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ROLE OF ECHOCARDIOGRAPHY IN THE DIAGNOSIS AND MANAGEMENT OF HEART FAILURE IN THE ELDERLY

Vincent L. Sorrell, MD FACC and Navin C. Nanda, MD FACC

INTRODUCTION

Congestive heart failure (CHF) is extremely common in elderly individuals, with more than 10% of those aged 80 to 89 years having heart failure.[1] Although heart failure remains a clinical diagnosis, echocardiography assists in determining the cause, systolic and diastolic function, and hemodynamic state. Important differences in the elderly cardiovascular system are present and need to be considered. The rate of myocardial contraction and relaxation is prolonged. This abnormality in relaxation may account for the higher prevalence of normal left ventricular (LV) systolic function seen in elderly patients with heart failure, where more than 50% of patients older than 80 years have normal or near normal systolic function.[2]

The clinical findings are essentially indistinguishable, making the history and physical examination inadequate for estimating LV function. Although heart failure patients with a diastolic blood pressure greater than or equal to 105 mm Hg and no jugular venous distention have been shown to have a normal LV systolic ejection fraction (EF) with a positive predictive value of 100%, this combination of findings is uncommon.[3] Most other historical (age, duration of symptoms, history of hypertension, ischemic heart disease, or heavy alcohol drinking) and clinical variables (S3 gallop, edema, cardiomegaly, pulmonary congestion, or edema) are not significantly different in heart failure patients with normal or abnormal LVEF.[4] This reiterates the importance of investigating LV performance with echocardiography and not relying solely on clinical findings.

DIFFERENTIAL DIAGNOSIS

Determining the cause of heart failure is paramount to developing an adequate treatment regimen. In addition to numerous myocardial diseases, the clinical findings of heart failure may be caused by such diverse things as valvular stenosis or regurgitation, chronic pulmonary disease, or constrictive pericarditis. With the combined approach of a detailed history and physical examination, coupled with a complete two-dimensional and Doppler echocardiogram, the majority of these causes can be identified or excluded.

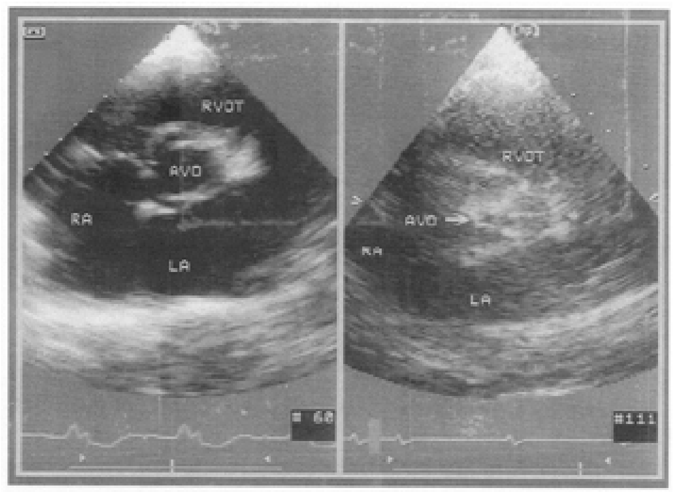

FIGURE 1. Two-dimensional echocardiography of the basal, parasternal, short-axis view in systole. The aortic valve opening (AVO) is easily visualized. Normal AVO (left) and severely reduced AVO (right) in a patient with aortic stenosis. RA = right atrium; LA = left atrium; RVOT = right ventricular outflow tract.

Aortic valve disease is extremely common in the elderly and ranges from calcific degeneration (aortic sclerosis) to severe, critical stenosis. Despite a detailed and careful physical examination, the severity of aortic stenosis is often in doubt, especially in the elderly.[5] Two-dimensional echo combined with conventional Doppler is well suited to investigate the severity of aortic stenosis (Figure 1). The modified Bernoulli equation converts measured velocities to mean and peak pressure gradients and the continuity equation provides an estimate of the aortic valve area. Color flow Doppler can assist in obtaining an accurate estimate of the aortic valve area.[6] When the findings of transthoracic echo are uncertain, both transesophageal echo and stress echo can provide additional insight into the severity and significance of the valve lesion.[7,8]

