What is Diastology?

Diastology for the Clinician

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Diastolic function at the molecular and cellular level

Calcium handling
from Troponin to SR and cytosol
SERCA
Phospholamban
Effect of calcineurin
Cytosolic Ca++ concn
Na/K pump

Energetic factors
ADP/ATP ratio
Rate of crossbridge cycling
Creatinine kinase
Role of PDE5A

Extracellular matrix
Collagen Type I and III
Collagenase expression
Metalloproteinase
TIMP (inhibit MMP)

Cellular apparatus
Cardiomyocyte skeleton
Endomysial proteins (tropomyosin, actin, myosin)
Endosarcomeric proteins (titin, alpha-actinin)
Cytoskeletal proteins (tubulin, desmin)
Membrane associated (dystrophin, spectrin)
Intercalated disc protein (desmosomal)
Affects myocardial viscoelastic forces
Diastolic function from a physiologic point of view

Emerging pathophysiology: Inflammation and the endothelium

What is Diastology?
Clinical Problem:
The heart cannot fill with blood
Result: high filling pressures and low output

What is Diastology?

• Understand how the heart fills
  • Normally
  • Abnormally
• Apply to the patient with a low EF
• Evaluate the patient with “heart failure” and a normal EF

What is Diastology?

Contraction
Relaxation
Active and passive filling
Atrial contraction
Contraction

Relaxation

Passive Filling

AC

Normal Filling

Impaired Relaxation

Early diastolic dysfunction
Impaired Relaxation

Relaxation

Impaired Relaxation

Decreased initial filling compensated by atrial contraction

Normal filling pressures at rest

Impaired Relaxation

Rest

PCWP:
13 mmHg

20 mmHg

0 mmHg

Decreased initial filling compensated by atrial contraction

Normal filling pressures at rest
Impaired Relaxation

Rest

Exercise

PCWP = 13

PCWP = 22

Impaired Relaxation

Cannot properly fill during exercise

Elevated pressures with exercise

PCWP = 22

Impaired Relaxation

Cannot handle increased fluids

Normal PAWP rest 15 mmHg

Marked elevation PAWP 35 mmHg

Elevated pressures with exercise
Impaired Relaxation
Exquisitely sensitive to afterload

BP 150 mmHg PAWP 18
BP 180 mmHg PAWP 30
BP 220 mmHg PAWP 48

Normal Filling
Early diastolic dysfunction
Impaired Relaxation
Compensated rest
Elevated filling pressures
Exercise
Increase afterload
Fluid load

Impaired Relaxation
Impaired Relaxation

Effect of increasing filling pressures
On top of delayed relaxation

Increased filling pressures with exercise
Increased filling pressures with fluids
Increased filling pressures with increased afterload

Diastology

Normal
40
0
Diastology

Normal
Abnormal relaxation

Fluids
BP
Ischemia

No change in filling pressure
No change in mitral inflow

Diastology

Normal
Abnormal relaxation
Pseudo-normalization
Restriction (reversible)

Fluids
BP
Ischemia

No change in filling pressure
No change in mitral inflow
Diastology

- Normal relaxation
- Pseudo-normalization
- Restriction (reversible)
- Restriction (irreversible)

Interstitial fibrosis
Abnormal muscle stiffness
Not “reversible”

Now let’s apply this foundation to:
Patient with reduced EF
Patient with normal EF

Low ejection fraction
What do you need to know?
If you have abnormal systolic function
You will not have normal diastolic function

Higher E:A ratio – shorter DT
Higher filling pressures – poorer prognosis

Etiology of LV dysfunction

ACE inhibitor
Beta blocker

Low filling pressures
Well compensated

High filling pressures
Diuresis
Afterload reduction
What is Diastology?

