

THE AMERICAN SOCIETY OF ECHOCARDIOGRAPHY RECOMMENDATIONS FOR THE EVALUATION OF LEFT VENTRICULAR DIASTOLIC FUNCTION BY ECHOCARDIOGRAPHY: A QUICK REFERENCE GUIDE FROM THE ASE WORKFLOW AND LAB MANAGEMENT TASK FORCE

This document summarizes key points from the 2016 ASE Left Ventricular Diastolic Function Guideline to serve as a quick reference for sonographers and interpreting physicians. (1) For details including the methodology and the rationale for current recommendations, the interested reader is referred to the complete Guideline statement. Figures and tables are reproduced from ASE Guidelines. (1)

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References:

1. Nagueh SF, Smiseth OA, Appleton CP, et al. [Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging](#). J Am Soc Echocardiogr 2016;29:277-314.

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GENERAL PRINCIPLES FOR ECHO ASSESSMENT OF DIASTOLIC FUNCTION

(For full recommendation refer to the [Left Ventricular Diastolic Function Guideline](#))

OVERVIEW OF THE ASSESSMENT OF DIASTOLIC FUNCTION

For a review of the Components of Diastolic Function and Parameters that may impact the Assessment of Diastolic Function , as well as Potential Pitfalls in the algorithms and a comprehensive list of the Echocardiographic Indices used in the assessment of Diastolic function, please refer to the original guideline document (pages 278, 279) and Table 2 in the guideline

DIAGNOSING DIASTOLIC DYSFUNCTION IN THE PRESENCE OF A NORMAL LV EF

(For full recommendation refer to the [Left Ventricular Diastolic Function Guideline](#) p. 279)

Age Independent Indices of Diastolic Function

- E/e' : > 14 is rare in normal individuals
- Change in mitral inflow with Valsalva: $\geq 50\%$ change in E/A
 - highly specific for increased LV filling pressures
 - supports diagnosis of diastolic dysfunction
 - requires continuous recording of the Doppler signal during 10 seconds of Valsalva
- Difference in duration between pulmonary vein Ar velocity and mitral A velocity (≥ 30 ms)
- Elevated pulmonary artery systolic pressure (PASP) in the absence of pulmonary vascular disease
- Consider all diastolic parameters in the context of other echo findings that may suggest the presence of abnormal myocardial function even with a normal EF
 - LA enlargement (in the absence of atrial arrhythmia or MV disease)
 - Left ventricular hypertrophy (LVH)
 - Abnormal global longitudinal function (assessed by mitral annular plane systolic excursion, mitral annulus s' , GLS)

Diastolic Function Assessment in the Presence of a Normal LVEF (Figure 8A)

- The presence or absence of diastolic dysfunction in patients with a normal LVEF is based on the assessment of four variables. These variables and their cutoff values include:
 - Septal $e' < 7$ cm/sec or Lateral $e' < 10$ cm/sec
 - Average $E/e' > 14$
 - LA volume index > 34 mL/m²
 - Peak TR velocity > 2.8 m/sec
- Diastolic function is normal if more than half of the available variables are normal ($< 50\%$ positive)
- Diastolic dysfunction is present if more than half of the available variables are abnormal ($> 50\%$ positive)
- In cases in which half of the variables do not meet the cutoff value, the study is indeterminate (50% positive)

