Learning Objectives for Diastology

After this talk, you should be able to

• Apply the new 2016 ASE/EACVI Guideline
• Classify and grade diastolic function
• Estimate filling pressure in most patients
Evaluation of Diastolic Function
2017 Update

• New 2016 ASE/EACVI Recommendation
• Typical cases: Gr. 1, 2, and 3
• Specific and challenging situations
  • Discordant Echo Parameters
  • Hypertrophic CM
  • Mitral Annulus Calcification
  • Mitral Regurgitation
  • Atrial Fibrillation

• My recommendation

Summary

Normal Diastole
Adequate LV filling without increased filling pressure at rest and exertion

Med e' ≥ 7 cm/s
Lat e' ≥ 10 cm/s
TR ≤ 2.8 m/sec
LAVI ≤ 34 mL/m^2
PV S = PV D
Abnormal diastole
Delayed relaxation, stiffness, and increased filling pressure

\[ e' = 5 \, \text{cm/s} \]
\[ \text{DT} = 140 \, \text{msec} \]
\[ \frac{E}{e'} = 20 \]

Evaluation of Diastolic Function
Mitral Inflow and Annulus Velocity

<table>
<thead>
<tr>
<th>Normal</th>
<th>Abn Relax</th>
<th>Pseudo</th>
<th>Restrictive</th>
</tr>
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<tbody>
<tr>
<td>Grade 1</td>
<td>Grade 2</td>
<td>Grade 3</td>
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</table>

**Mitral flow**

- Normal
- Abn Relax
- Pseudo
- Restrictive

**Mitral annulus velocity**

- Preload dependent
- Preload independent

Sohn et al: JACC, 1997
Estimation of LV Filling Pressures


Four Major Parameters in Diastology

1. E’ velocity ≥ 7 (med), 10 (lat) cm/s
2. E/e’ ≤ 14 (Av), 15 (Med)
3. TR velocity ≤ 2.8 m/sec
4. LAVI ≤ 34 mL/m²

ASE/EACVI GUIDELINES AND STANDARDS

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

Sherif F. Naghchi, Chair, MD, FASE,1 Otto A. Smiseth, Co-Chair, MD, PhD,2 Christopher P. Appleton, MD,1 Benjamin F. Byrd, III, MD, FASE,1 Hisham Dokainish, MD, FASE,1 Thor Edvardsen, MD, PhD,2 Frank A. Flachskampf, MD, PhD, FESC,2 Thierry C. Gillebert, MD, PhD, FESC,2 Allan L. Klein, MD, FASE,1 Patrizio Lancellotti, MD, PhD, FESC,2 Paolo Marino, MD, FESC,2 Jae K. Oh, MD,3 Bogdan Alexandru Popenac, MD, PhD, FESC, FASE,3 and Alan D. Waggoner, MHS, RDCS,4, Houston, Texas

Four Major Diagnostic Parameters
Normal Values

1. E’ velocity ≥ 7 (med), 10 (lat) cm/s
2. E/e’ ≤ 14 (Av), 15 (Med)
3. TR velocity ≤ 2.8 m/sec
4. LAVI ≤ 34 mL/m²

JASE and EJ CV Imaging April 2016
New Criteria for Diastolic Function Assessment

1. In patients with normal LVEF ≥ 50%

   - Septal e’ velocity ≥ 7 cm/s or lateral e’ velocity ≥ 10 cm/s
   - Average E/e’ ≤ 14, 15 (Med)
   - TR velocity ≤ 2.8 m/s
   - LA volume index ≤ 34 mL/m²

   ≥ 3 Normal

   Normal Diastolic Function

   ≥ 3 Abnormal

   Diastolic Dysfunction

   Indeterminate

   2 and 2

In patients with depressed LVEF or normal EF with diastolic dysfunction

- Mitral inflow
  - E/A ≤ 0.8 + E ≤ 50 cm/s
  - E/A ≤ 0.8 + E > 50 cm/s
  - E/A > 0.8 ≤ 2
  - E/A ≥ 2

