Understand the physiology of diastole (filling).

Further emphasized the need to more fully have normal systolic (emptying) function has diagnosis of congestive heart failure (CHF) patients admitted to hospitals with the recent recognition that up to 50% of patients admitted to hospitals with the diagnosis of congestive heart failure (CHF) have normal systolic (emptying) function has further emphasized the need to more fully understand the physiology of diastole (filling).

"You can know the name of a bird in all the languages of the world, but when you're finished, you'll know absolutely nothing whatever about the bird... So let's look at the bird and see what it's doing -- that's what counts. I learned very early the difference between knowing the name of something and knowing something."

Richard Feynman 1918-1988

In an effort to better understand the filling process cardiologists have noted certain relationships between pressures in the atrium and ventricle and transmural flow, motion of the mitral annulus, atrial function etc.
Pericardial anatomy

The pericardium is the thin sac enclosing the heart.

Ventricular filling: form and function

Anatomy and terminology

Anatomy

Cardiovascular Anatomy and Physiology

LV gram via 6F pigtail catheter

Cardiac MRI Cine Loop (Courtesy CMRL)

"four-chamber view"

So let's look at the heart and see what it's doing – that's what counts.
Cardiac MRI Cine Loop
‘short-axis view’

Cardiac MRI Cine Loop
“short-axis (salami slices) view”

The cardiac cycle as taught in a textbook of medical physiology

Simultaneous, high fidelity LAP, LVP and transmittal Doppler in closed chest canine. Note reversal of sign of A-V pressure gradient as flow accelerates (LAP > LVP) and decelerates (LAP < LVP).

What Happens in Diastole?

Ventricles fill in two stages (E-and A-waves)

Ventricle fills in 2 phases:
1) Early rapid filling (dP/dV < 0)
2) Atrial filling (dP/dV > 0)

Mechanics of filling:

Ventricular filling: form and function

(isovolumic relaxation, early rapid filling, diastasis, atrial contraction)
We all agree that:
At mitral valve opening, and for a little while thereafter, the LV simultaneously decreases its pressure while increasing its volume!

Therefore it is a mechanical SUCTION PUMP!

How the Heart Works When it Fills

We summarize: to explain the contours of clinically observed Doppler E-waves we utilize the heart’s role as a suction pump whose kinematics can be modeled as a Simple Harmonic Oscillator (SHO) driven by a linear, bi-directional spring!

We summarize:

The heart is a constant volume pump!

Mechanics of filling:

Given:

Another basic attribute about how the heart works:

The heart is a constant volume pump!

Plot of # of voxels vs. fraction R-R interval for 3-D data set
**How the Heart Works:**

**Constant-Volume Attribute of the Four-Chambered Heart**

Via MRI - how are images analyzed? (with Bowman, Caruthers, Watkins)

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**How the Heart Works:**

Cine MRI loop of pericardium for one cardiac cycle

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**How the Heart Works:**

Right heart vs. left heart (n=20)

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**How the Heart Works:**

CONCLUSIONS:

The 'constant-volume pump' and 'suction pump' attributes of the heart, when modeled correctly predict and explain the observations pertaining to why:

1) \( \frac{E}{E'} \) is a legitimate index of diastolic function,
2) \( \frac{E}{E'} \) is linearly related to LVEDP,
3) the relationship of maximal rate of wall thinning to the Doppler E-wave
   and
4) We can now solve the "Load Independent Index of Diastolic Function" problem!

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