Mitral valve disease may also result in the clinical presentation of CHF. Mitral regurgitation (MR) is extremely common when the LV systolic function is reduced and the LV is enlarged. With mitral annular dilatation, coaptation of the valve is compromised and secondary, central MR occurs. The two-dimensional appearance of the valve is often normal and the degree of regurgitation is rarely severe until late in the disease. When LV dysfunction is secondary to MR, the two-dimensional appearance of the mitral valve is universally abnormal. In this situation, the degree of MR is often severe, and the direction of the regurgitant jet is commonly eccentric (directed away from a prolapsing and flail leaflet or toward a restricted or scarred leaflet). Quantifying the degree of MR is vitally important when considering surgery, but is beyond the scope of this article.[9] Importantly, it is becoming evident that, when feasible, severe MR should be repaired early to minimize progression of LV systolic dysfunction; in some cases this provides a surgical cure for CHF.[10]

Normal-appearing LV size and function associated with an enlarged right ventricular (RV) cavity, reduced RV function, and an elevated pulmonary artery pressure are indicative of cor pulmonale and raise the suspicion of pulmonary artery thromboemboli or primary lung disease.[11] A regional RV wall motion abnormality, dilated right pulmonary artery branch, paradoxical interventricular septal motion, plethora of the inferior vena cava, and hyperdynamic LV systolic function provide further support for the diagnosis of pulmonary artery thromboemboli.[12,13] If the RV free wall (best seen with subcostal imaging) is not significantly thickened (≥5 mm), then chronic elevation of the pulmonary artery pressure is unlikely, reducing the diagnostic possibilities to more acute causes. Severe pulmonary hypertension, marked RV dilatation, and prominent thickening of the RV free wall in the absence of left heart pathology should raise the suspicion for primary pulmonary hypertension.

M-MODE & TWO-DIMENSIONAL ECHOCARDIOGRAPHY

Echocardiography is ideal for assessing LV function, and this has become the most common reason for performing the study. Echocardiography can accurately resolve the endocardial borders throughout the cardiac cycle in multiple well-defined anatomic planes. With M-mode, the fractional shortening [(LV diastolic diameter-LV systolic diameter)/LV diastolic diameter] can be used as a rapid method for estimating LV systolic performance. With two-dimensional echo, inspection of the initial parasternal long axis view often correctly identifies patients with either normal or severely reduced LV systolic function. Additional views are required to characterize accurately intermediate degrees of LV systolic dysfunction.

Two-dimensional echocardiography, using validated geometric equations, can determine the LVEF, stroke volume (SV), and cardiac output (CO). By calculating the LV end-diastolic (EDV) and end-systolic (ESV) volumes, the SV is readily derived as SV = EDV - ESV. In the absence of significant valvular regurgitation, CO is estimated as the product of the SV and heart rate (HR): CO = HR X SV. The EF can then be calculated as EF = SV/EDV.

Each of these parameters requires accurate estimates of LV volumes. Although M-mode estimates have been reported to correlate reasonably well with angiographic volumes, the accuracy of this technique is contingent on the following assumptions: (1) the LV short axis diameter, measured at the mitral valve chordae tendinae, coincides with the minor axis; (2) the two minor axes are equal in length; and (3) the long axis is twice the length of the minor axis. This technique, termed the *cube*, or *cuboid method*, correlates with angiography only when the LV shape is ellipsoid and no regional wall motion abnormalities are present.[14] Unfortunately, when LV systolic function is reduced, the LV shape is often distorted and regional wall motion abnormalities are common. The use of M-mode echo as the sole means for estimating LV function is not recommended.

Two-dimensional echo offers considerable advantages over M-mode methods for determining LV volumes and should be used for quantitative assessment. It also provides excellent correlation with angiographic techniques, even in the presence of wall motion abnormalities.[15] Current ultrasound systems include software that can calculate volumes based on hand-traced regions of interest (Figure 2). Technically good quality images are necessary and recently have been improved by the development of second harmonic imaging.[16] When LV border delineation remains suboptimal, intracardiac contrast agents can be used. These agents cross the pulmonary circuit following intravenous injection and opacify the LV cavity for several cardiac cycles.[17] Additionally, newer software allows the LV chamber to be traced automatically on-line using real-time, automated border detection providing beat-to-beat estimates of EDV, ESV, and LV ejection fraction.

