain the effect of a failing heart in other vital organs. Understanding the pathophysiological mechanisms and organ-organ interactions is key to the management of acute decompensated heart failure. The routine use of invasive hemodynamic monitoring is not recommended in acute decompensated heart failure and has not been shown to improve clinical outcomes. However, it has a utility in symptomatic patients who are refractory to standard treatment and most importantly those who are candidates for mechanical circulatory support or cardiac transplantation. There is now a role for the early initiation of mechanical circulatory support before cardiogenic shock leads to end-organ dysfunction including the use of percutaneous VADs in the setting of acute heart failure from myocardial infarction and as a bridge to recovery or definitive treatments like LVAD or heart transplantation. These advanced therapy options have significantly changed survival and quality of life for patients with heart failure who do not respond to optimal medical therapy. The clinical outcomes associated with these emerging therapeutic alternatives continue to be studied aiming to improve outcomes, and make these options available and recognizable by health care providers.

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