ASSESSMENT OF LV FILLING PRESSURES AND DIASTOLIC DYSFUNCTION GRADE

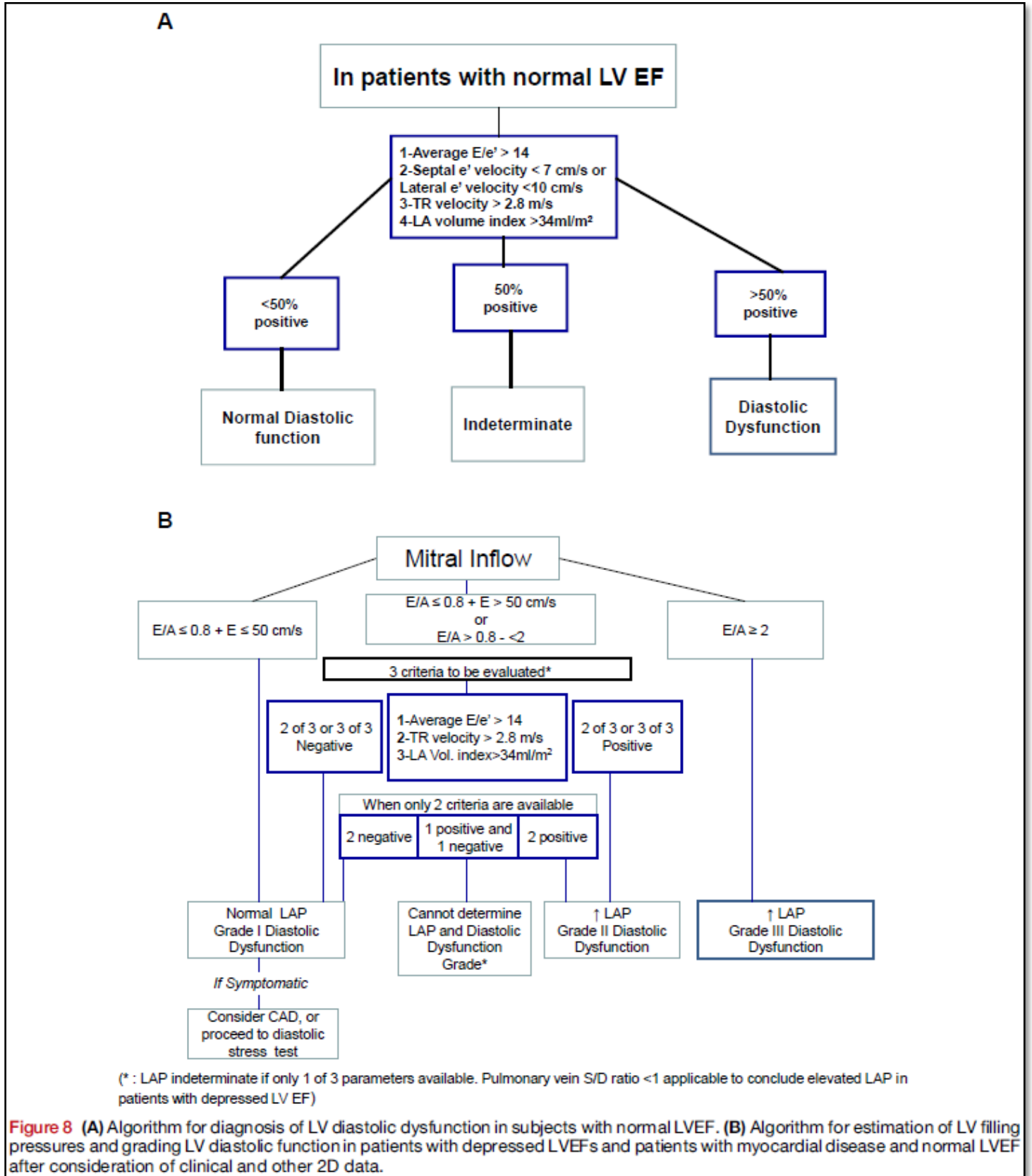
(For full recommendation refer to the [Left Ventricular Diastolic Function Guideline](#) p. 281)