In addition to providing a quantitative assessment of EF, many echo laboratories, including our own, visually estimate this important parameter. In experienced hands, visual estimates are associated with a standard error of less than or equal to 11%, which compares favorably with quantitative echo methods (SE = 0.10) and radionuclide angiographic methods (MUGA scan; SE = 0.07).[18] As noted previously, visual estimates are most accurate when the LV function is either normal or severely reduced. When LV function is intermediate or indeterminate, quantitative techniques should be used.

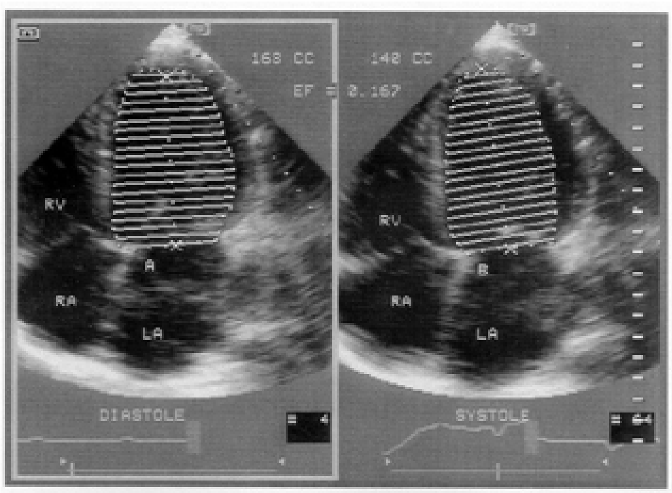

FIGURE 2. Two-dimensional echocardiography, apical four-chamber view. Modified Simpson's volumetric method for estimating left ventricular volume. After tracing the LV endocardial border, the software of the sonogram system automatically provides the volume in diastole (168 mL; left) and systole (140 mL; right) and calculates the ejection fraction (EF; 16.7%). RV = right ventricle; RA = right atrium; LA = left atrium.

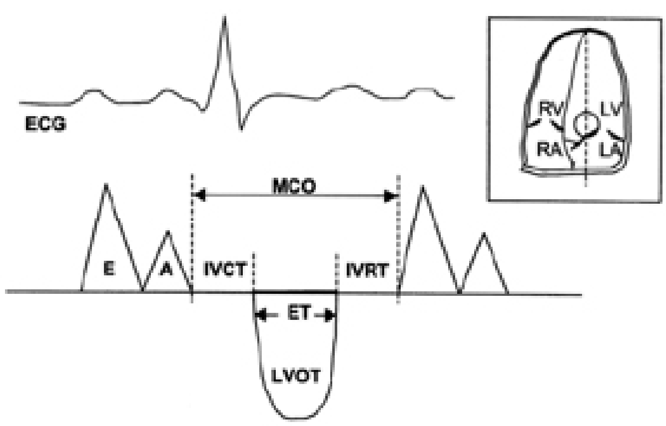

FIGURE 3. The method of measuring the index of myocardial performance. The inset represents an apical four-chamber view with the pulsed-wave Doppler sample volume in between the mitral valve leaflet tips and the left ventricular outflow tract allowing measures of both. Index of myocardial performance = (IVCT + IVRT)/ET or (MCO – ET)/ET. MCO = mitral valve closure-to-opening interval; E = mitral inflow early wave; A = mitral inflow atrial wave; IVCT = isovolumic contraction time; IVRT + isovolumic relaxation itme; ET = ejection time; LVOT = left ventricular outflow tract Doppler envelope; RV = right ventricle; LV = left ventricle; RA = right atrium ; LA = left atrium.

DOPPLER ECHOCARDIOGRAPHY

Pulsed or continuous wave Doppler echocardiography is also capable of estimating cardiac output. By placing the sample volume within the LV outflow tract (LVOT), the Doppler envelope can be obtained and traced to provide the time velocity integral. This stroke distance (cm) is then multiplied by the LVOT area (LVOT diameter^2 × 0.785; cm^2) to obtain the stroke volume (cm^3). Stroke volume multiplied by HR provides CO.[19] More recently, a global index of myocardial performance that combines both systolic and diastolic parameters has been described for both the right and left ventricles, but the clinical use of this index in older CHF patients has not yet been defined (Figure 3).[20]

ASSESSMENT OF DIASTOLIC FUNCTION

Echocardiographic assessment of diastolic function is primarily performed using pulsed Doppler echocardiography to interrogate various cardiac and venous chambers. Although no noninvasive technique can directly measure diastolic function, Doppler echo uses diastolic filling parameters to infer diastolic function parameters.