• Understand how the heart fills
  • Normally
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Looks restrictive
Looks bad

28 y/o competitive tri-athlete
Mild DOE after 20 miles

In patients with systolic dysfunction
Higher E:A and shorter DT
Higher filling pressure
Poorer prognosis

There is a major difference for patients with normal EF
Relaxation

Faster rate of relaxation
Suction of blood
Allows more volume into LV

Suction: enhanced relaxation

Diastology: Normal EF
If you have normal systolic function
Higher E:A ratio – good or bad

Diastology: Normal EF

EF 60%
Normal (good) vs. Pseudonormal (bad)

Doppler Tissue Imaging
Diastology: Normal EF

End diastole

Diastology: Normal EF

Systole

Diastology: Normal EF

Relaxation
**Diastology: Normal EF**

*Tissue Doppler*

*Annular motion*

E’ is the rate of ventricular relaxation

Higher E’ = faster relaxation

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**Diastology: Normal EF**

- Supra-Normal
- Normal relaxation
- Abnormal normalization
- Restriction

\[ E/E' < 8-10 \] \text{Good}

\[ E/E' > 12-15 \] \text{Bad}

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**Diastology: Normal EF**

- Normal diastolic function
- Normal filling pressures
- Abnormal diastolic function
- Very high filling pressures
Now let’s evaluate the patient with known heart failure (elevated JVP, rales, CXR congestion, elevated BNP) but preserved EF.

Clinical presentation of heart failure
Normal systolic function

74 y/o woman – history HTN and DM
Severe SOB after holidays
Exam: BP 190/88, rales, S3
EF 66%
E/E’ 17

BP 190/88
PA = 70/30 mmHg
Mean LAP = 30 with “V” 55 mmHg

BP 122/65
PA = 35/15 mmHg
Mean LAP = 12 with “V” 20 mmHg
This is HFpEF
Heart Failure Preserved EF

74 y/o woman – history HTN and DM
Severe SOB after holidays
Exam: BP 190/88, rales, S3
EF 66%

Marked improvement with diuretics
BP control

Clinical presentation of heart failure
2017
This is HFpEF
Heart Failure Preserved EF

Concept of “ventriculo-vascular coupling”
Baseline abnormal relaxation (HTN, CAD)
Exacerbated by BP, excess salt, ischemia
Responds well to treatment

Treatment of HFpEF

Direct Effect on Diastolic Function

Drugs that don’t work
ACE Inhibitor
ARB blockers
Beta blockers
Calcium blockers
Sildenafil

Drugs that may work
Aldosterone antagonist
ARNI

Treatments that improve symptoms
Rx BP
Decrease salt

Abnormal relaxation
Pseudo-normalization
Restriction (reversible)
Restriction (irreversible)

40
0
Emerging pathophysiology: Inflammation and the endothelium

Pro-inflammatory co-existing conditions
- HTN, DM, obesity
- Smoking, OSA
- Increased oxidative stress
- Systemic microvascular endothelial inflammation
- Increased murmur stiffness
- Muscle inflammation
- Microvascular dysfunction

Cardiac remodeling
- Impaired coronary reserve
- Impaired oxygen delivery uptake and utilization

Treatments that work!!!
- Diet and exercise
- Weight loss
- CPAP

Clinical presentation of heart failure
Normal systolic function

55 y/o man – progressive DOE 6 months
- Edema and ascites
- Exam BP 90/60, JVP elevated 20 cm
- No murmurs S3 present

Redfield NEJM 2016
**Myocardial Restrictive Disease**

- Abnormal relaxation
- Pseudo-normalization
- Restriction (reversible)
- Restriction (irreversible)

Primary heart muscle stiffness
- Not reversible
- Not hypertensive

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**Clinical presentation of heart failure**

- Normal systolic function

This is NOT HFpEF!

- Not hypertensive
- Predominant ascites, edema
- Marked elevation JVP
- Clear lungs

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**Clinical presentation of heart failure**

- Normal systolic function

Severe myocardial restrictive disease

1. Amyloidosis
2. Radiation heart
3. Sarcoid, HCM

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Clinical presentation of heart failure
Normal systolic function

Severe myocardial restrictive disease

1. Amyloidosis
2. Radiation heart
3. Sarcoid, HCM

Further workup
Bloods
Sed rate
Free light chains
Ferritin
MRI scan
Pyrophosphate scan
Endomyocardial biopsy

“True” HFpEF
Ventriculovascular Coupling

Episodes pulmonary edema
Hypertensive
Responsive to:
Diuretics,
Vasodilators

Restrictive Myocardial Disease

Right heart failure
Hypotensive
Not responsive to:
Diuretics,
Vasodilators

Clinical presentation of heart failure
Don’t forget this one

Clinical presentation of heart failure

Apical 4-Chamber View
Clinical presentation of heart failure
Normal systolic function

“True” HFpEF
Ventriculo-vascular
Coupling

Restrictive
Myocardial
Disease

Constrictive
Pericarditis

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