



DIASTOLIC DYSFUNCTION IN MY DAILY PRACTICE

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A photograph of the Toronto skyline at night, featuring the CN Tower and various illuminated buildings, serving as the background for the symposium title.

**Seventeenth Annual Toronto
Perioperative TEE Symposium**

November 2-3, 2019



Outline

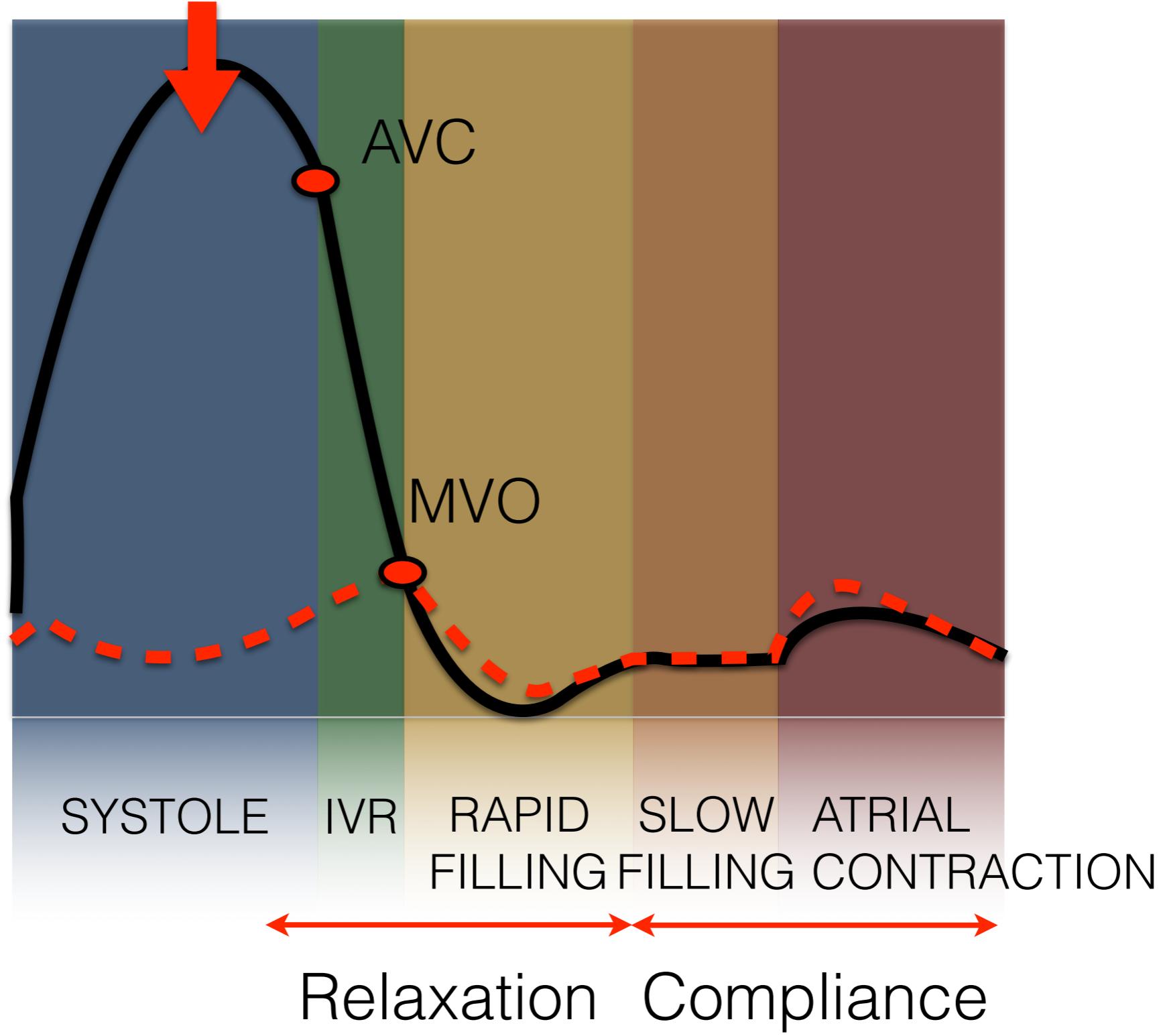
- What is diastolic dysfunction?
- Can we measure diastolic function?
- Is our measurement accurate?
- How do we use this information?



Diastole

LV Pressure

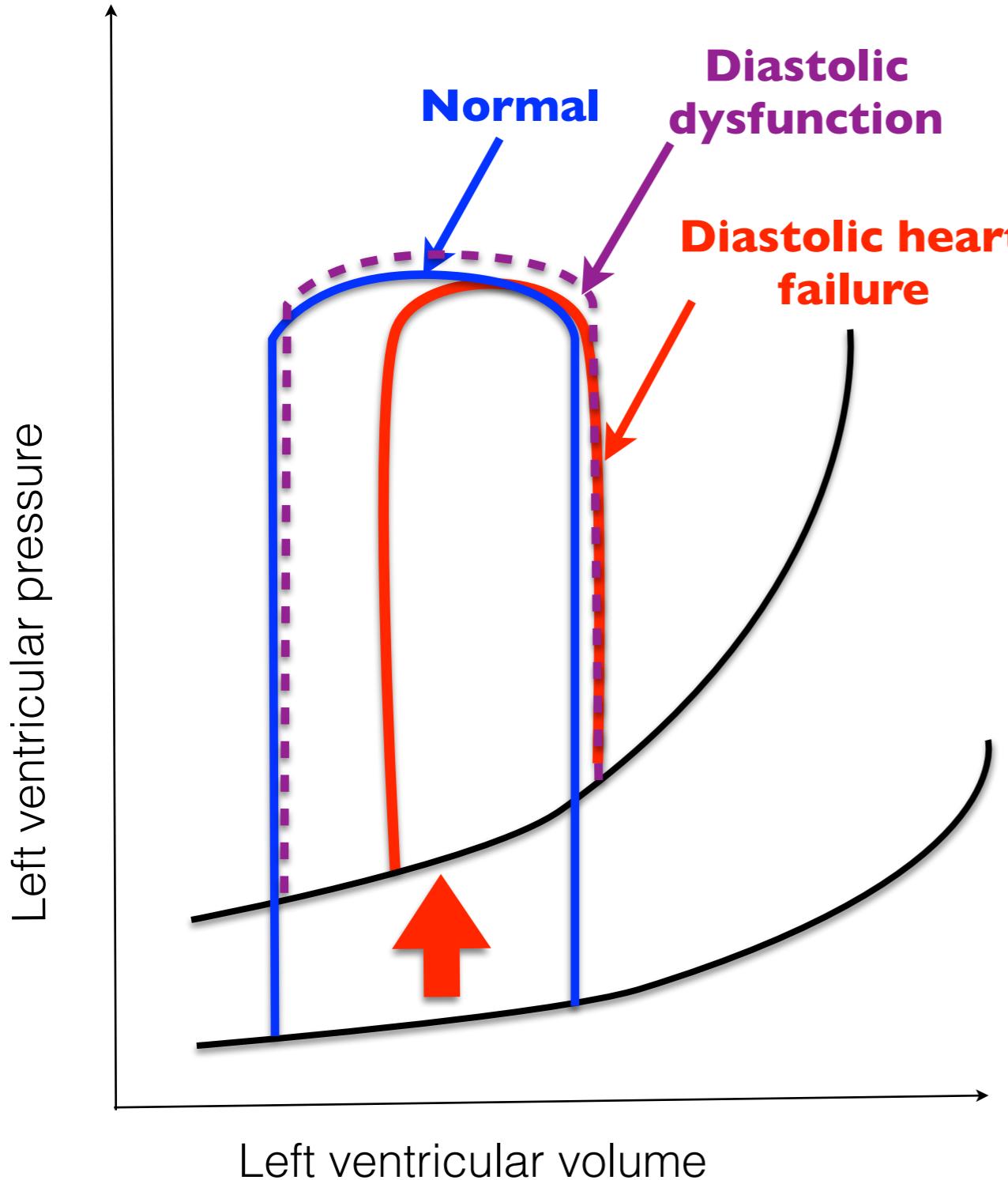
LA Pressure





Diastolic Dysfunction

Diastolic Heart Failure



Diastolic Dysfunction

Inability to fill at low pressure, asymptomatic

Diastolic Heart Failure

Decreased cardiac output, symptomatic



Diastolic dysfunction

“ ... 60% of surgical patients >65 years of age and with normal LVEF had diastolic filling abnormalities ... ”

Philip et al Anesth and Analg 2003;97:1214-21

- arrhythmias
- tachycardia
- myocardial ischemia ⇒ Diastolic Heart Failure
- fluid shifts
- myocardial edema



Perioperative risk factor?

- Difficult separation from cardiopulmonary bypass
 - Predictor of mortality in cardiac surgery patients
 - Prolonged and more complicated ICU or hospital stay
-
- Merello et al., J. Ann. Thorac. Surg. 2008; 85:1247-1255
 - Bernard et al., Anesth. Analg. 2001; 92:291-298
 - Sanders et al., Anesthesiology 2008; 109:A1592



Outline

- What is diastolic dysfunction?
- Can we measure diastolic function?
- Is our measurement accurate?
- How do we use this information?

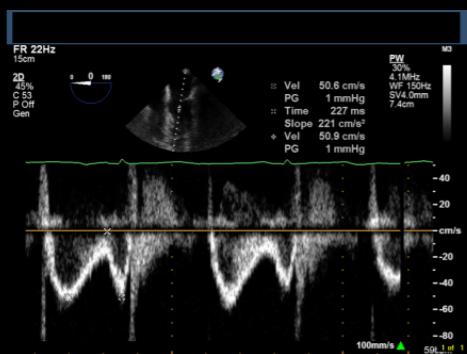
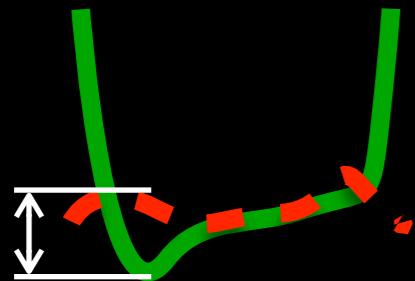


Quantification

- Transmitral Flow
- Pulmonary Vein Flow
- Tissue Doppler Imaging
- Color M-mode flow propagation



Transmitral Flow

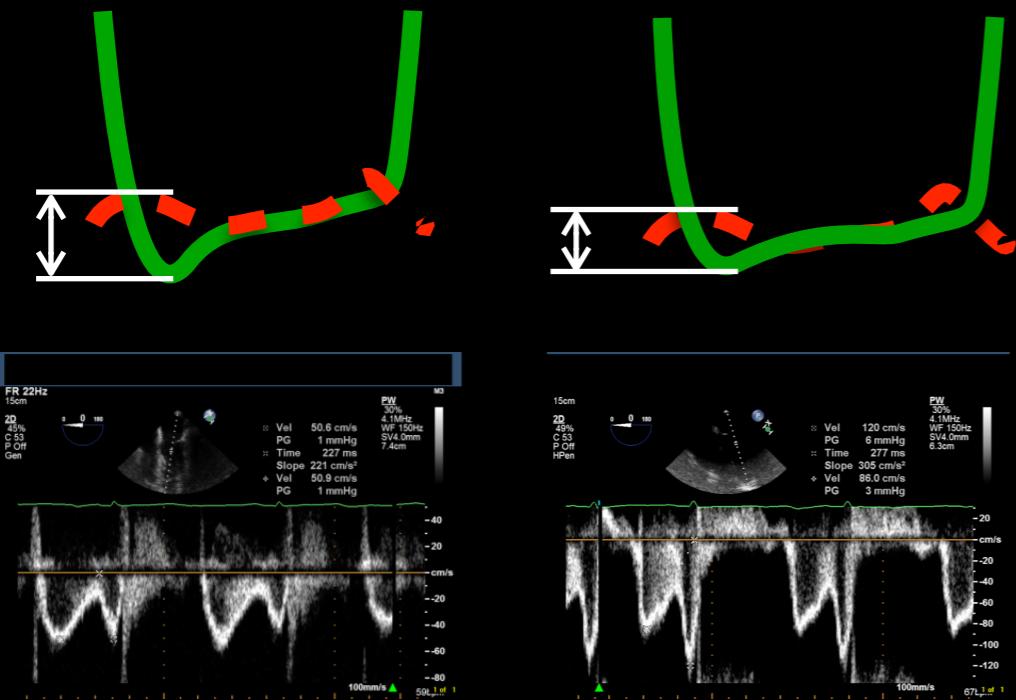


Normal

E/A 0.8-1.5
DT 160-200ms
IVRT 70-90ms



Transmitral Flow



↓LV relaxation

Normal

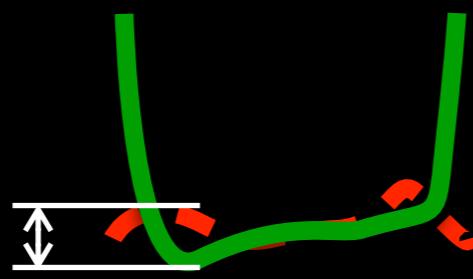
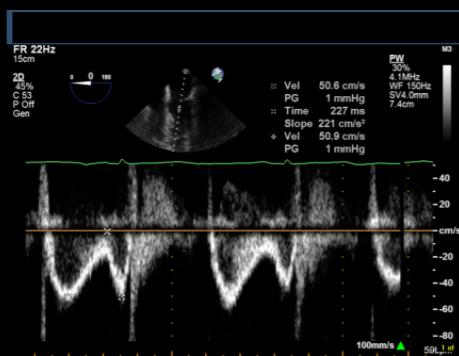
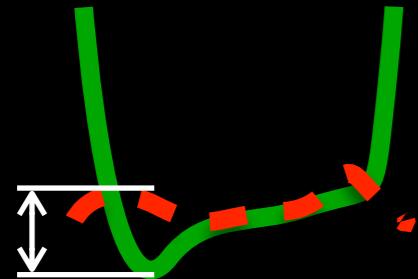
E/A 0.8-1.5
DT 160-200ms
IVRT 70-90ms