In most cases, a careful assessment of the transmitral and pulmonary venous flow patterns, combined with the two-dimensional echo findings, can provide an accurate estimate of diastolic performance. Generally, the mitral valve inflow velocity acceleration pattern is strongly influenced by ventricular relaxation and the deceleration pattern is closely related to ventricular compliance. The peak velocity, the most commonly measured Doppler parameter of diastolic filling, reflects a very complex interaction between the competing effects of both the acceleration and deceleration components. The spectrum of diastolic filling parameters is wide and related to differing degrees of pathology, varying contributions of abnormal relaxation, changes of ventricular and atrial compliance, and to the heart rate and volume status.

The various physiologic factors that affect mitral inflow velocities have been studied in experimental settings, allowing the individual contributions of each to be considered.[21] These experiments have shown that (1) elevated left atrial pressure causes an increased acceleration rate, shortened isovolumic relaxation time (IVRT), and significantly increased peak velocities; (2) impaired relaxation causes a delay in filling, and slightly lower peak velocities and acceleration; (3) increased ventricular stiffness markedly blunts the E-wave velocity; and (4) reduced systolic function causes a similar effect as increasing stiffness (ie, reducing the E-wave velocity).

MITRAL VALVE INFLOW AND PULMONARY VEIN ANALYSIS

The simplest and most commonly used technique for evaluating diastolic function is the mitral valve inflow assessment. With the sample volume placed at the tips of the mitral valve leaflets, the early diastolic (E wave) and the later, atrial contraction (A wave) Doppler velocity envelopes can be assessed. With a slightly more medial placement and larger sample volume, the LVOT Doppler velocity pattern can be assessed simultaneously, providing a measure of the IVRT. Simple pattern recognition allows the identification of three common abnormal pulsed Doppler patterns of mitral valve inflow: a LV relaxation abnormality pattern (mild); a pseudonormal pattern (moderate); and a restrictive physiology pattern (severe diastolic dysfunction) (Figure 4).[22]

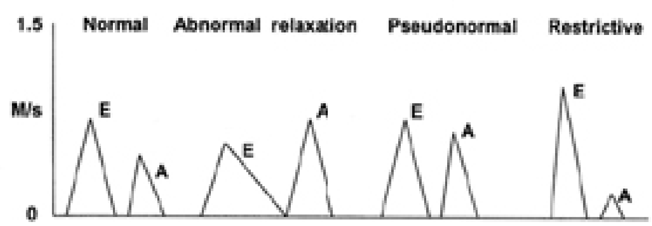

FIGURE 4. Pulsed-wave Doppler evaluation at the tips of the mitral valve leaflets. The velocity profiles of the mitral E and A waves for the most characteristic categories of diastolic dysfunction are shown from left to right. M/s = meters per second.

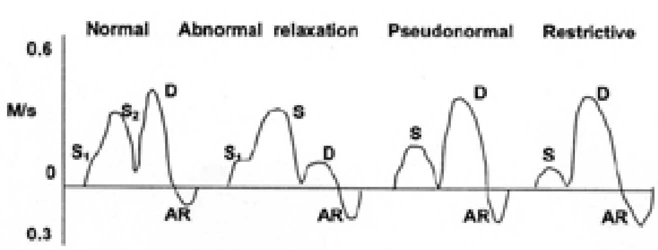

FIGURE 5. Pulsed-wave Doppler evaluation of the pulmonary vein. The velocity profiles of the pulmonary systolic (S1 and S2), diastolic (D), and the atrial reversal (AR) waves for the most characteristic categories of diastolic dysfunction are shown from left to right. M/s=meters per second.