Diastolic Function Assessment in Patients with Normal vs Abnormal LVEF

- In patients with a normal LVEF, the initial assessment is to determine the presence or absence of diastolic dysfunction based on the algorithm presented above and in Figure 8A
 - If there is evidence of myocardial disease or diastolic dysfunction, the second goal is to estimate LV filling pressures and the grade of diastolic dysfunction based on the parameters presented below and the algorithm in Figure 8B
- In patients with heart failure and reduced EF (HFrEF), the main goal is to estimate LV filling pressures and grade the degree of diastolic dysfunction (diastolic dysfunction is presumed to be present in these patients) based on the parameters presented below and the algorithm in Figure 8B
- The algorithm (Figure 8B) focuses on the assessment of mean LA pressure (LAP) as it correlates best with pulmonary capillary wedge pressure and pulmonary congestion
- The algorithm starts with mitral inflow velocities and does not apply in several specific cardiovascular diseases which are addressed in the next section
- Assessment of Filling Pressures and Diastolic Function in Heart Failure with preserved EF (HFpEF) or HFrEF (Fig 8 of Guidelines):
 - If mitral E/A ratio ≤ 0.8 and peak mitral E ≤ 50 cm/s
 - Mean LAP is normal or low
 - Grade I diastolic dysfunction
 - If mitral E/A ≥ 2
 - Mean LAP is elevated
 - Grade III diastolic dysfunction
 - If mitral E/A ≤ 0.8 and Peak E > 50 cm/s **or** E/A > 0.8 but < 2 the following 3 parameters should be evaluated:
 - Average E/e' > 14
 - LA volume index > 34 mL/m²
 - Peak TR velocity > 2.8 m/sec
 - Interpretation:
 - If 2/3 or 3/3 are negative, LAP is normal (Grade I Diastolic Dysfunction)
 - If 2/3 or 3/3 are positive, LAP is increased (Grade II Diastolic Dysfunction)
 - If only 2 parameters are available, if both are normal, LAP is normal. If both are abnormal, LAP is increased. If 1 is normal and the other abnormal, results are inconclusive
- Other Scenarios
 - If one of the 3 above variables is not available:
 - PVs:PVD velocity ratio or VTI ratio < 1 supports the presence of elevated filling pressures
 - Note: In individuals < 40 yrs old, PVs:PVD ratio may be < 1 ; Use e' and LA volume index to avoid misclassifying diastolic function
 - If only 1 variable is available do not comment on diastolic function
- Caveats in the Diastolic Function Assessment Algorithm
 - After cardioversion of AF:
 - E decel time should be used in the assessment of diastolic function as the mitral A wave velocity may be decreased due to atrial stunning and thus the E/A ratio may be ≥ 2 despite the absence of elevated filling pressures
 - Young patients:
 - E/A ratio may be ≥ 2 in normal young patients
 - Use other parameters to detect abnormal diastolic function
 - Note: e' will be normal in individuals with normal diastolic function

Additional Considerations in the Diastolic Function Assessment in Preserved EF Patients

- Evaluate 2D and Doppler parameters
 - LVEF
 - Regional wall motion abnormalities (RWMA)
 - LVH
 - Best confirmed by LV mass that exceeds gender-specific norms
- LA size: If LA > RA size in the apical 4C view, this suggests chronically elevated LV filling pressures in absence of:
 - Atrial fibrillation
 - Mitral valve disease
 - Anemia
 - Normal LA volume index does not exclude diastolic dysfunction
 - Can be normal in early diastolic dysfunction
 - Can be normal in acutely elevated filling pressures
- Estimated PASP: Elevation in the absence of pulmonary vascular or parenchymal disease suggests elevated LV filling pressures
- PVs:PVD ratio: Not helpful in patients with normal EF

Figure 8 – from [Left Ventricular Diastolic Function Guideline](#)

CONCLUSIONS ON DIASTOLIC FUNCTION IN THE CLINICAL REPORT

(For full recommendation refer to the [Left Ventricular Diastolic Function Guideline](#) p. 288)

- Conclusions about diastolic function should be included in the report, particularly if the indication is for dyspnea or HF including:
 - Filling pressures
 - Grade of diastolic dysfunction
 - Comparison to prior studies
- Consider diastolic stress test in borderline cases
- Consider right heart catheterization if there is a concern for discordance between RV and LV filling pressures suggesting pulmonary vascular disease

Table 4 LV relaxation, filling pressures and 2D and Doppler findings according to LV diastolic function

	Normal	Grade I	Grade II	Grade III
LV relaxation	Normal	Impaired	Impaired	Impaired
LAP	Normal	Low or normal	Elevated	Elevated
Mitral E/A ratio	≥ 0.8	≤ 0.8	>0.8 to <2	>2
Average E/e' ratio	<10	<10	10–14	>14
Peak TR velocity (m/sec)	<2.8	<2.8	>2.8	>2.8
LA volume index	Normal	Normal or increased	Increased	Increased