Impaired Relaxation

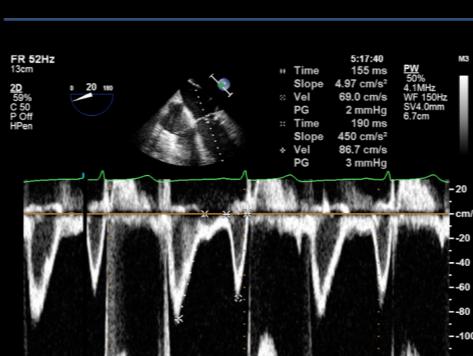
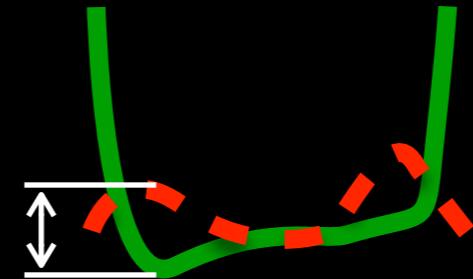
E/A < 0.8
DT > 200ms
IVRT > 100ms



Transmitral Flow



↓LV relaxation



↓LV relaxation
↓LV compliance
↑LA pressure

Normal

E/A 0.8-1.5
DT 160-200ms
IVRT 70-90ms

Impaired Relaxation

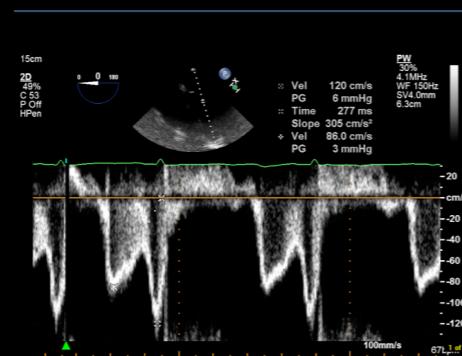
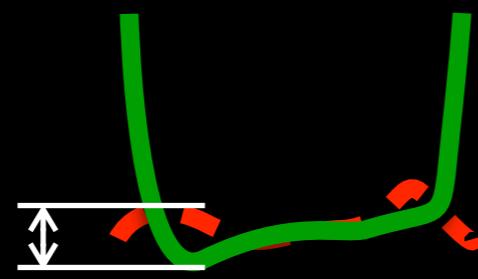
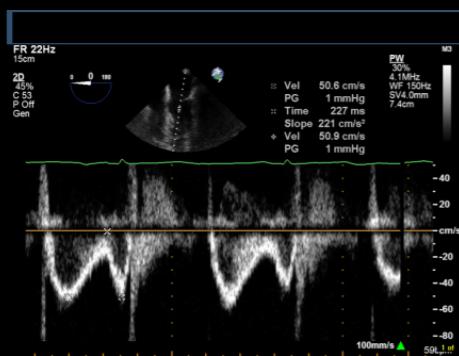
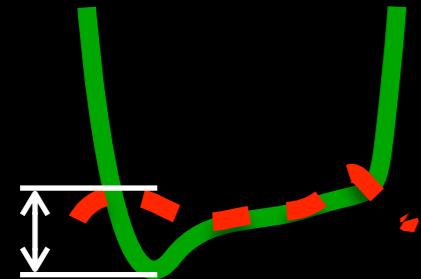
E/A < 0.8
DT > 200ms
IVRT > 100ms

Pseudonormal

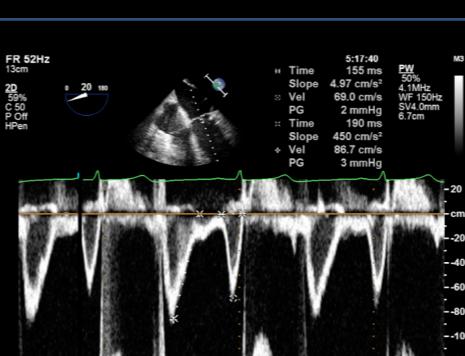
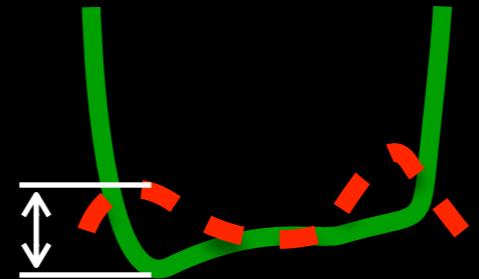
E/A 0.8-1.5
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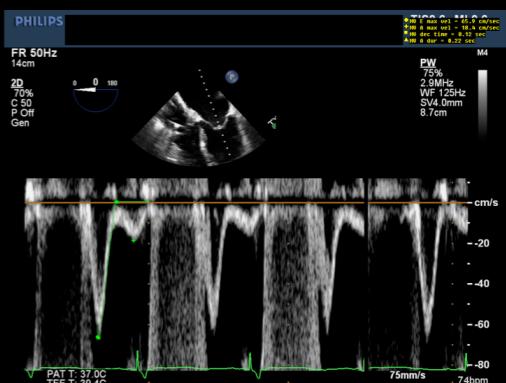
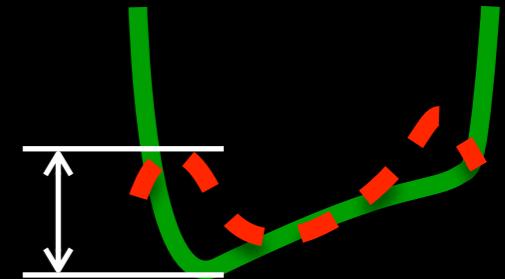
Transmitral Flow