Because mitral inflow findings in persons with abnormal diastolic function overlap with the findings in those with normal diastolic function, additional parameters must be used to characterize diastolic function more fully. Interrogating the pattern of pulmonary vein flow is both feasible and helpful. The pulmonary vein is assessed by using color Doppler guidance to assist in placing a pulsed Doppler sample volume in the right upper pulmonary vein, located along the atrial septum (apical four-chamber view). Three distinct waves are seen: (1) the systolic (PV-S), (2) diastolic (PV-D), and (3) atrial reversal (AR) waves (Figure 5). Often, the sample volume must be repositioned more distally to optimize the AR Doppler velocity envelope.

A reduced E wave and increased A wave, with resultant reversal of the normal E/A ratio, is suggestive of an LV relaxation abnormality (mild diastolic dysfunction). If the left atrial (LA) pressure is known to be increased, this finding is a reliable marker for delayed relaxation. Such a pattern, however, is also noted in patients with reduced LA pressure or normal aging. This pattern in isolation should be interpreted with caution. Other echo findings that occur with the impaired relaxation pattern include prolongation of the IVRT (>90 ms) and deceleration time (DT) of the E wave (DT > 240 ms). The PV-D wave parallels the mitral E wave and is decreased with an associated increase in the PV-S wave (S/D ratio ± 1.1).

Some patients with abnormal diastolic function have normal-appearing E/A velocities and ratios. In these patients, preload increases are a compensatory mechanism, and may result in a pseudonormal pattern, representing a moderate degree of diastolic dysfunction. Administering nitroglycerin or having the patient sit upright or perform a Valsalva maneuver reduces the preload and may unmask reversal of the E/A ratio.[23] Other associated Doppler findings in this group include a normal DT and IVRT, but a reduced PV-S and increased PV-D (reversed PV S/D ratio < 1), and accelerated PV AR velocity (AR > 35 cm/s) and duration (>30 ms longer than mitral valve A wave). The presence of significant structural heart disease on two-dimensional echo provides further evidence that abnormal diastolic function exists despite the normal appearance of the E/A ratio.

Despite the limitations of echo for evaluating lesser degrees of diastolic dysfunction, the presence of a restrictive mitral inflow filling pattern is fairly specific for the combination of reduced ventricular compliance and elevated left atrial filling pressure. The reduction in ventricular compliance may be caused by a primary abnormality of diastolic performance or secondary to marked systolic dysfunction. The presence of restrictive filling pattern has significant prognostic implications. In patients with dilated cardiomyopathy, this pattern is more predictive of the development of severe symptoms than are indices of systolic function. In patients with amyloidosis, restrictive filling is associated with a very poor 1-year survival.[24, 25] Additional Doppler alterations that are associated with severe diastolic dysfunction include reduced DT (<160 ms); reduced IVRT (<70 ms); reduced S/D ratio (usually < 0.6); and an increased AR velocity (> 35 cm/s).

Although most diastolic filling parameters are affected by normal aging, age-associated nomograms have been developed to identify acceptable values for different age groups.[26] For individuals greater than 60 years old, the following extreme values (obtained by adding two standard errors to the normal mean value) may be used as a reference: (1) E/A ratio less than 0.60; (2) DT more than 260 millisecond; (3) AR more than 43 cm/s; and (4) IVRT more than 101 millisecond. It is very unlikely that these extreme values would be exceeded in normal aging, and they may be useful for evaluating the elderly patient with heart failure.

Another limitation of current methods for evaluating diastolic filling is that they have been validated in sinus rhythm only. Many elderly patients have atrial fibrillation with variable cardiac cycle length and no organized atrial contraction. In these patients, the DT, IVRT, and PV-S waves may not accurately reflect diastolic performance. More studies are needed to optimize the assessment of diastolic function in patients with atrial fibrillation, but the peak acceleration rate of the E wave appears to correlate well with the LV filling pressure.[27]

Although many variables affect Doppler-derived diastolic filling properties, serial changes in an individual patient are useful for evaluating changes in diastolic performance and for assessing the effectiveness of treatment. For example, failure of a restrictive filling pattern to improve after treatment is a marker for poor prognosis in patients with dilated cardiomyopathy.[28] To date, treatment of patients with diastolic dysfunction has not been well investigated, but it seems likely that serial Doppler echo studies will play a significant role in evaluating the effectiveness of various treatment regimens.