ESTIMATION OF FILLING PRESSURES IN SPECIFIC CARDIOVASCULAR DISEASES

(For full recommendation refer to the [Left Ventricular Diastolic Function Guideline](#) p.288)

General Considerations

- Many disease states, valvular and other anatomic abnormalities, as well as dysrhythmias may modify the relationship between indices of diastolic function and LV filling pressure
- The algorithm for assessing diastolic function and estimating LV filling pressures presented in the prior discussion has several limitations in these circumstances
 - The TR jet remains a valid marker of LAP, assuming there is no evidence of pulmonary vascular or parenchymal disease that may result in increased right ventricular systolic pressure (RVSP)
 - LA enlargement usually reflects an elevated LAP, except in the setting of atrial fibrillation / flutter, significant mitral valve disease, high flow states or cardiac transplantation
 - In the absence of these conditions, an enlarged LA with a normal RA strongly suggests elevated LAP
 - LA enlargement may persist in patients with well treated congestive heart failure and normal filling pressures. If the TR jet is > 2.8 m/s, an elevated LAP is suggested
 - Additional parameters such as pulmonary vein (PV) flow, Isovolumic Relaxation Time (IVRT), A_r-A wave duration (time difference between the pulmonary vein atrial reversal wave duration and transmitral A wave duration), T_{E-e'} (time difference from onset of E wave and e') and the IVRT / T_{E-e'} ratio may need to be assessed
- In patients with pulmonary hypertension, the lateral E/e' may be helpful in differentiating whether or not a cardiac etiology is the underlying reason for an elevated RVSP

- With non-cardiac pulmonary hypertension, the lateral E/e' is <8
- In the presence of a cardiac etiology, the lateral E/e' is >13

Specific Conditions in Which the Standard Algorithm (Figure 8) May Not Apply (The algorithms presented in the Appendix on Page 9 may be used) Include:

- Hypertrophic Cardiomyopathy
- Restrictive Cardiomyopathy
- Valvular Heart Disease
- Cardiac Transplantation
- Atrial Fibrillation
- AV Block and Pacing

DIASTOLIC STRESS TEST

(For full recommendation refer to the [Left Ventricular Diastolic Function Guideline](#) p. 298)

Indications

- Diastolic stress testing is indicated when resting echocardiography does not explain the symptoms of heart failure or dyspnea, especially with exertion
- Diastolic stress testing is most appropriate in patients with dyspnea and grade 1 diastolic dysfunction at rest

Performance of Diastolic Stress Testing

- Diastolic stress testing should be performed using supine bike or treadmill stress testing (not pharmacologic stress testing)
- At rest, mitral E and annular (TDI) e' velocities should be acquired, along with the peak velocity TR jet from multiple windows
- The above parameters are acquired during exercise at each stage (if a bike) or 1 to 2 minutes after termination of treadmill exercise with the expectation that the E and A velocities will become unmerged.
- Increased filling pressures usually persist for a few minutes post exercise which makes this information clinically relevant

Pitfalls to Diastolic Stress Testing

- Higher level of MD/sonographer experience is needed for acquisition and interpretation of diastolic stress tests
- Acquisition of the indices can be a challenge to due body habitus and exercise/ post stress conditions
- One needs to be cautious in drawing conclusions with discrepant indices (when all three conditions are not met)

Interpretation

- The test is considered positive when all of the following three conditions are met during exercise:
 - average $E/e' > 14$ or septal E/e' ratio > 15
 - peak TR velocity > 2.8 m/sec
 - septal e' velocity < 7 cm/sec

NOVEL INDICES OF LV DIASTOLIC FUNCTION

(For full recommendation refer to the [Left Ventricular Diastolic Function Guideline](#) p. 301)

A variety of new indices of LA and LV systolic and diastolic function (e.g. global longitudinal systolic strain, global longitudinal diastolic strain, LV untwisting rate) have been proposed as markers of LV and LA filling pressures. For the most part, these parameters have not been incorporated in to daily practice.