↓LV relaxation



↓LV relaxation
↓LV compliance
↑LA pressure



↓LV relaxation
↓↓LV compliance
↑↑LA pressure

Normal

E/A 0.8-1.5
DT 160-200ms
IVRT 70-90ms

Impaired Relaxation

E/A < 0.8
DT > 200ms
IVRT > 100ms

Pseudonormal

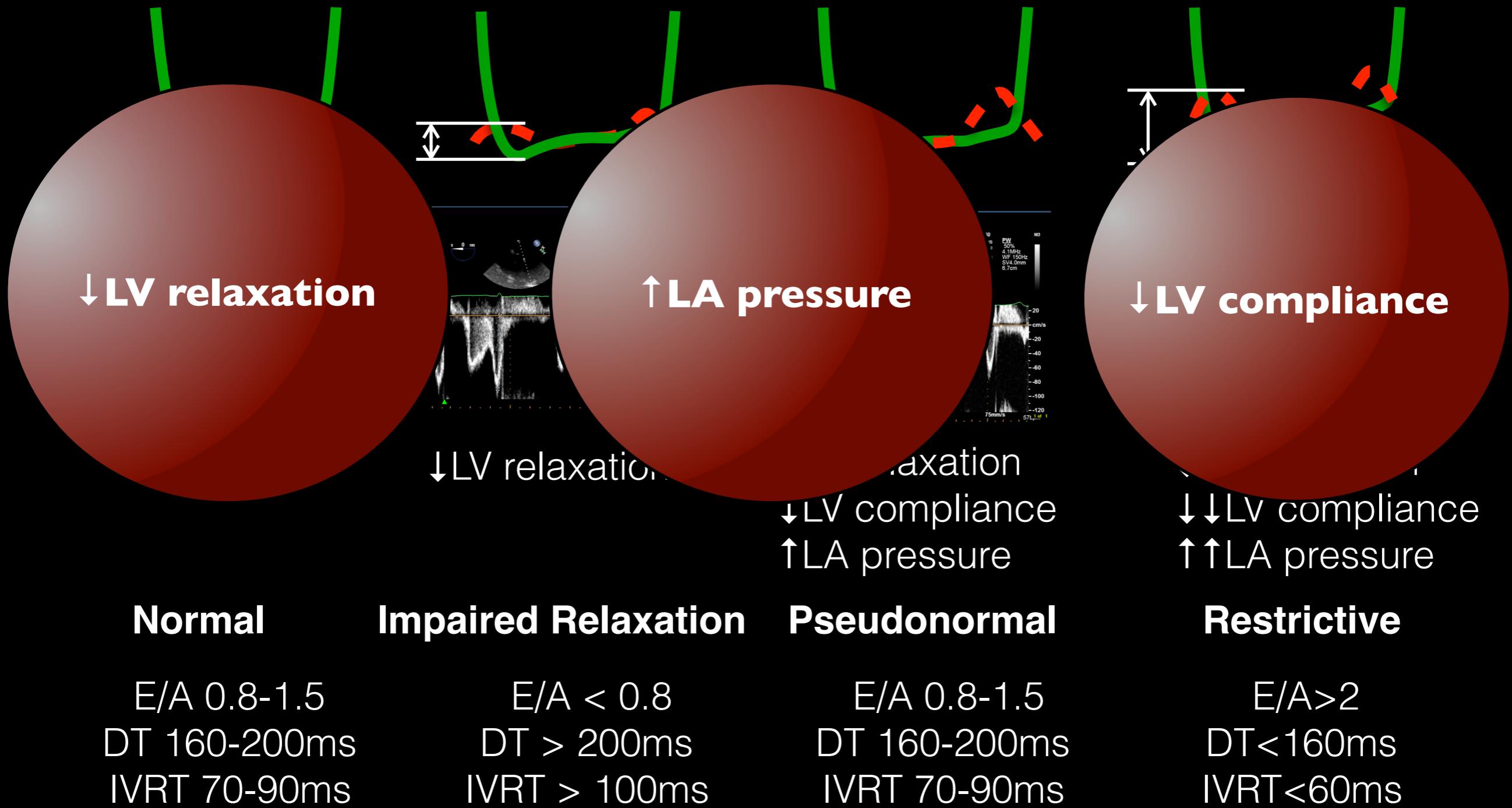
E/A 0.8-1.5
DT 160-200ms
IVRT 70-90ms

Restrictive

E/A>2
DT<160ms
IVRT<60ms

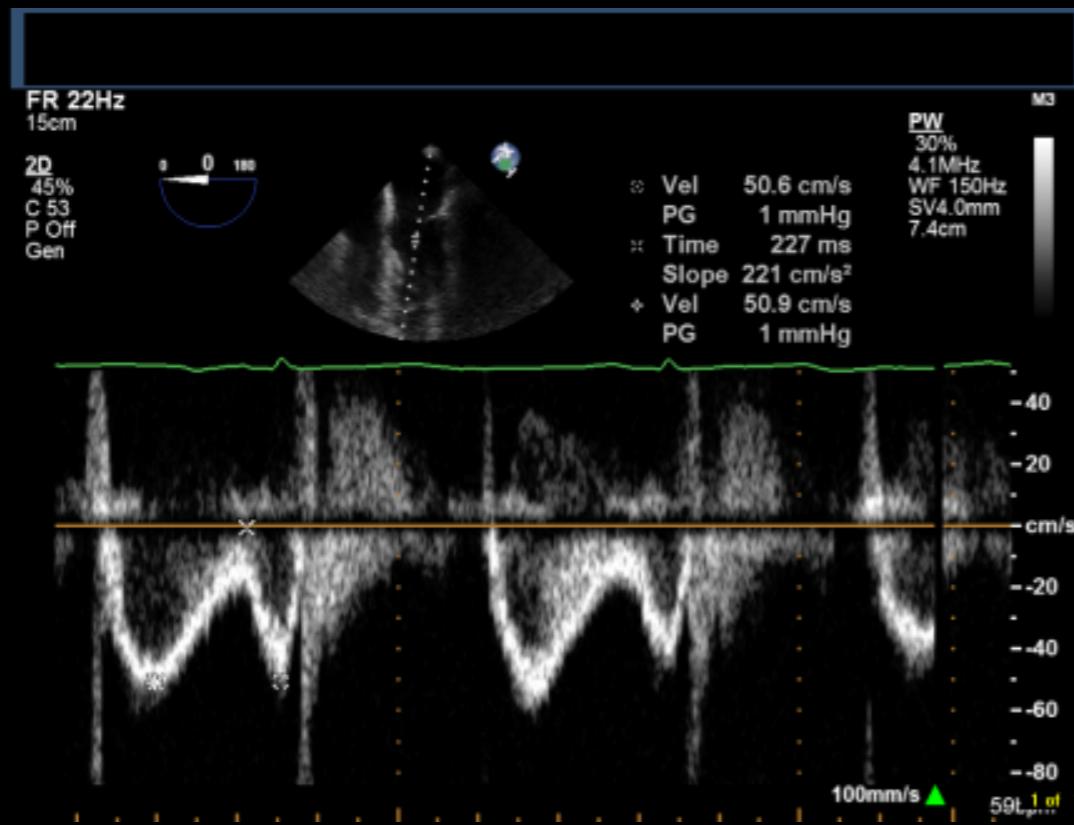


Transmitral Flow



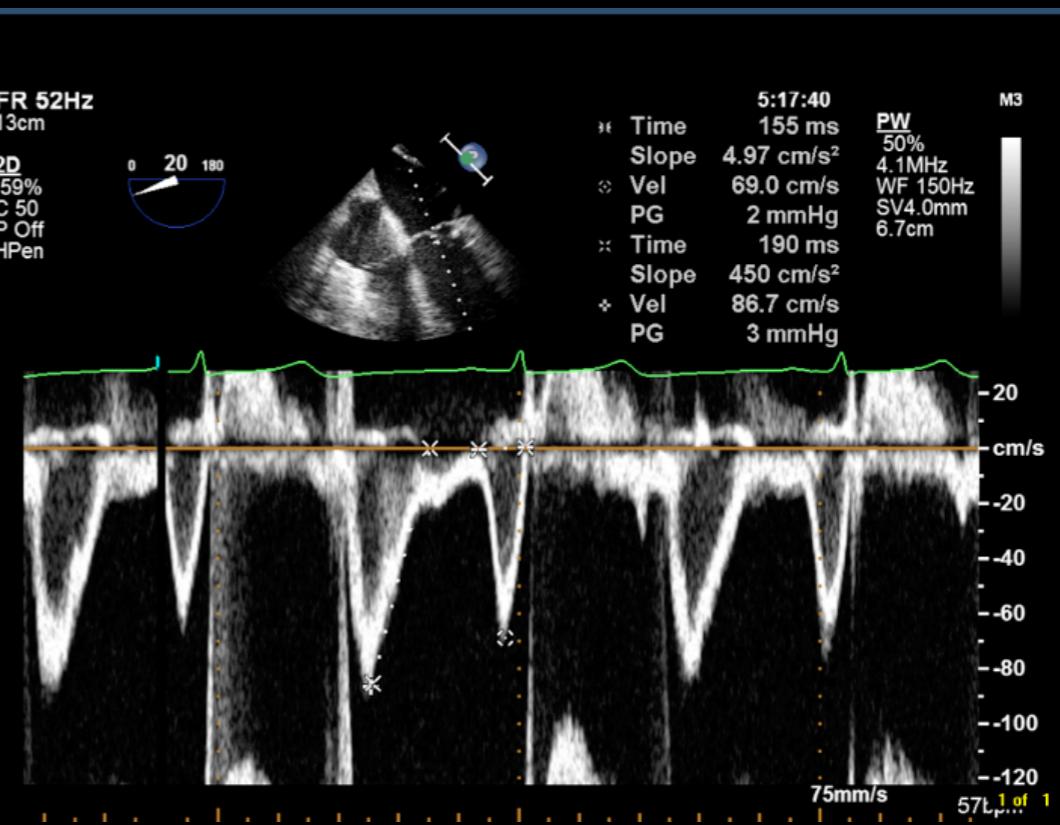


Transmitral Flow



Normal

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DT 160-200ms
IVRT 70-90ms

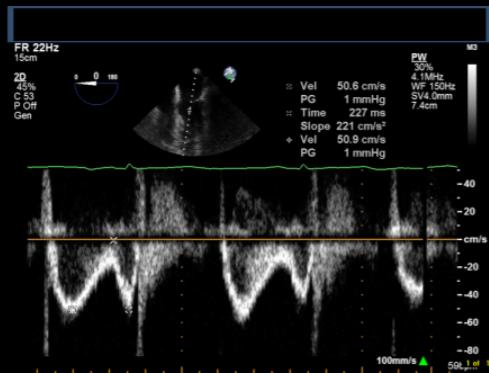


Pseudonormal

E/A 0.8-1.5
DT 160-200ms
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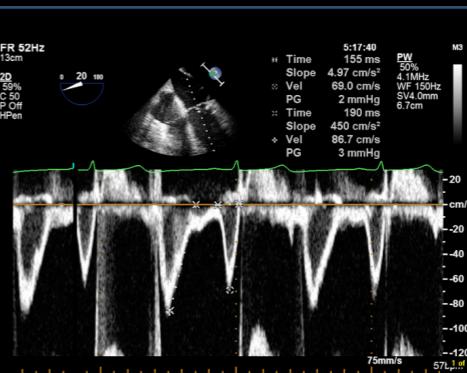
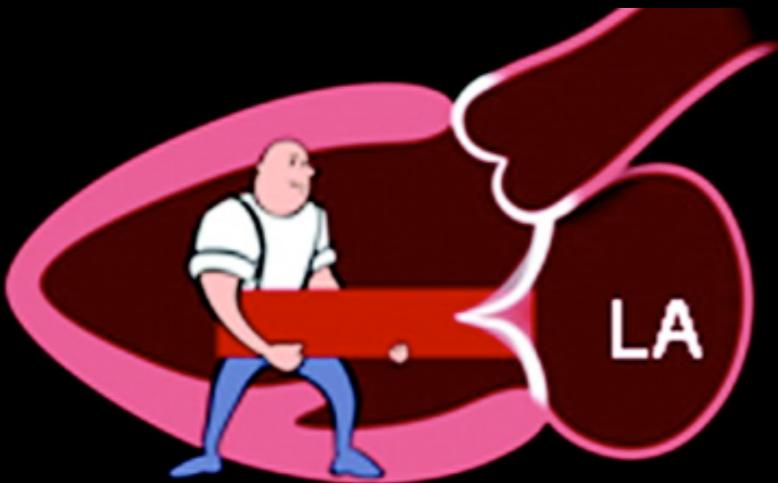


Transmitral Flow



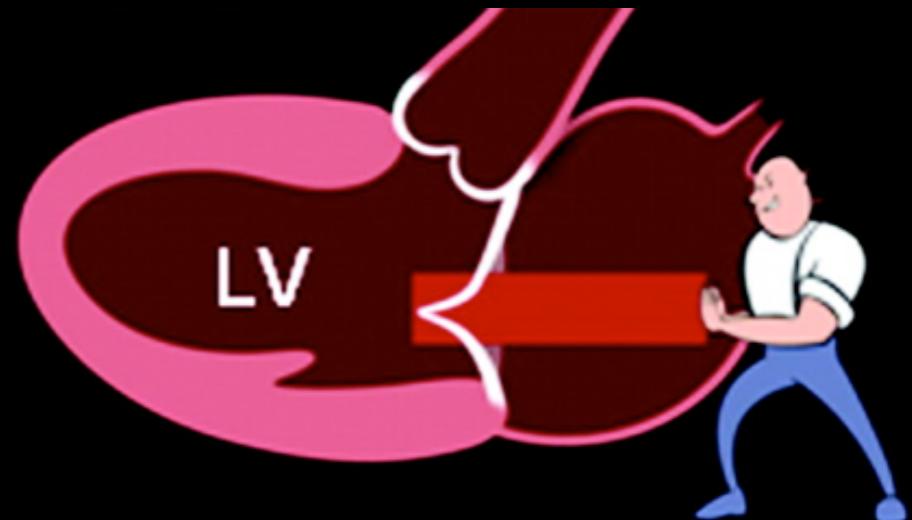
Normal

E/A 0.8-1.5
DT 160-200ms
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Pseudonormal

E/A 0.8-1.5
DT 160-200ms
IVRT 70-90ms





Quantification

- Transmitral Flow
- Pulmonary Vein Flow
- Tissue Doppler Imaging
- Color M-mode flow propagation



Filling Pressures

Continuum of disease

Normal

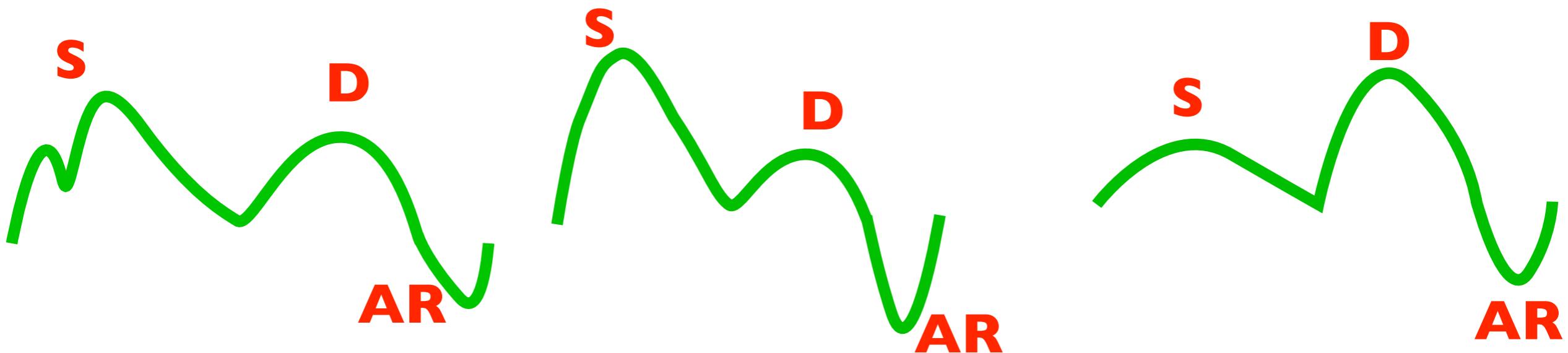
↓LV relaxation

↓LV relaxation
↓LV compliance

Normal LVEDP
Normal LAP

High LVEDP
Normal LAP

High LVEDP
High LAP





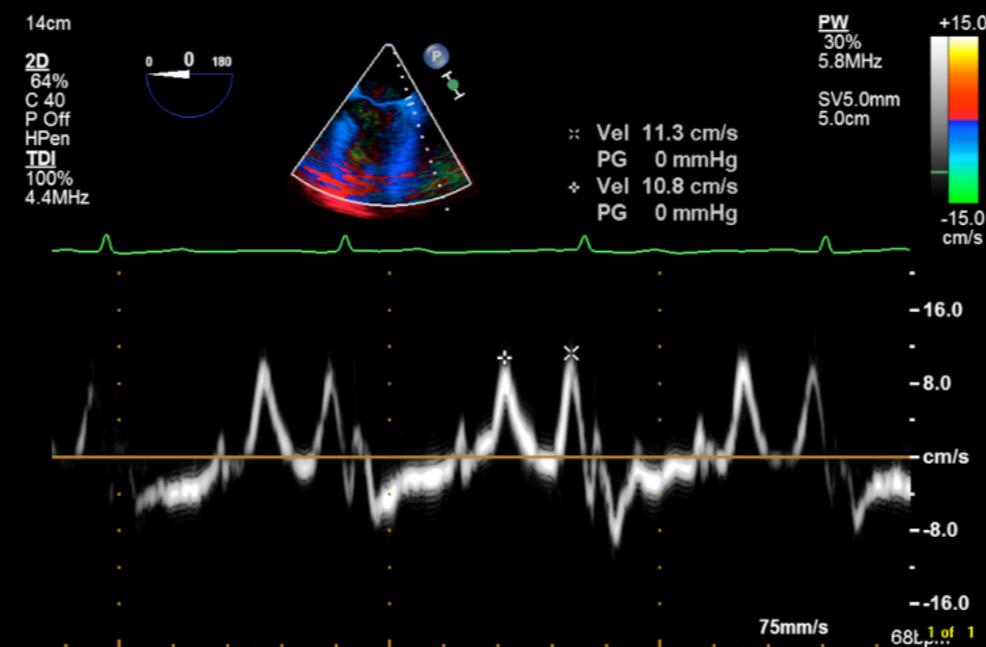
Quantification

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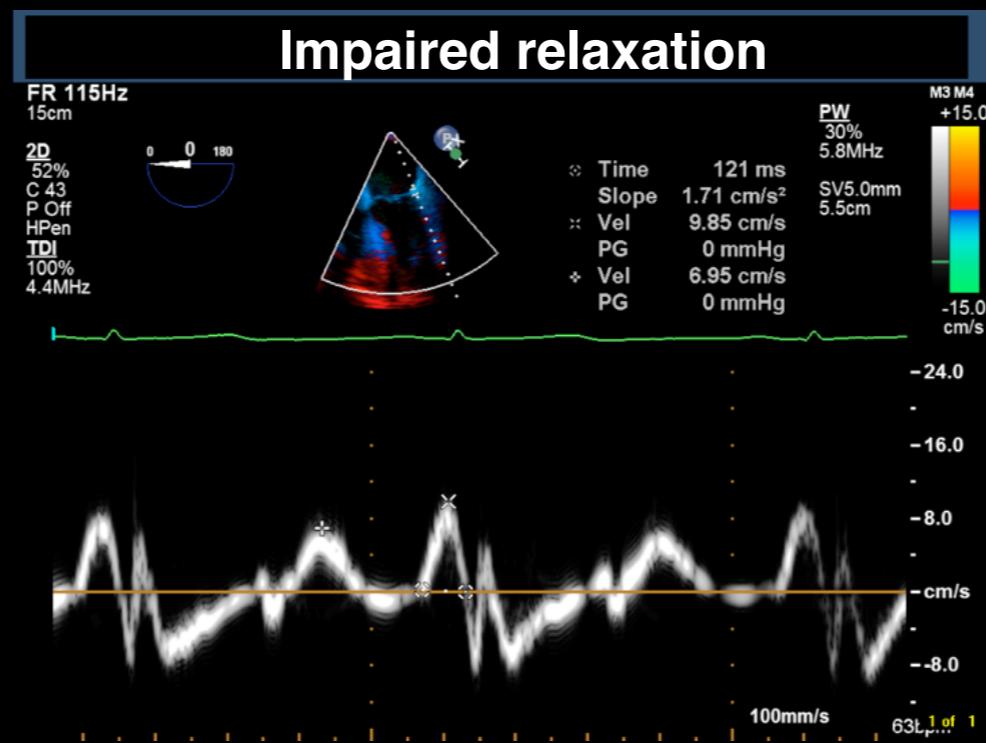