In summary, Doppler echo provides a useful tool for assessing diastolic function in elderly patients. There are no absolute, individual variables, however, that routinely categorize patients into mild, moderate, or severe diastolic dysfunction. It is important to evaluate all available measurements to minimize interpretive errors. Although normal aging alters these parameters, the aforementioned extreme values are provided in an effort to minimize false diagnoses. In the near future, diastolic dysfunction may be more accurately determined with tissue Doppler imaging or color M-mode evaluations.[29,30]

HEART FAILURE WITH NORMAL SYSTOLIC AND DIASTOLIC FUNCTION

In addition to diastolic dysfunction, transient LV systolic dysfunction, as seen with myocardial ischemia, may also present as CHF with normal, resting LV systolic function. A regional wall motion abnormality, often subtle at rest, may be the only echo finding. In patients with severe heart failure symptoms, normal wall motion, and normal or mildly abnormal diastolic function, myocardial ischemia should be suspected and consideration given for the performance of stress echocardiography.

PROGNOSIS DETERMINATION

Not only is the differentiation of normal versus reduced LV systolic function vitally important for subsequent treatment considerations, but it also impacts prognosis. In one study, the single greatest predictor of mortality in elderly patients with heart failure (and associated coronary artery disease) was the EF.[31] This prospective evaluation revealed that 47% of all elderly patients with CHF had normal LV systolic function. In the group with coronary artery disease, 41% had normal systolic function. Survival rates in this group were 78%, 62%, and 44% at 1, 2, and 4 years, respectively. In contrast, survival rates for patients with reduced LV systolic function were only 53%, 29%, and 15% at 1, 2, and 4 years, respectively. In the Vasodilator Heart Failure Trial, patients with CHF and normal EF had an average annual mortality rate of 8%, but those with abnormal EF had an annual mortality rate of 19%.[32] Echocardiography can assist in determining prognosis.

Patients with CHF and hypertension may present with two different, echocardiographically identifiable profiles, depending on whether there is coexistent coronary artery disease. By measuring the degree of LV thickening and the diameter of the LV cavity, the ventricular mass-volume ratio can be obtained and may facilitate the separation of patients likely and unlikely to have myocardial ischemia, despite similar degrees of diastolic dysfunction and exercise intolerance. Patients with a low ratio (<1.8), indicating less myocardial mass, are more likely to have significant coronary artery disease with up to 80% having severe coronary artery stenosis.[19] Conversely, in patients with a ventricular mass-volume ratio more than 1.8, the cause is more often progressive left ventricular hypertrophy (LVH) caused by hypertension, and these patients are less likely to have significant coronary artery stenosis. This assessment allows therapy to be properly aimed at either LVH regression or, more specifically, the improvement of myocardial ischemia.

In addition to the LVEF, the size and shape of the LV and the Doppler findings may predict the development and severity of CHF symptoms. In a substudy of the Studies of Left Ventricular Dysfunction, 311 patients with symptomatic LV dysfunction (treatment arm) and 258 patients with asymptomatic LV dysfunction (prevention arm) were evaluated.[33] Compared with patients without symptoms, symptomatic patients had larger LV end-diastolic diameters and end-systolic volumes; higher sphericity indexes (a measure of the roundness of the LV); and greater ratios of early-to-late diastolic filling velocities (E/A ratio). These patients also had a greater incidence of ventricular dysrhythmias. These data suggest that both diastolic properties and the degree of ventricular remodeling affect the clinical status of patients with LV dysfunction, and that echo provides useful information in this assessment.