PROGNOSTIC INFORMATION OBTAINED FROM DIASTOLIC FUNCTION ASSESSMENT

Prognosis in Patients with HFrEF

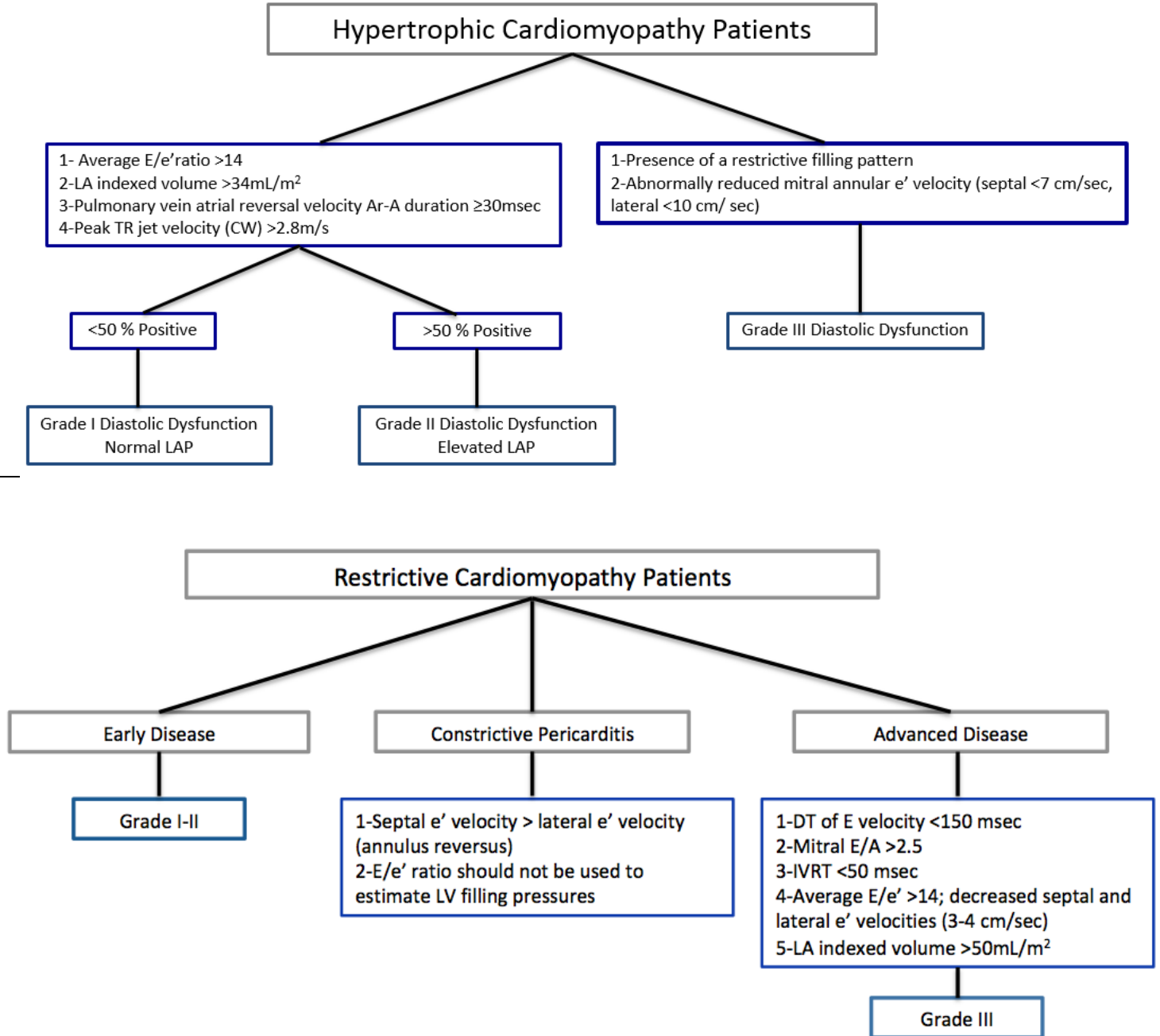
- In patients with left ventricular systolic dysfunction, classic simple measures of diastolic function including E/A ratio and deceleration time carry important prognostic significance
- Short Mitral E deceleration time (DT) (< 140-150 ms) is associated with heart failure symptoms, death and hospitalization in patients presenting with acute myocardial infarction
- DT provides incremental prognostic information to clinical parameters of wall motion score and LVEF in patients with HFrEF
- Grade II or grade III diastolic dysfunction that does not improve despite adequate medical therapy is highly predictive of worse outcomes in this patient population (see guidelines for references)
- A pseudonormal mitral Doppler inflow pattern has also been associated with poorer outcomes in patients with heart failure and coronary disease in one meta-analysis
- Recent studies assessing the prognostic power of e' and the E/e' ratio demonstrate that these variables are predictive of adverse events after acute MI and in patients with and without heart failure (see guidelines for references)
- Low values of mitral annular tissue Dopplers' velocity, in addition to e' , were found to be predictors of death after myocardial infarction in one study
- Increased left atrial and right atrial volume indices have been shown to be predictive of adverse prognosis with myocardial infarction and heart failure
- Lastly, there is growing literature showing LV global strain, diastolic strain rate, as well as LA strain provide incremental prognostic information in several disease states including patients presenting with acute myocardial infarction, AF, and HFrEF