Tissue Doppler Imaging

Normal

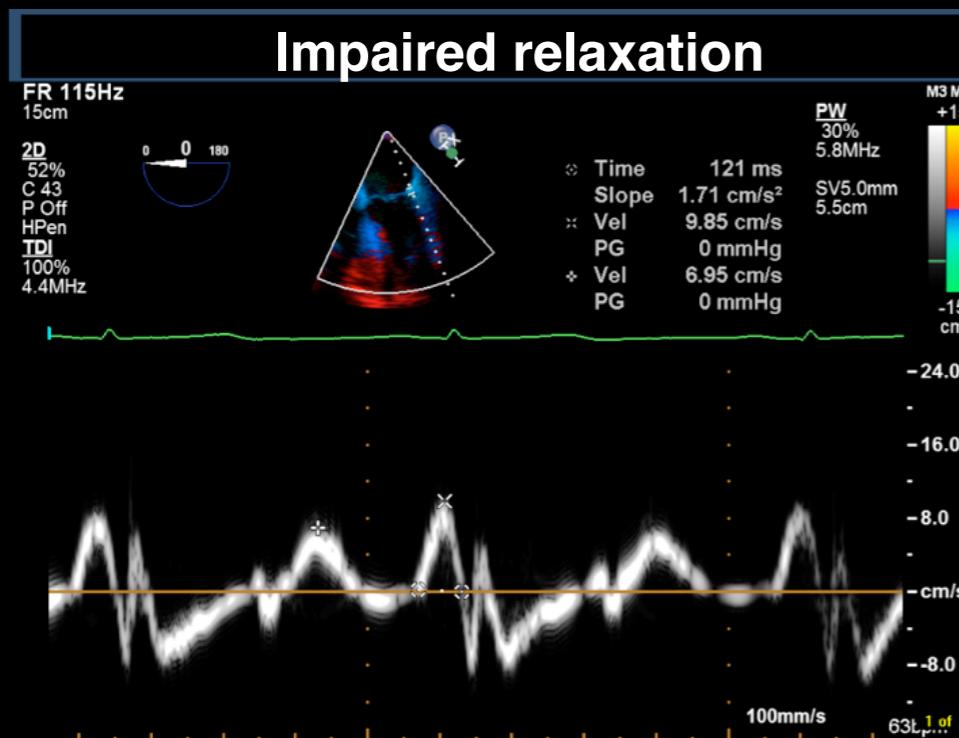
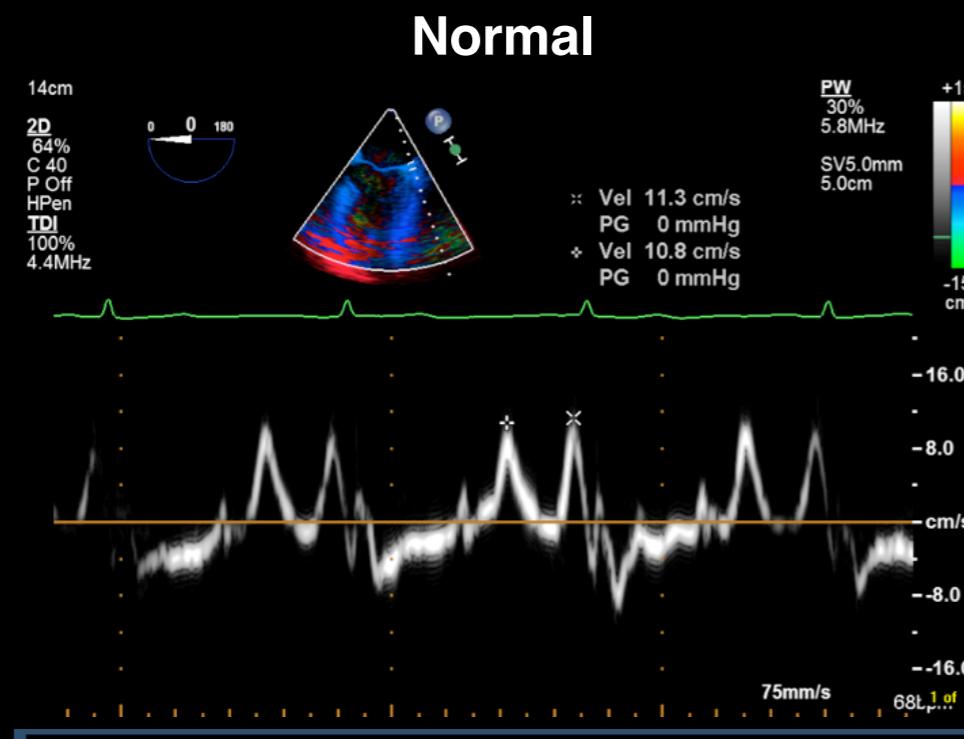


Impaired relaxation





Tissue Doppler Imaging



Elevated LAP:

↑ E velocity

↓ E' velocity

↑ E/E'

Lateral E' < 10 cm/s
Septal E' < 8 cm/s

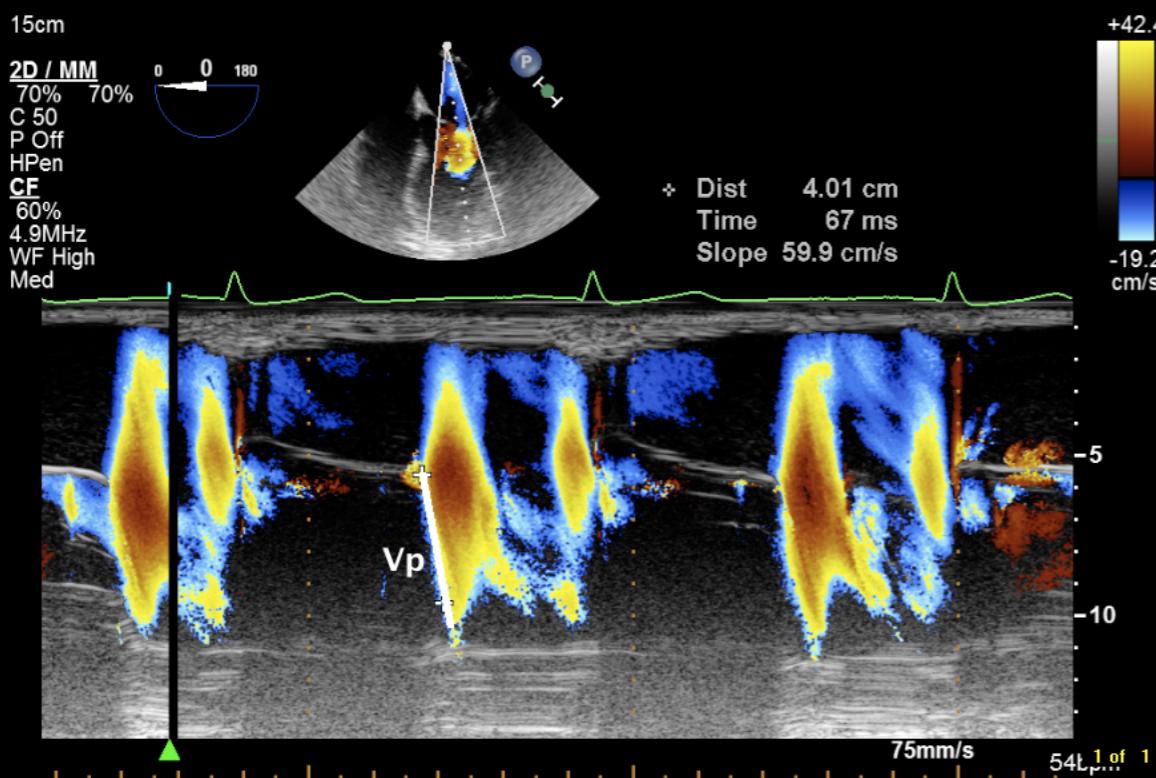


Quantification

- Transmitral Flow
- Pulmonary Vein Flow
- Tissue Doppler Imaging
- Color M-mode flow propagation



Propagation Velocity



- V_p depends on the intraventricular pressure gradients
- V_p measures LV relaxation
- \downarrow LV relaxation = $\downarrow V_p$



Outline

- What is diastolic dysfunction?
- Can we measure diastolic function?
- Is our measurement accurate?
- How do we use this information?



Quantification

GUIDELINES AND STANDARDS

Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography

Sherif F. Nagueh, MD, Chair,[†] Christopher P. Appleton, MD,[†] Thierry C. Gillebert, MD,*

Paolo N. Marino, MD,* Jae K. Oh, MD,[†] Otto A. Smiseth, MD, PhD,*

Alan D. Waggoner, MHS,[†] Frank A. Flachskampf, MD, Co-Chair,*

Patricia A. Pellikka, MD,[†] and Arturo Evangelista, MD,* *Houston, Texas; Phoenix, Arizona; Ghent, Belgium; Novara, Italy; Rochester, Minnesota; Oslo, Norway; St. Louis, Missouri; Erlangen, Germany; Barcelona, Spain*



Quantification

TTE

TEE

Left lateral decubitus

Supine

Breathing spontaneously Positive pressure ventilation

Awake

Under general anesthesia

Post-sternotomy



Quantification

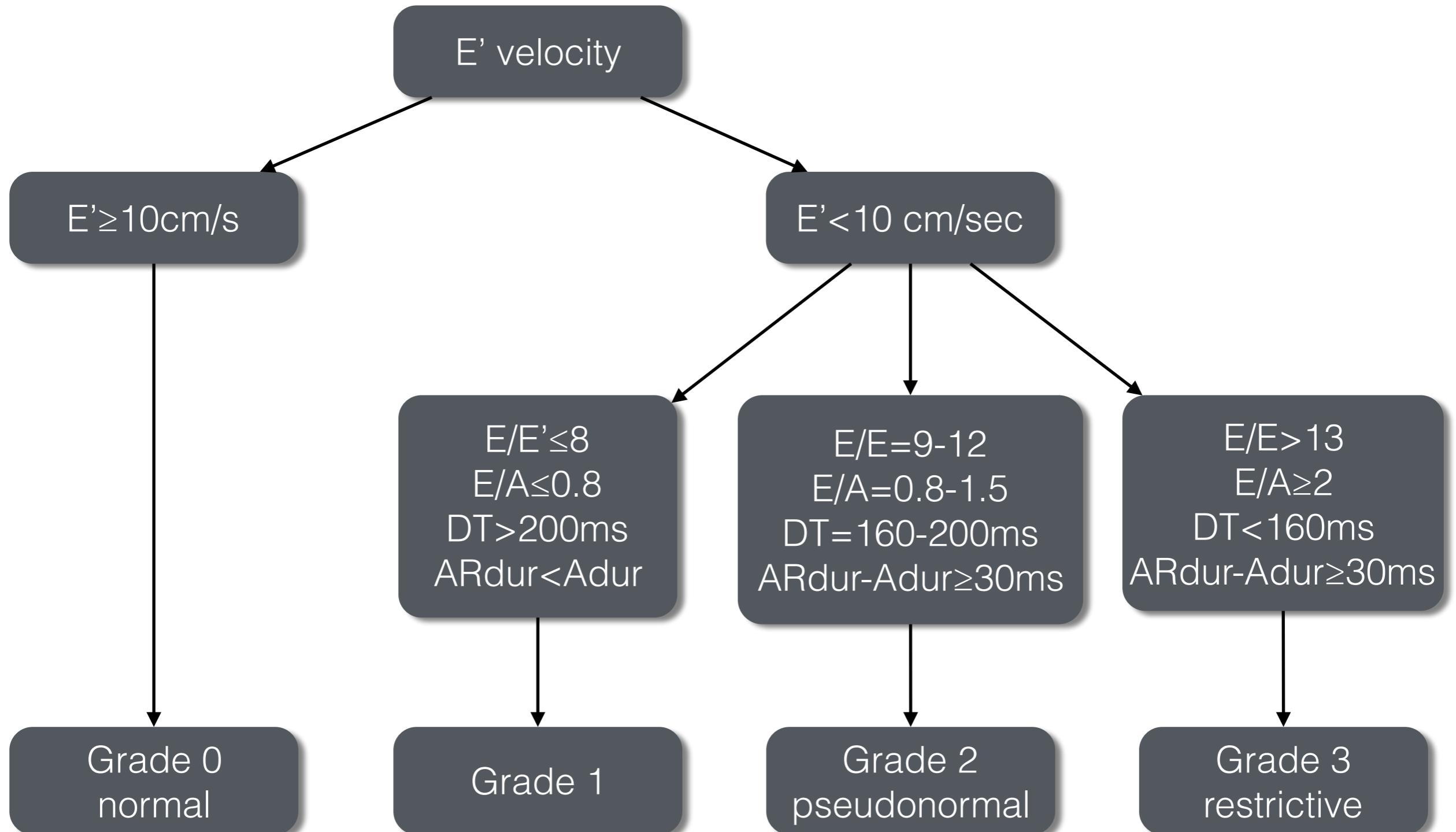
Utility of a Simple Algorithm to Grade Diastolic Dysfunction and Predict Outcome After Coronary Artery Bypass Graft Surgery

Madhav Swaminathan, MD, Alina Nicoara, MD, Barbara G. Phillips-Bute, PhD, Nicolas Aeschlimann, MD, Carmelo A. Milano, MD, G. Burkhard Mackensen, MD, PhD, Mihai V. Podgoreanu, MD, Eric J. Velazquez, MD, Mark Stafford-Smith, MD, Joseph P. Mathew, MD, and the Cardiothoracic Anesthesia Research Endeavors (CARE) Group*

Departments of Anesthesiology and Medicine, Duke Clinical Research Institute; and Department of Surgery, Duke University Medical Center, Durham, North Carolina