ECHO-GUIDED TREATMENT CONSIDERATIONS IN THE ELDERLY

Treatment options for heart failure in the elderly often must be modified because of the higher prevalence of renal dysfunction and cerebral vascular disease that increase the risk of drug side effects. Often, lower starting doses or reduced target doses are used. In addition, the effectiveness of vasodilators and sympathetic agonists (acute treatment) and antagonists (chronic treatment) may be reduced. Echo provides a method to assess the effectiveness of these medications with serial monitoring, and could potentially aid in minimizing adverse effects. For example, if a patient initially has dilated LV systolic and inferior vena caval dimensions, but these become significantly reduced after treatment, it is likely that the intravascular volume status has also been reduced. These findings support the reduction or discontinuation of diuretic therapy and may assist in preventing diuretic-induced side effects (electrolyte imbalance, renal insufficiency, hypotension, or perceived intolerance to angiotensin-converting enzyme [ACE] inhibitor therapy). Another situation in which echo findings might assist in determining the dosage of medications is the patient with persistently elevated mitral E/A wave ratios. Because this finding indicates elevated left-sided filling pressures, additional preload reduction or diuretic treatment may be considered. In patients with acute cardiac decompensation requiring the use of intropic therapy, we use echo during the titration of dobutamine to determine the lowest dose required to improve LV systolic function, avoiding the common adverse effects associated with higher doses.

DISCUSSION

Very few studies have investigated the use and impact of echocardiography in the management of CHF. In one such study, the management and clinical outcome of patients with CHF were classified according to whether or not an echocardiogram was performed.[34] Although limited by its retrospective design, this study revealed that patients who did not receive an echo had decreased survival, increased morbidity, and underuse of ACE inhibitor therapy. In another retrospective study of 505 patients on diuretic therapy, 74% who were hospitalized for acute CHF treatment were evaluated. Of these, only 31% received an echo and only 17% were treated with an ACE inhibitor.[35]

Patients with CHF and a normal LVEF present with a clinical profile that is indistinguishable from heart failure with a low EF. Echocardiography can rapidly, accurately, and relatively inexpensively determine if there is systolic or diastolic LV dysfunction. The subsequent treatment and prognosis are directly related to this important distinction.

In addition to determining the type of LV dysfunction, echocardiography, coupled with Doppler, can identify the hemodynamic status of the patient. Cardiac output, filling pressures, and pulmonary artery pressures can be calculated. Other causes of heart failure, such as aortic stenosis, MR, pericardial diseases, and hypertrophic cardiomyopathy can readily be identified and appropriate surgical options considered.

With the aid of echocardiography, the elderly patient with heart failure can be skillfully treated, assessed for treatment response, referred for surgery when indicated, and counseled regarding prognosis. Without knowledge of LV systolic and diastolic function, ACE inhibitor, digoxin, and diuretics may be used inappropriately in the 40% to 50% of elderly patients who have normal LV systolic function. The unfortunate patient with unsuspected, surgically correctable, valvular heart disease would go untreated and remain at risk for progressive, irreversible myocardial damage.

CONCLUSION

Patients with minimally symptomatic or unsuspected LV systolic dysfunction may be identified and receive the benefits of ACE inhibitor therapy. Echocardiography is also useful for assessing prognosis and can be used serially to evaluate the effectiveness of treatment. Intracardiac filling pressures, pulmonary artery pressures, and cardiac output can be sequentially determined.

We believe that all patients with heart failure should receive careful assessment with two-dimensional, M-mode, and Doppler echocardiography, especially the elderly, who have the poorest prognosis and are more likely to have diastolic dysfunction.

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ROLE OF ECHOCARDIOGRAPHY IN THE DIAGNOSIS & MGMT OF HEART FAILURE IN THE ELDERLY POST TEST

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1. What percentage of the individuals aged 80 to 89 suffer from heart failure?
- a. less than 1%
- b. 3 %
- c. 6%
- d. greater than 10%

2. Compared to younger individuals, the elderly
- a. often have a prolonged rate of myocardial contraction and relaxation.
- b. often have a shortened rate of myocardial contraction and relaxation.
- c. have a lower prevalence of normal LV systolic function when heart failure is present.
- d. are easier to accurately diagnose and treat based solely on clinical findings.

3. The majority of the causes of heart failure can be identified or excluded with
- a. a detailed history.
- b. a careful physical examination.
- c. two-dimensional and Doppler echocardiogram.
- d. a CT examination.