- 3 criteria to be evaluated:
  - Average E/e’ > 14
  - TR velocity > 2.8 m/s
  - LA volume index > 34 mL/m²

- If symptomatic consider CAD or proceed to diastolic stress test

- Normal LAP
  - Grade I diastolic dysfunction

- Cannot determine LAP and diastolic dysfunction grade

- ↑ LAP
  - Grade II diastolic dysfunction
  - Grade III diastolic dysfunction
67 year old man with ischemic CM and HF
Gr. 1 dysfunction with normal filling pressure

E= 45 cm/sec  A= 90 cm/sec  
E/A = 0.5

Grade 1 Dysfunction
E/A ≤ 0.8
E <50 cm/sec

2 months before
E= 120 cm/sec  E/A =0.9
E/e’ = 30
TR Vel = 3 m/sec

E= 45 cm/s  E/A = 0.5
E/e’= 12
Medial e’ = 4 cm/s
Ischemic Cardiomyopathy Echo Predictor
STICH Trial (N=1511)

Best survival with E/A 0.6-0.8

Lin et al. 2014 AHA

67 year old man with ischemic CM and HF

E= 120 cm/sec E/A = 0.9

E/e' = 4 E/e' = 30

TR Vel = 3 m/sec

Mitrail inflow

E/A > 0.8 + E < 50 cm/s

3 criteria to be evaluated*

2 of 3 negative

9 - Average E/e' > 14
2 - TR velocity > 2.8 m/s
3 - LA volume index > 34 mL/m²

2 of 3 positive

When only 2 criteria are available

2 negative 1 positive and 1 negative 2 positive

Normal LAP
Grade I diastolic dysfunction

Cannot determine
LAP and diastolic dysfunction grade*

T LAP
Grade II diastolic dysfunction

T LAP
Grade III diastolic dysfunction
After anterior STEMI: Grade 2

Lat e' = 6

Med e' = 5

E = 120 A = 110 E/A = 1.1

Cardiac Amyloidosis
Grade 3 Dysfunction

E/A = 6

E' = 4 cm/sec

E/e' = 30

TR = 4 m/sec
Mid-diastolic mitral flow (L)  
*Delayed relaxation*

What to do in indeterminate cases?
Case #1

67 year old woman with HPT and SOB
LAVI = 54 and TR = 2.8 m/s

1. E’ +/-
2. E/e’ NL
3. TR ≤ 2.8
4. LAVI ++

Med e’ = 7
E/e’ = 13

Indeterminate?

• E’ +/-
• E/e’ < 15
• LA > 34
• TR > 2.8 m/sec

TR = 2.83 m/s
Valsalva Maneuver: E/A reduced > 0.5
Grade 2 Dysfunction

E = 90  A = 40  E/A = 2.3
E = 60  A = 60  E/A = 1.0

Case #2
23 YO with HCM
1. Grade 1
2. Grade 2
3. Grade 3
4. Possibly normal

E = 70 cm/s  A = 30 cm/s  E/A = 2.3
23 yo with HCM

Medial e’ = 8 cm/sec  
Lateral e’ = 10 cm/sec

E/e’ = 9  
E/e’ = 7

Can he have a normal diastolic function?

23 yo man with HCM

LAVI 29 mL/m²

TR = 2 m/sec  
IVRT = 120 msec
Valsalva in 23 yo HCM
Normal filling pressure

E/A = 2.3
E/A = 2.0

Mitral A duration is shorter than PV AR
Increased LVEDP
LVEDP can be increased with normal mean LV diastolic pressure.