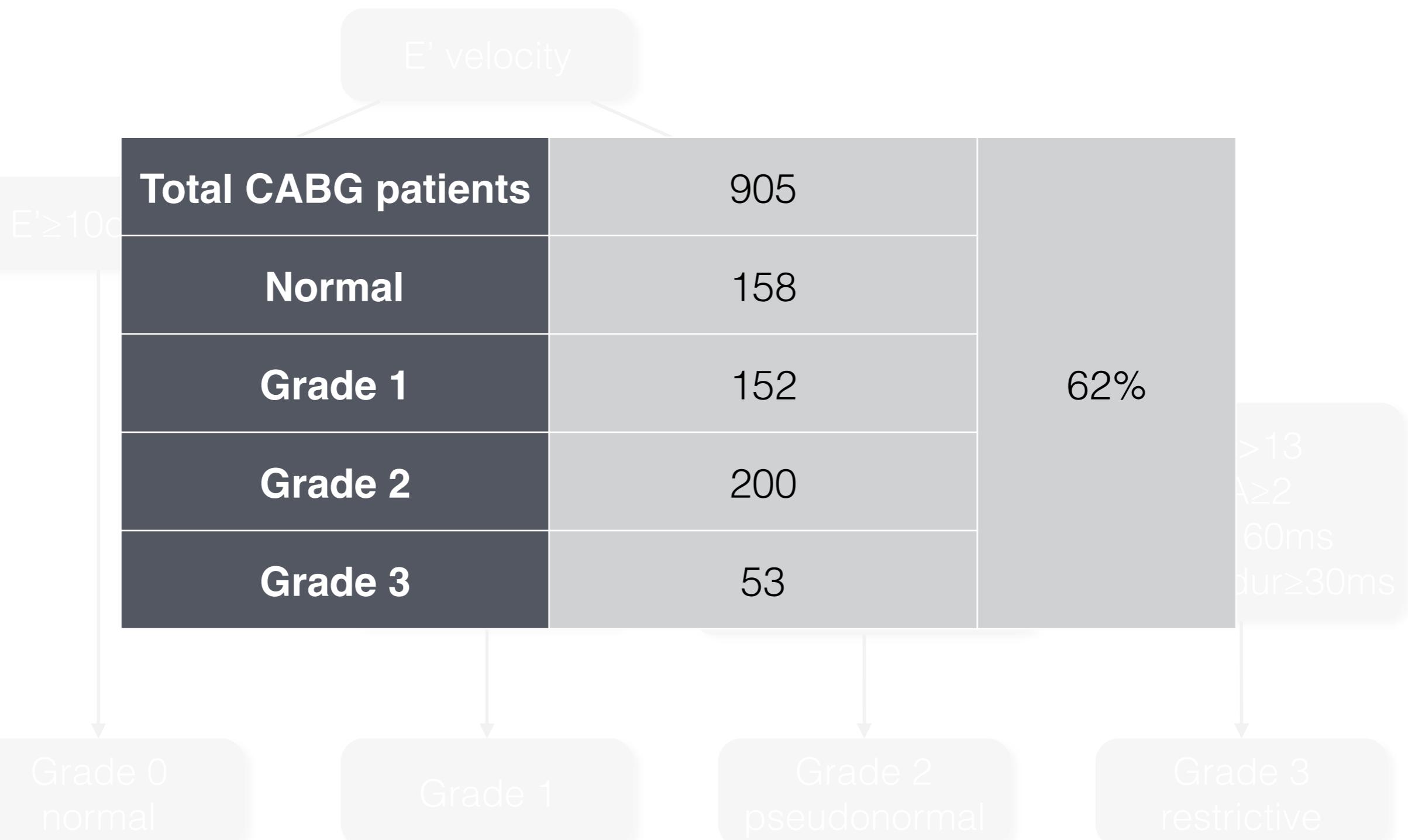


ASE algorithm



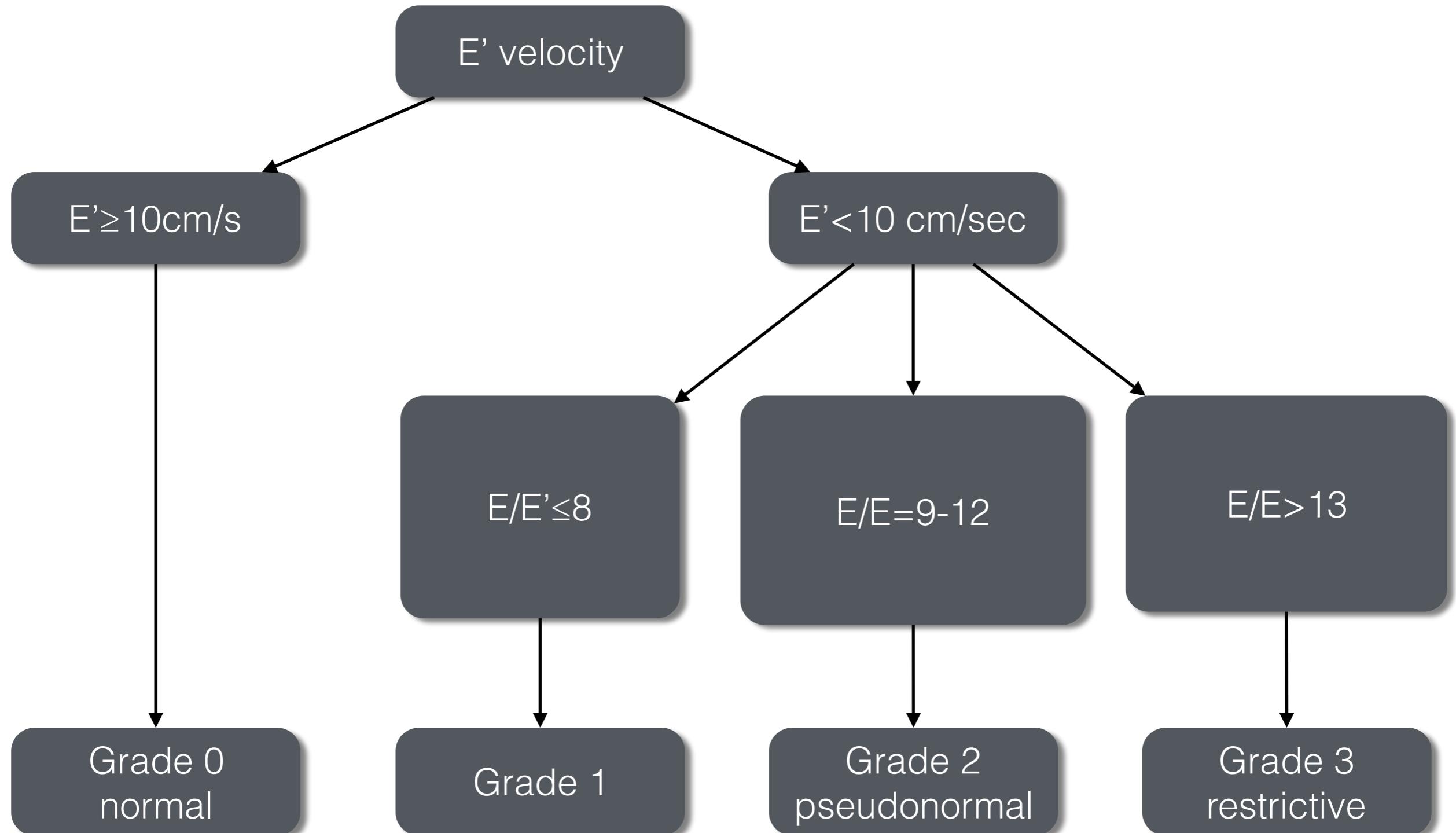


ASE algorithm



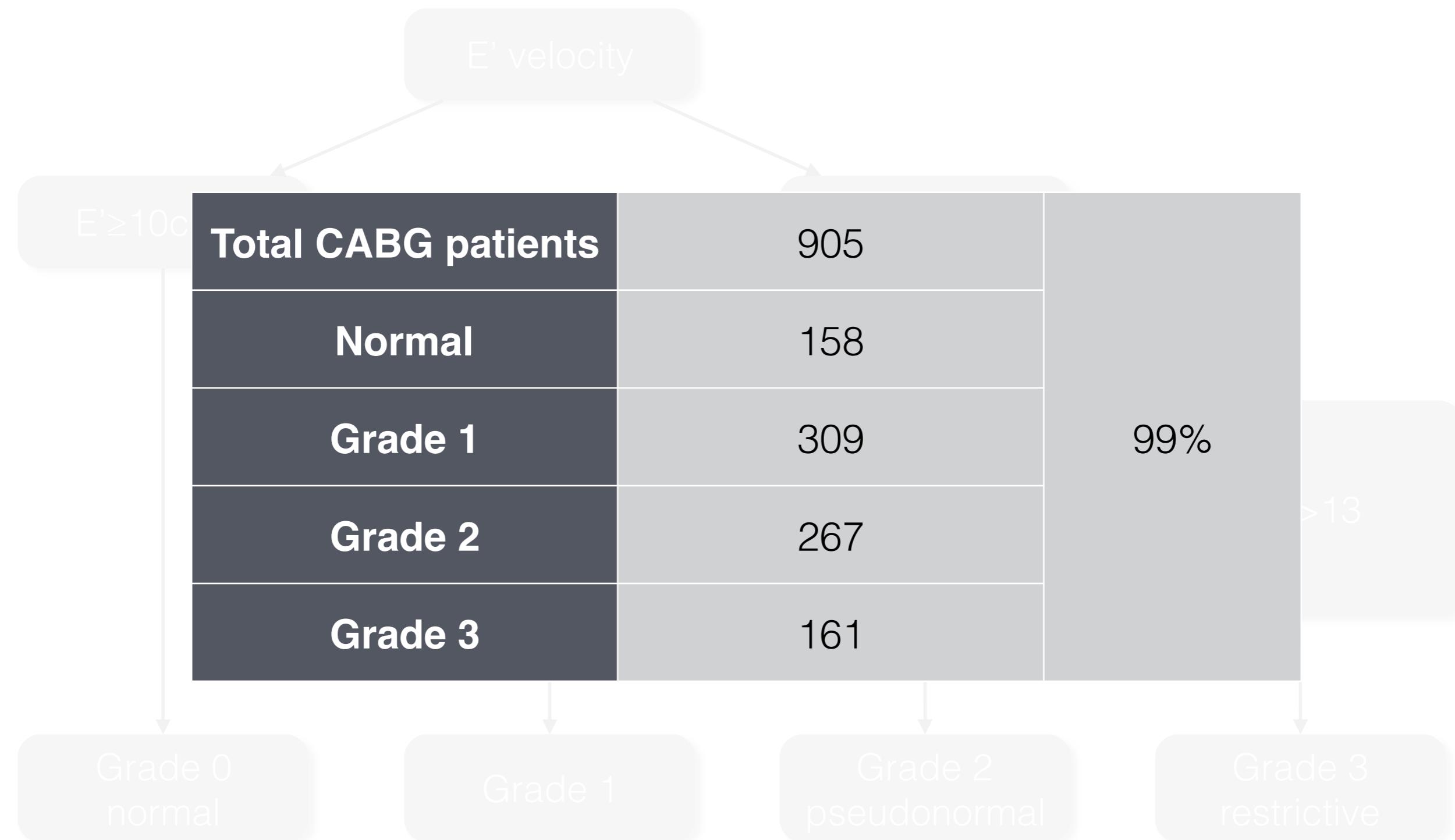


ASE algorithm, simplified





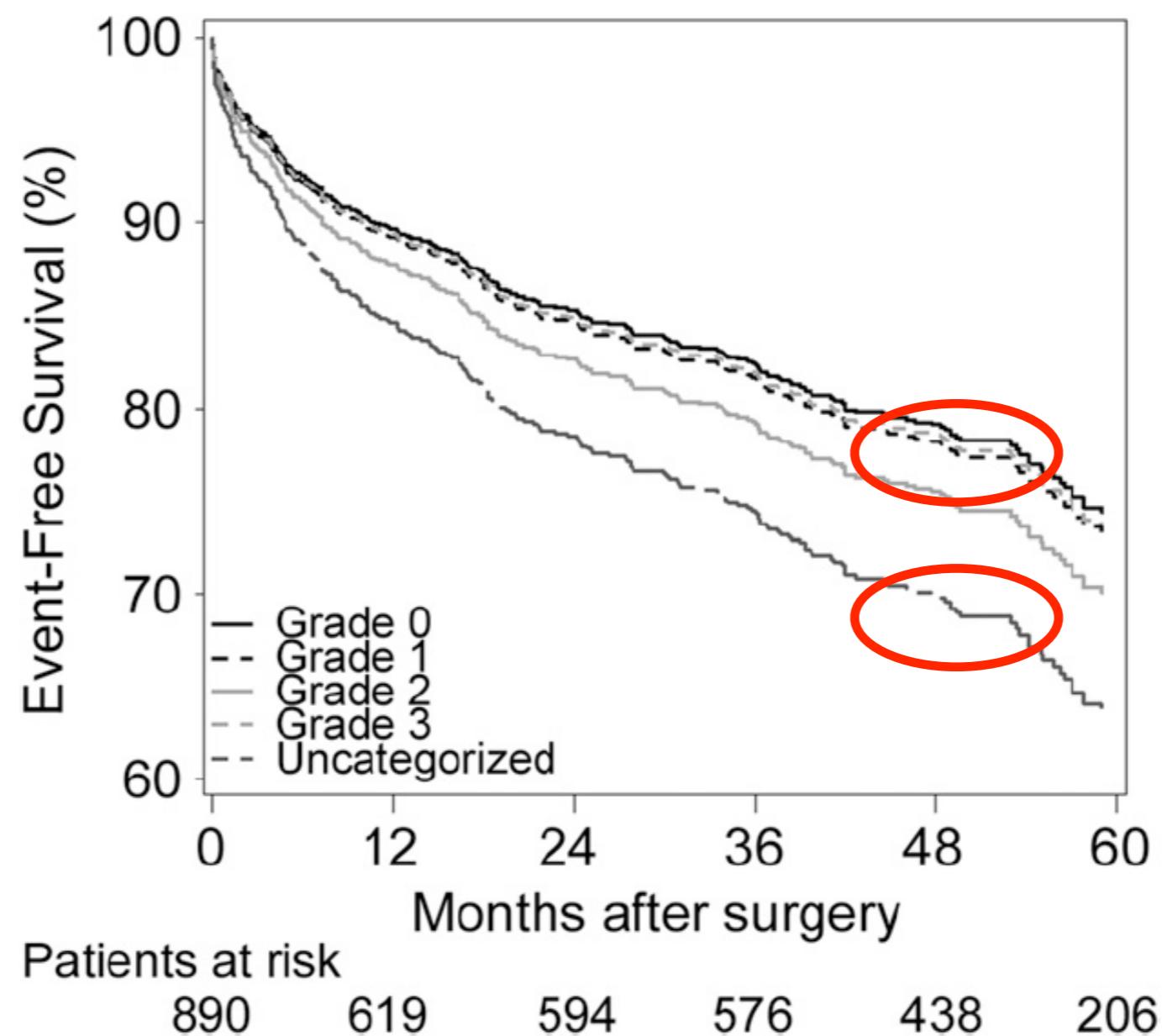
ASE algorithm, simplified





ASE algorithm

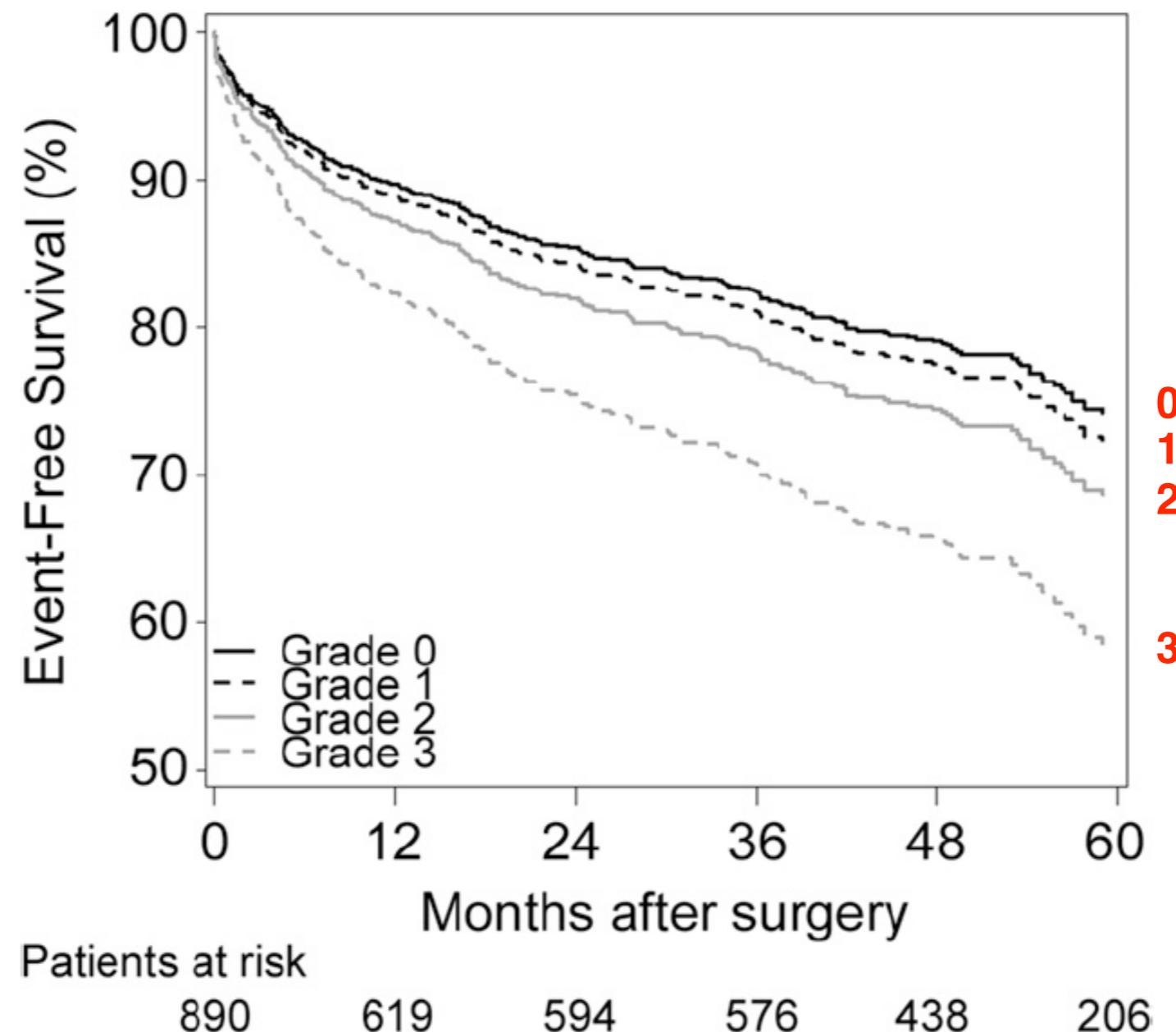
Kaplan-Meier Survival curves for MACE





ASE algorithm, simplified

Kaplan-Meier Survival curves for MACE



Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography

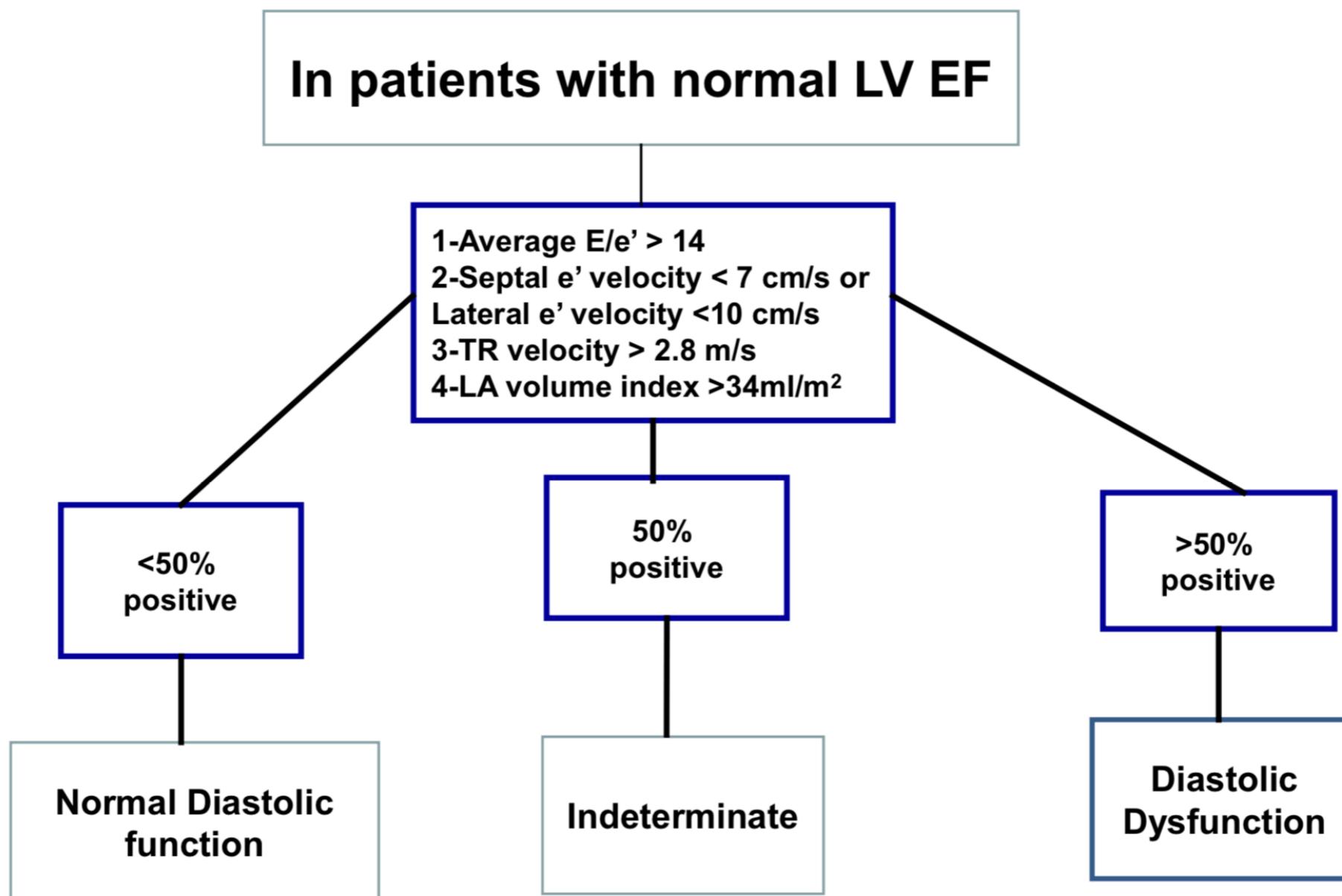