4. Two-dimensional echocardiography, using validated geomentric equations, can determine the
1. LVEF
2. stroke volume
3. cardiac output
   - a. 1 only
   - b. 2 only
   - c. 1 and 3
   - d. 1, 2, and 3

5. Which of the following raise the suspicion of primary pulmonary hypertension?
- a. Normal-appearing LV size and function in conjunction with an enlarged RV cavity
- b. Dilated right pulmonary artery branch and paradoxical interventricular septal motion
- c. Severe pulmonary hypertension, marked RV dilatation, and prominent thickening of the RV free wall in the absence of left heart pathology
- d. Plethora of the inferior vena cava and hyperdynamic LV systolic function

6. How can the SV be calculated?
- a. SV = EDV – ESV
- b. SV = HR × CO
- c. SV = EDV + ESV
- d. SV = HR/CO

7. The use of M-mode echo as the sole means for estimating LV function is NOT recommended because
- a. M-mode estimates seldom correlate well with angiographic volumes.
- b. The cuboid method never correlates with angiography.
- c. When LV systolic function is reduced, the LV shape is often distorted and regional wall motion abnormalities are common.
- d. Elderly patients can not tolerate the examination.

8. Echocardiographic assessment of diastolic function is primarily performed using
- a. continuous wave Doppler.
- b. pulsed wave Doppler.
- c. M-mode echo.
- d. two-dimensional echo.

9. The spectrum of diastolic filling parameters is related to
1. varying contribution of abnormal relaxation.
2. changes of ventricular and atrial compliance.
3. heart rate and volume status.
   - a. 1 only
   - b. 1 and 2
   - c. 2 and 3
   - d. 1, 2, and 3

10. Administering nitroglycerin, having the patient sit upright, or having them perform a Valsalva maneuver may
- a. unmask reversal of the E/A ratio.
- b. hide abnormal diastolic function.
- c. render the examination useless.
- d. increase the preload, degrading the exam.

11. Which is a TRUE statement concerning diastolic filling parameters?
- a. Normal aging will have no affect on diastolic filling.
- b. Normal aging has only a slight affect on diastolic filling and can be ignored in evaluating the elderly patient with heart failure.
- c. Because normal aging affects diastolic filling parameters, ranges can be used to help identify acceptable values for different age groups.
- d. Aging affects diastolic filling parameters in such an unpredictable way that guidelines cannot be developed.

12. In patients with severe heart failure symptoms, normal wall motion, and normal or mildly abnormal diastolic function
1. myocardial ischemia can be ruled out.
2. myocardial ischemia should be suspected.
3. stress echocardiography should be considered.
   - a. 1 only
   - b. 3 only
   - c. 1 and 3
   - d. 2 and 3

13. In the Vasodilator Heart Failure Trial, what was the annual mortality rate of the patients with abnormal EF?
- a. 3%
- b. 8%
- c. 19%

d. 35%

14. Patients with a ventricular mass-volume ratio of less than 1.8
a. have higher myocardial mass.
b. are more likely to have significant coronary artery disease and severe coronary artery stenosis.
c. are likely to have progressive LVH caused by hypertension.
d. are less likely to have significant coronary artery stenosis.

15. In addition to the LEF, what else may predict the development and severity of CHF symptoms?
1. Size of the LV
2. Shape of the LV
3. Doppler findings
   a. 1 only
   b. 2 only
   c. 3 only
   d. 1, 2, and 3

16. Treatment options for heart failure in the elderly must take into consideration
1. the prevalence of renal dysfunction.
2. the very high rate of patient noncompliance.
3. the increased risk of drug side effects.
   a. 1 only
   b. 2 only
   c. 1 and 3
   d. 1, 2 and 3

17. The use of vasodilators and sympathetic agonists for heart failure is considered
a. acute treatment.
b. ineffective treatment.
c. experimental treatment.
d. chronic treatment.

18. Using echo during the titration of dobutamine may
a. help to avoid further treatment.
b. help to determine the lowest dose required.
c. increase the chance of adverse effects.
d. lead to misdiagnosis.

19. Patients with CHF and a normal LVEF, present with a clinical profile that is indistinguishable from
a. pulmonary emboli.
b. emphysema.
c. heart failure with a low EF.
d. acute MI.

20. Patients with unsuspected valvular heart disease are
a. at risk for progressive, irreversible myocardial damage.
b. always asymptomatic, making diagnosis impossible.
c. never surgically treatable.
d. at little, or no risk for myocardial damage.

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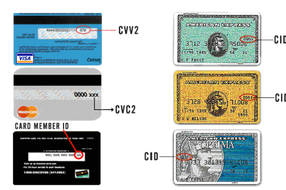

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