Prognosis in Patients with HFpEF

- RV dysfunction has been noted in a subset of HFpEF patients and is associated with worse outcomes
- Other echo parameters associated with worse outcomes in HFpEF include LV hypertrophy, LA volumes, E/e' ratio, peak velocity of TRjet, and GLS
- Arterial function with its resistive and pulsatile aspects further refines the prognostic evaluation of patients with HFpEF

APPENDIX – Flow Charts

Filling Pressures in Specific Cardiovascular Diseases flow charts



Valvular Heart Disease Patients

MS

- 1-IVRT <60 msec
- 2-IVRT/T_{E-e'} <4.2
- 3-Mitral A velocity >1.5 m/sec

MR

- 1-Ar-A ≥30 msec (with normal EF)
- 2-IVRT <60 msec (with normal EF)
- 3-IVRT/T_{E-e'} <5.6 (with normal EF)
- 4-Average E/e' >14 (consider only in patients with depressed EF)

MAC

- 1-Increased transmitral velocities
- 2-Decreased e' due to decreased excursion
- 3-Increase in E/e' ratio

AS and AR

- Aortic Stenosis:**
Apply the GL regardless of severity; unless severe MAC
- Aortic Regurgitation:**
LA enlargement, average E/e' ratio > 14, and TR peak velocity > 2.8 m/sec support the presence of increased LV filling pressures

Heart Transplant Patients

- 1-Patients with preserved EFs and normal diastolic function commonly have restrictive appearing filling
- 2-No single diastolic parameter appears reliable enough to predict graft rejection.
- 3-PASP estimation using the TR jet can be helpful as a surrogate measurement of mean LAP in the absence of pulmonary disease.

Patients with Arrhythmias

Atrioventricular Block and Paced Patients

- 1-In patients with first degree AV block, the variables used to evaluate diastolic function and filling pressures likely remain valid as long as there is no fusion of mitral E and A velocities.
- 2-The accuracy of mitral annular velocities and E/e' ratio is less in the presence of left bundle branch block, RV pacing, and in patients who have received cardiac resynchronization therapy.
- 3-If only mitral A velocity is present, only TR peak velocity (>2.8 m/sec) can be used as an indicator of LV filling pressures.

Atrial Fibrillation Patients (with impaired EF)

- 1-Peak acceleration rate of mitral E velocity (≥ 1,900 cm/sec²)
- 2-IVRT (≤ 65 msec)
- 3-DT of pulmonary venous diastolic velocity (≤220 msec)
- 4-E/Vp ratio (≥1.4)
- 5-Septal E/e' ratio (≥11)