(J Am Soc Echocardiogr 2016;29:277-314.)

- Emphasis on reproducible and feasible measurements
- Start with clinical data/ 2D/ color flow Doppler information
- If abnormal EF, likely diastolic dysfunction



Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography

(J Am Soc Echocardiogr 2016;29:277-314.)

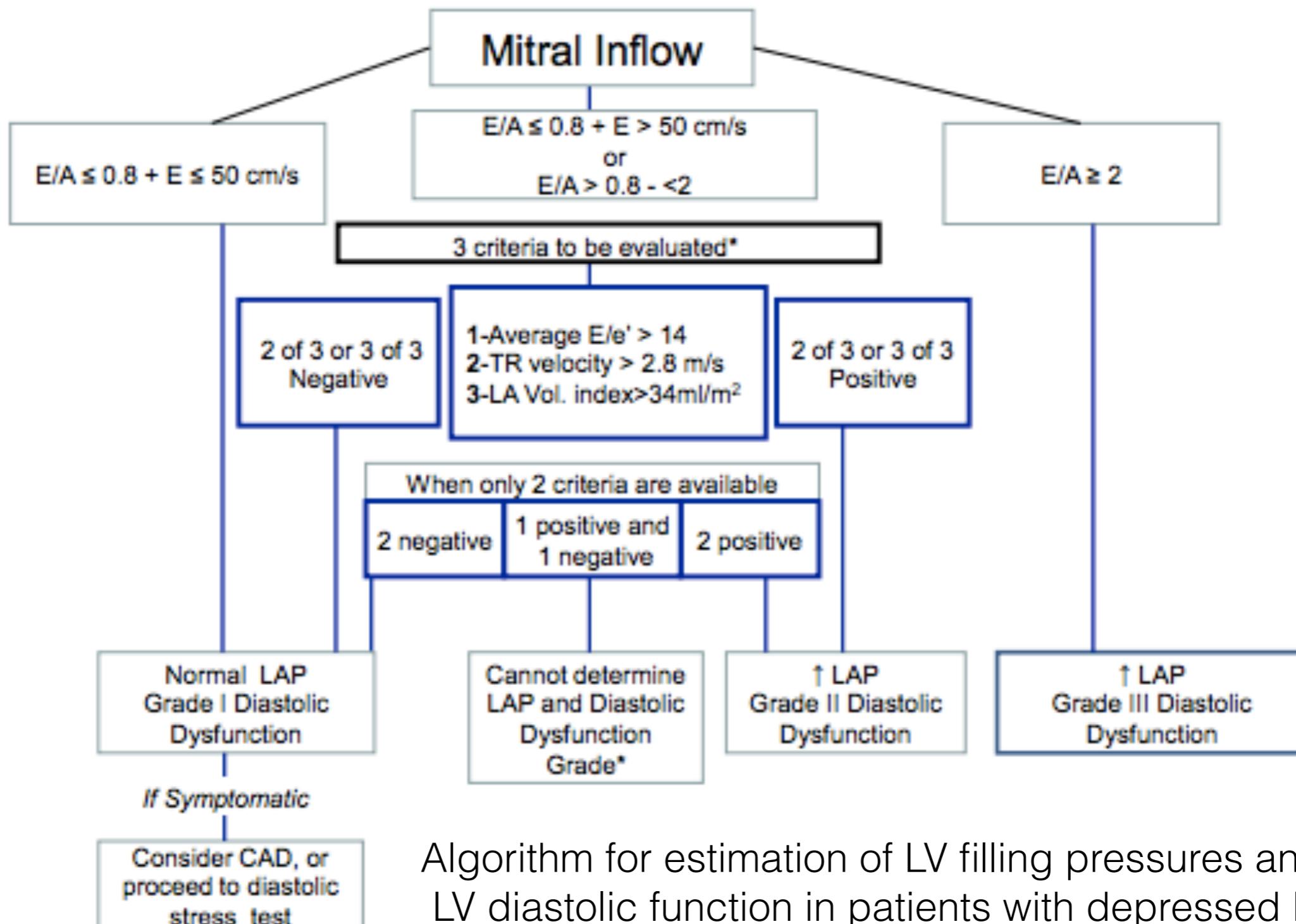


Algorithm for diagnosis of LV diastolic dysfunction in subjects with normal LV EF



Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography

(J Am Soc Echocardiogr 2016;29:277-314.)