In patients with depressed LVEF or normal EF with diastolic dysfunction, consider CAD or proceed to diastolic stress test.
Case #3

72 yo woman with HCM

Med e' = 2  \(E/e' = 40\)

Lat e' = 5  \(E/e' = 15\)

72 yo woman with apical HCM
Grade 2 dysfunction with LAVI 37 mL/m^2

TR = 3 m/sec
Medial $E/e'$ Ratio Versus Mean LAP


Mean LAP vs Medial E-e’ ratio
Hypertrophic CM


All studies
All = 0.45x + 11.5
$r=0.44$
P<0.001

Simultaneous studies
$y=0.28x + 13.8$
$r=0.28$
P=0.07
Mitral annulus e’ velocity

- ASE/EACVI recommends average value
- E’ from one location is acceptable
- We need a caution in using e’
  - Primary pulmonary hypertension
  - Pacemaker
  - LBBB
  - Wall motion abnormality
  - Mitral annulus calcification
  - Hypertrophic CM

Case # 4
Mitral annulus calcification and TAVR

![Image](E= 100 cm/sec)

Lat e’ = 4 cm/s

Med e’ = 3 cm/s
Mitral annulus calcification and TAVR
E’ is reduced

TR = 2.4 m/sec

Mitral annulus e’ velocity vs MAC
Mean age 73 years

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1 n=79 no MAC</th>
<th>Group 2 n=38 mild MAC</th>
<th>Group 3 n=38 mod-severe MAC</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agatston Score</td>
<td>0</td>
<td>1-119</td>
<td>&gt;119</td>
<td></td>
</tr>
<tr>
<td>Septal e’</td>
<td>5.96±1.82</td>
<td>5.15±1.56</td>
<td>5.05±1.93</td>
<td>0.01</td>
</tr>
<tr>
<td>Lateral e’</td>
<td>7.37±2.44</td>
<td>6.89±2.71</td>
<td>6.28±1.81</td>
<td>0.01</td>
</tr>
<tr>
<td>Average e’</td>
<td>6.63±2</td>
<td>6.02±1.79</td>
<td>5.67±1.69</td>
<td>0.01</td>
</tr>
<tr>
<td>E/avg e’ ratio</td>
<td>13±4.93</td>
<td>15±8.95</td>
<td>18±8.26</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

LV diastolic parameters are altered in the presence of MAC. This could be due to direct effects of MAC or might reflect truly reduced diastolic function. Interpretation of diastolic parameters in patients with MAC should be performed with caution.

Codolosa et al: Am J Cardiol 2016;117:847-852
71 year old woman with LAVI = 39 mL/m²

Lateral e' = 10 cm/sec
Medial e' = 9 cm/sec

E/e’ NL < 14
E’ NL > 7
LAVI Enlarged
TR NL < 2.8

71 year old woman with Scleroderma
Normal Diastolic Function with large LA

LVOT TVI = 26 cm
Reasons for LA enlargement

• Diastolic dysfunction
• Increased filling pressure (Not always)
• Increased volume
• Athlete’s heart
• Measurement error

Mitral Annulus Velocity in the Evaluation of Left Ventricular Diastolic Function in Atrial Fibrillation

Dae-Won Sohn, MD, Jong-Min Song, MD, Joo-Hee Zo, MD, In-Ho Chai, MD, Hyo-Soo Kim, MD, Hong-Gu Chun, MA, and Hee-Chan Kim, PhD, Seoul, Korea

E=120 L wave

E’= 6 E/e’ =20

LVFP (mmHg)

JASE 1999
Diastolic Function in A. Fib

- DT < 160 msec (with reduced EF)
- DT < 130 msec poor survival (Hurley, Oh)
- Other measurements
  - E acceleration > 1900 cm/sec^2
  - IVRT ≤ 65 msec
  - E/e’ ≥ 11
  - IVRT/ T E-e’
  - TR velocity

69 year old man with dyspnea
PFO velocity

LAP- RAP = 36 mmHg
Learning Points

• Earliest diastolic abnormality is delayed relaxation which can be detected by reduced e’ velocity by tissue Doppler

• Integrated approach with 4 parameters
  • E’ velocity
  • E/e’ ratio
  • LAVI
  • TR velocity

• If indeterminate with 4 parameters, use other parameters (PV, Valsalva, PFO, IVRT, T E-e’

From Chandra, MD & Will Miranda, MD