Algorithm for estimation of LV filling pressures and grading LV diastolic function in patients with depressed LVEF and patients with myocardial disease and normal LVEF



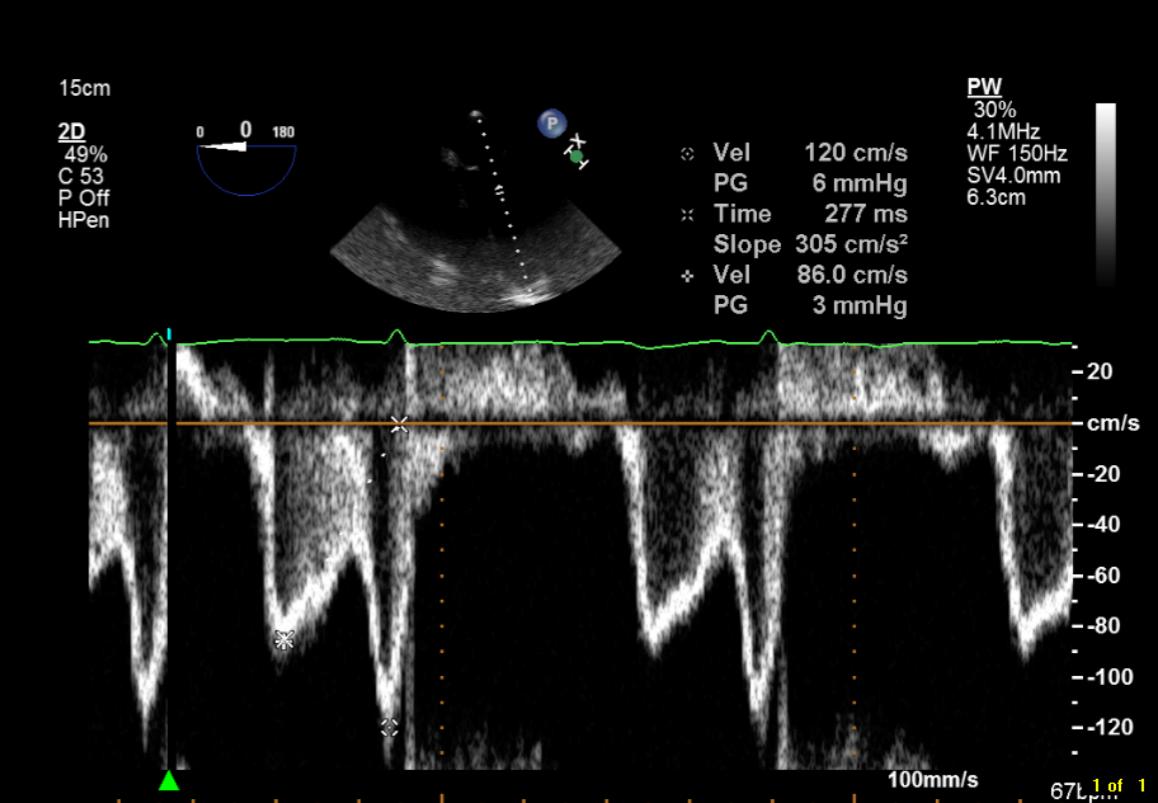
Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography

(J Am Soc Echocardiogr 2016;29:277-314.)

Mitral Flow

$E/A \leq 0.8 + E \leq 50 \text{ cm/sec}$

Normal LAP
Grade I diastolic dysfunction

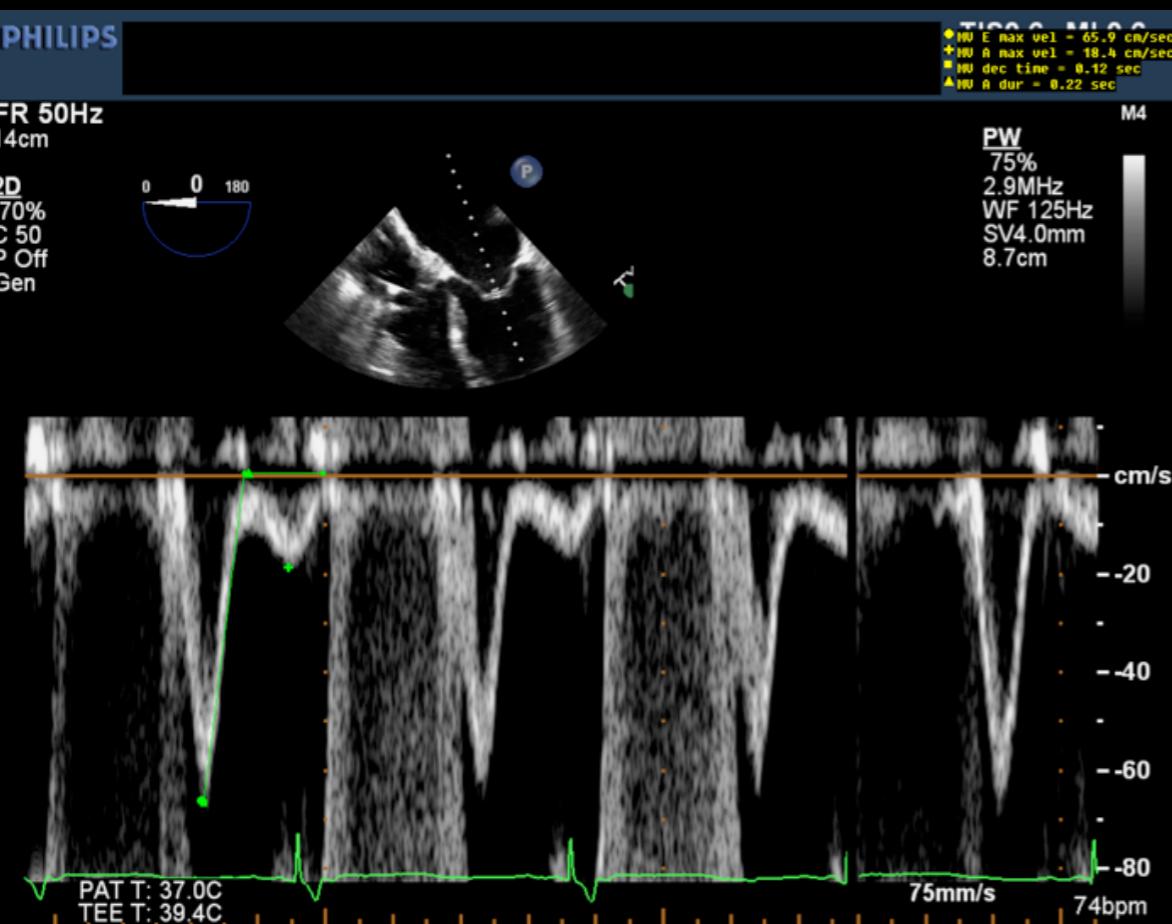




Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography

(J Am Soc Echocardiogr 2016;29:277-314.)

Mitral Flow



E/A > 2
↓
Elevated LAP
Grade III diastolic dysfunction



Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography

(J Am Soc Echocardiogr 2016;29:277-314.)

Mitral Flow



$E/A \leq 0.8 + E > 50 \text{ cm/sec}$

$0.8 < E/A < 2$



Average $E/e' > 14$

TR velocity $> 2.8 \text{ m/s}$

LA volume index $> 34 \text{ ml/m}^2$



2/3 positive \rightarrow elevated LAP
grade II DD



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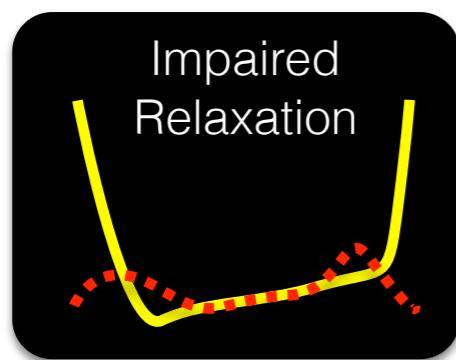
Impaired stress response

- They do not tolerate atrial fibrillation well
- They do not tolerate tachycardia well
- They do not tolerate elevations in systemic blood pressure
- Ischemia results in acute worsening of diastolic dysfunction

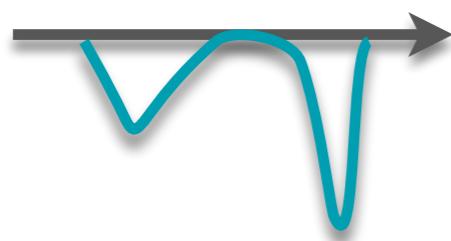


Diastolic dysfunction

Grade 1



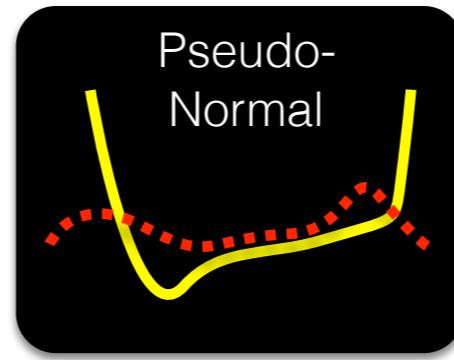
$DT > 200$ ms
 $E/A < 0.8$



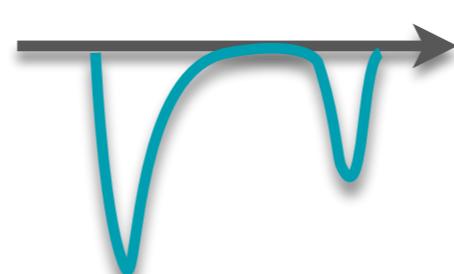
$E' < 8$



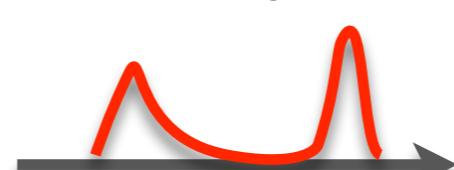
Grade 2



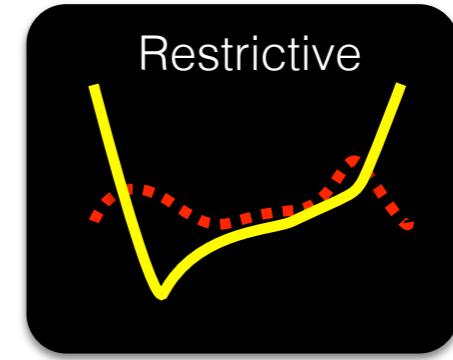
E/A 0.8-1.5



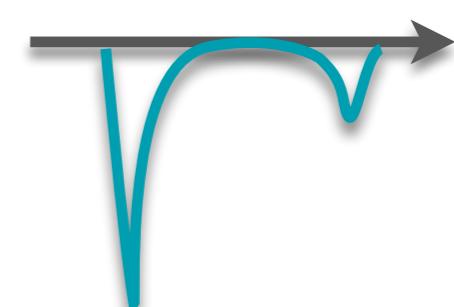
$E' < 8$



Grade 3



$E/A > 1.5$
 $DT < 150$ ms



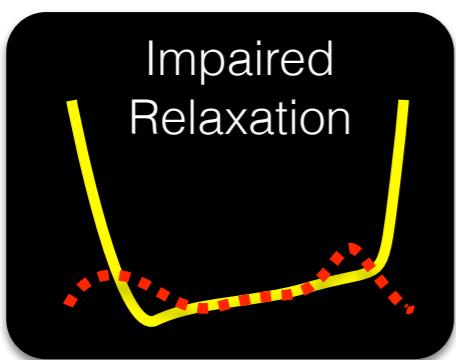
$E' < 8$



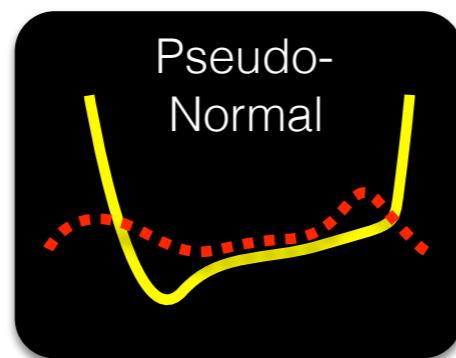


Diastolic dysfunction

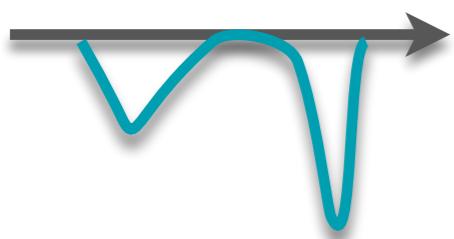
Grade 1



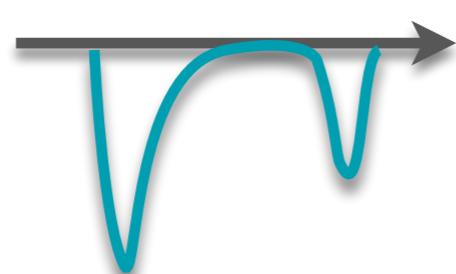
Grade 2



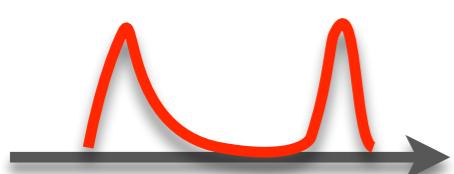
DT>200 ms
E/A < 0.8



E/A 0.8-1.5



$E' < 8$



$E' < 8$

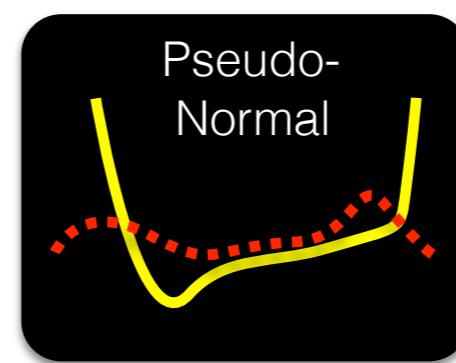


↓ LV relaxation

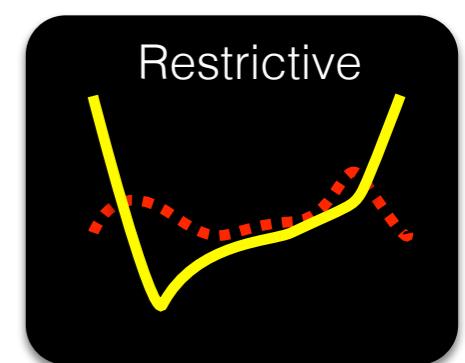


Diastolic dysfunction

Grade 2

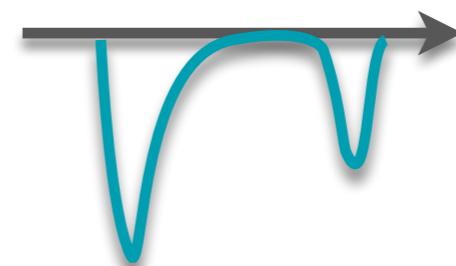


Grade 3

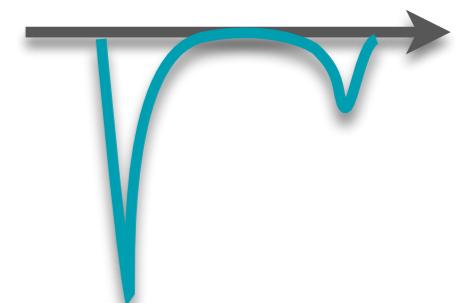


↓ LV compliance

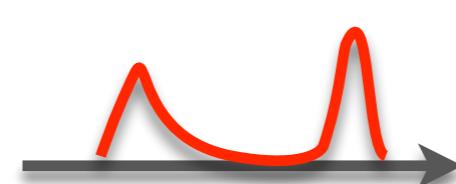
E/A 0.8-1.5



E/A > 1.5
DT < 150 ms



E' < 8

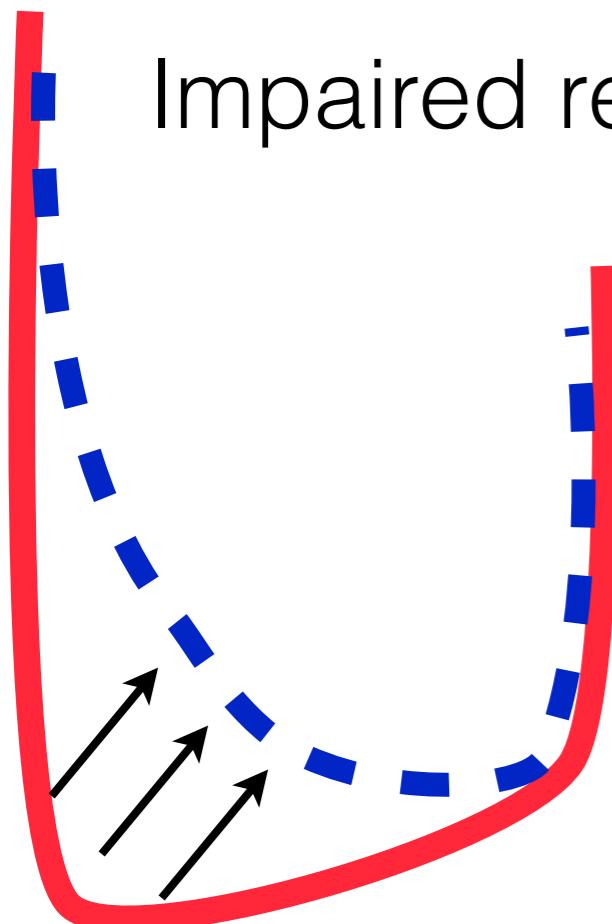


E' < 8





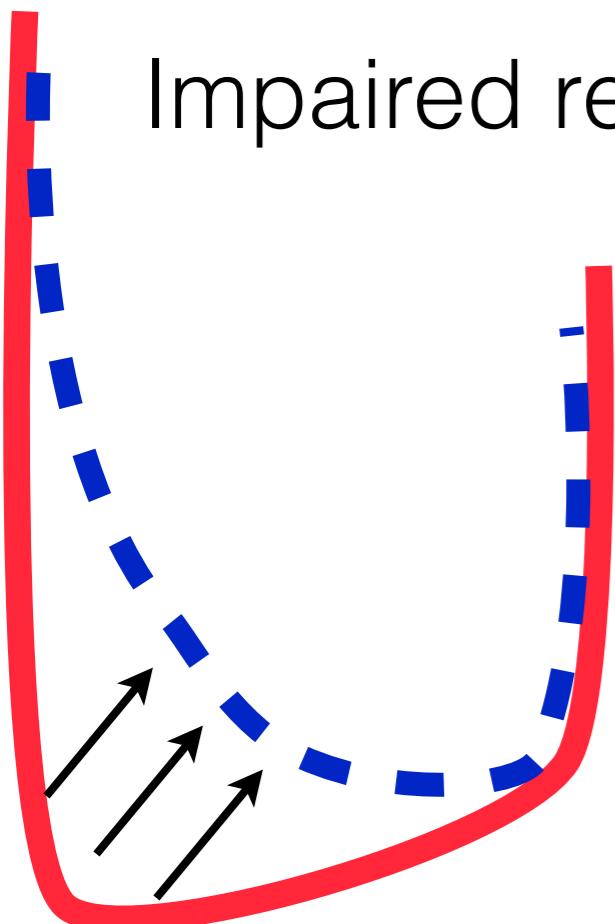
Decreased LV relaxation (grade 1, 2 DD)



- Require a longer filling time
- Dependent on atrial contraction
- Preload tolerant



Decreased LV relaxation (grade 1, 2 DD)



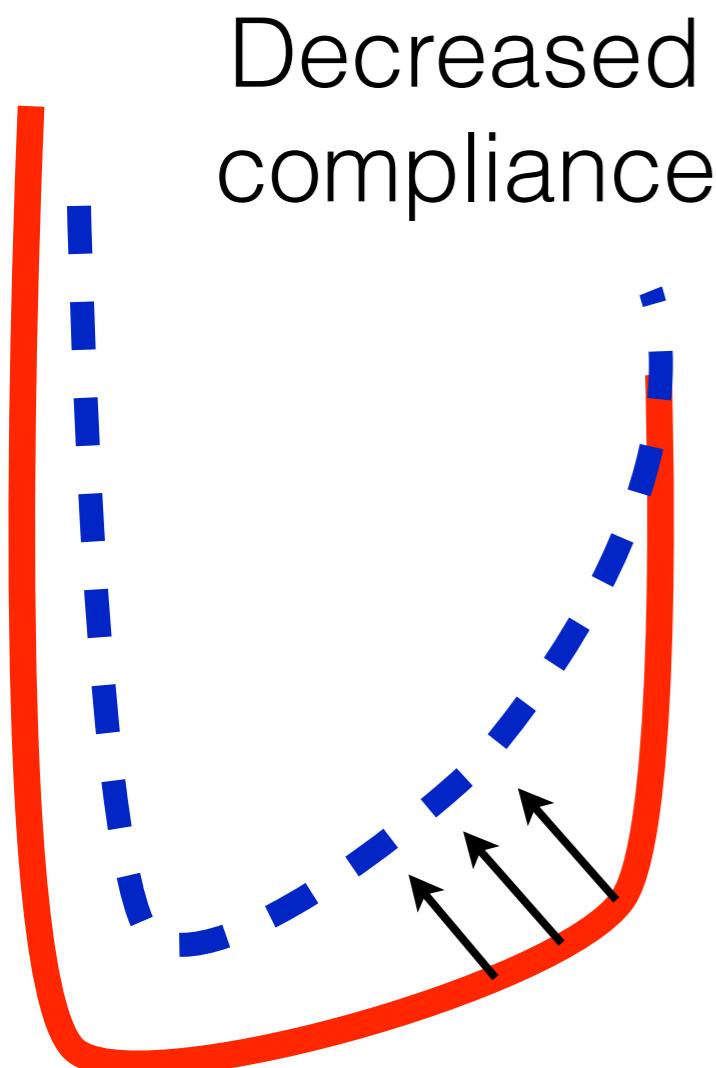
Impaired relaxation

Anesthetic management:

- Fluid administration
- Avoid tachycardia
- Avoid hypertension
- Maintain sinus rhythm



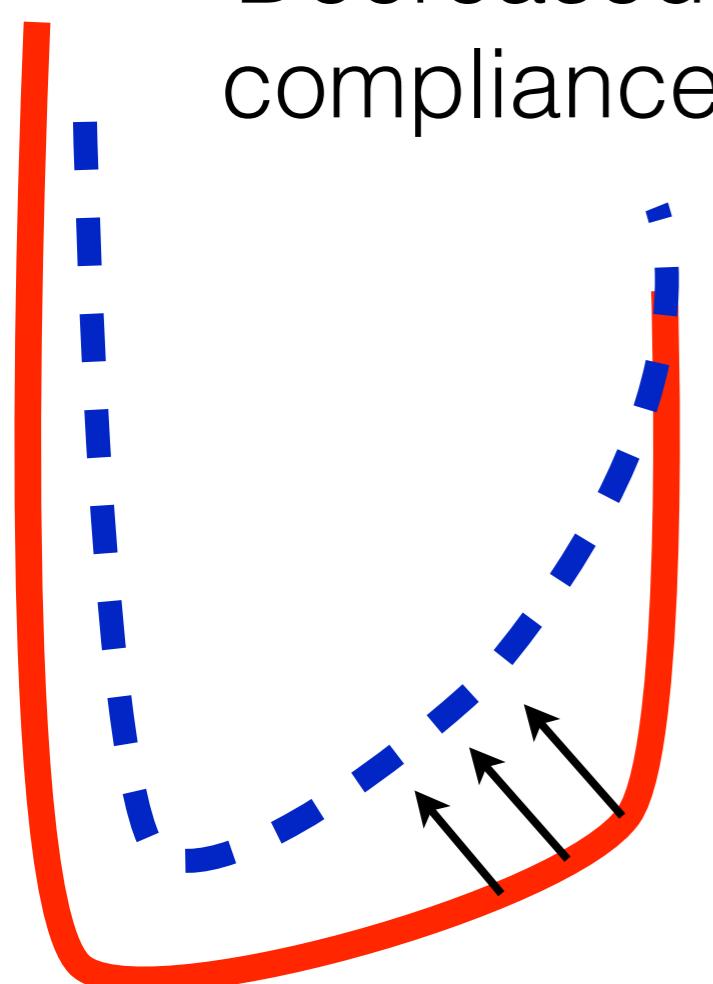
Decreased LV compliance (grade 2, 3 DD)



- Stiff LV → fixed stroke volume
- Preload intolerant
- Dependent on heart rate
- Increased LVEDP → dependent on SVR



Decreased LV compliance (grade 2, 3 DD)

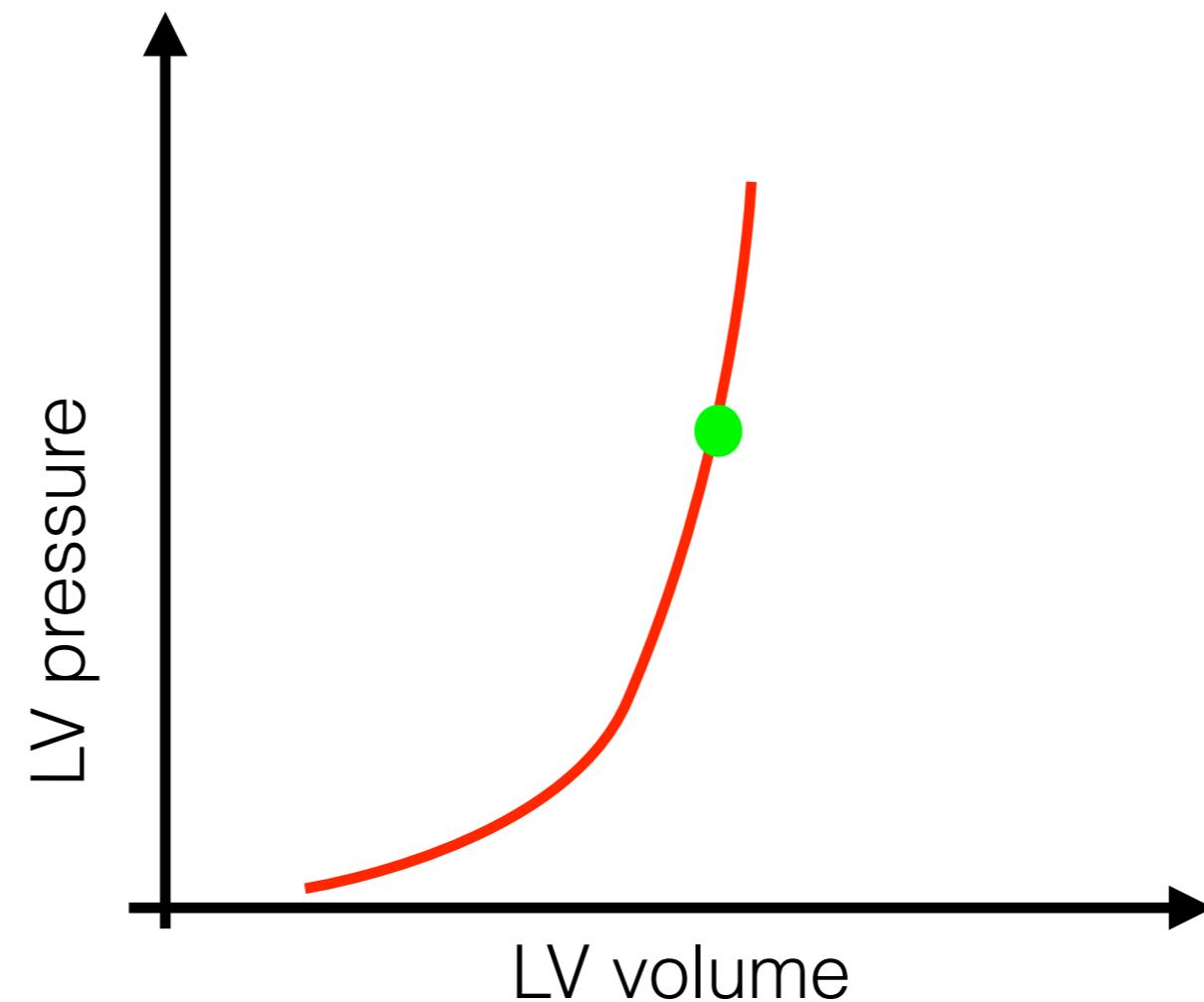


Anesthetic management

- Carefully titrate fluids
- Maintain SVR
- Avoid increase in afterload
- Avoid bradycardia
- Mild diuresis → better LV filling



Decreased LV compliance (grade 2, 3 DD)



- Mild diuresis → better LV filling



Summary

- The number of patients with DHF will increase
- DD is associated with perioperative morbidity and mortality
- Knowledge of the underlying pathophysiological changes is paramount