open.michigan

Author(s): Louis D'Alecy, 2009

Citation Key

for more information see: http://open.umich.edu/wiki/CitationPolicy

Use + Share + Adapt

{ Content the copyright holder, author, or law permits you to use, share and adapt. }

PD-GOV **Public Domain – Government**: Works that are produced by the U.S. Government. (USC 17 § 105)

PD-EXP **Public Domain – Expired**: Works that are no longer protected due to an expired copyright term.

PD-SELF **Public Domain – Self Dedicated**: Works that a copyright holder has dedicated to the public domain.

ZERO **Creative Commons – Zero Waiver**

BY **Creative Commons – Attribution License**

BY-SA **Creative Commons – Attribution Share Alike License**

BY-NC **Creative Commons – Attribution Noncommercial License**

BY-NC-SA **Creative Commons – Attribution Noncommercial Share Alike License**

GNU-FDL **GNU – Free Documentation License**

Make Your Own Assessment

{ Content Open.Michigan believes can be used, shared, and adapted because it is ineligible for copyright. }

PD-INEL **Public Domain – Ineligible**: Works that are ineligible for copyright protection in the U.S. (USC 17 § 102(b)) *laws in your jurisdiction may differ

{ Content Open.Michigan has used under a Fair Use determination. }

FAIR USE **Fair Use**: Use of works that is determined to be Fair consistent with the U.S. Copyright Act. (USC 17 § 107) *laws in your jurisdiction may differ

Our determination **DOES NOT** mean that all uses of this 3rd-party content are Fair Uses and we **DO NOT** guarantee that your use of the content is Fair.

To use this content you should **do your own independent analysis** to determine whether or not your use will be Fair.

Cardiac Hydraulics

M1 – Cardiovascular/Respiratory Sequence

Louis D'Alecy, Ph.D.

Fall 2008

University of Michigan
Medical School

Wednesday 10/29/08, 11:00
Cardiac Hydraulics

30 slides, 50 min.

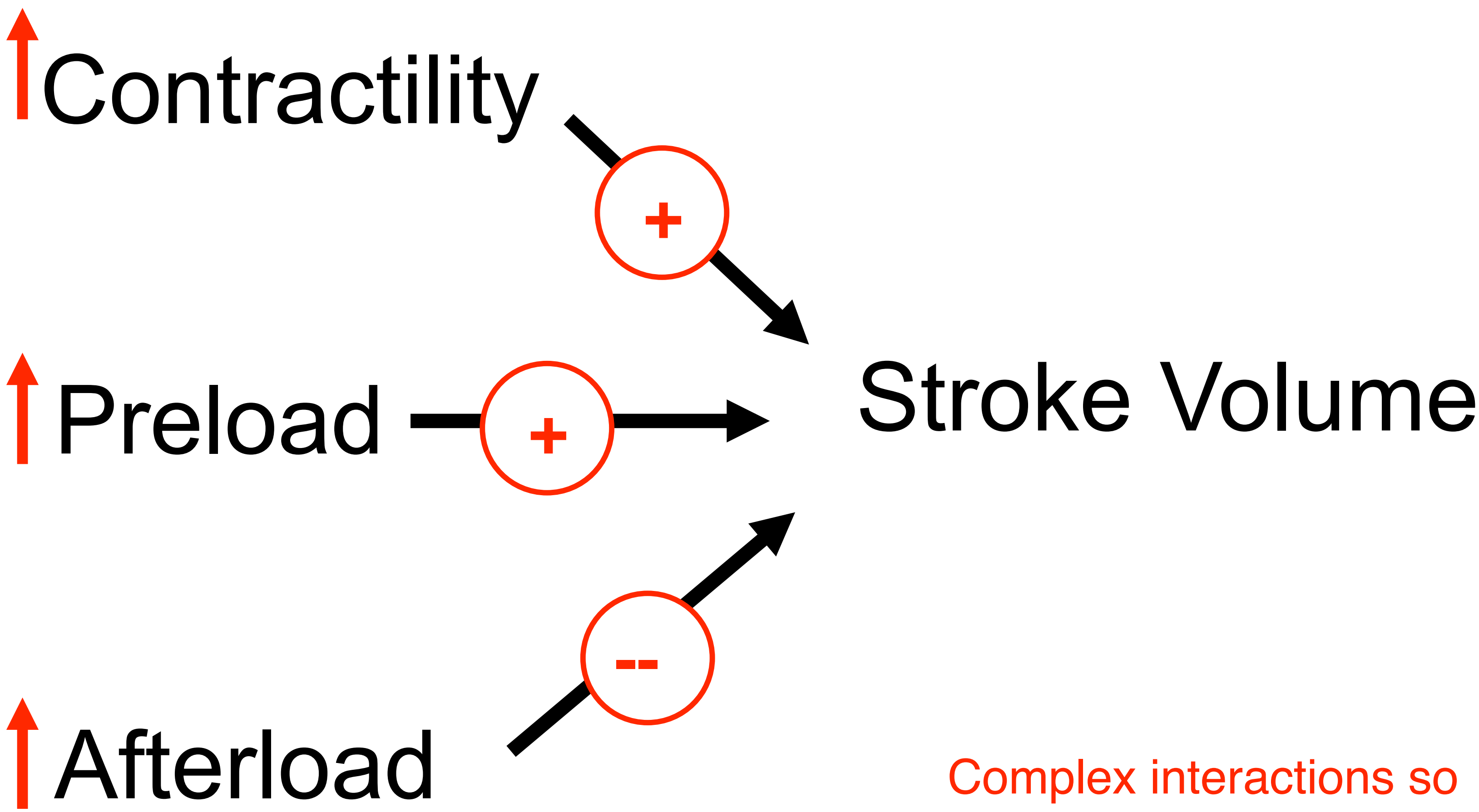
1. Contractility
2. Control of Stroke Volume
3. Ventricular function
4. Estimation of Preload
5. Measurement of stroke volume

Terms Related to Cardiac Performance

Preload - The ventricular wall tension at the end of diastole.

Afterload -- The ventricular wall tension during contraction; the resistance that must be overcome for the ventricle to eject its contents. Approximated by systolic ventricular or arterial pressure.

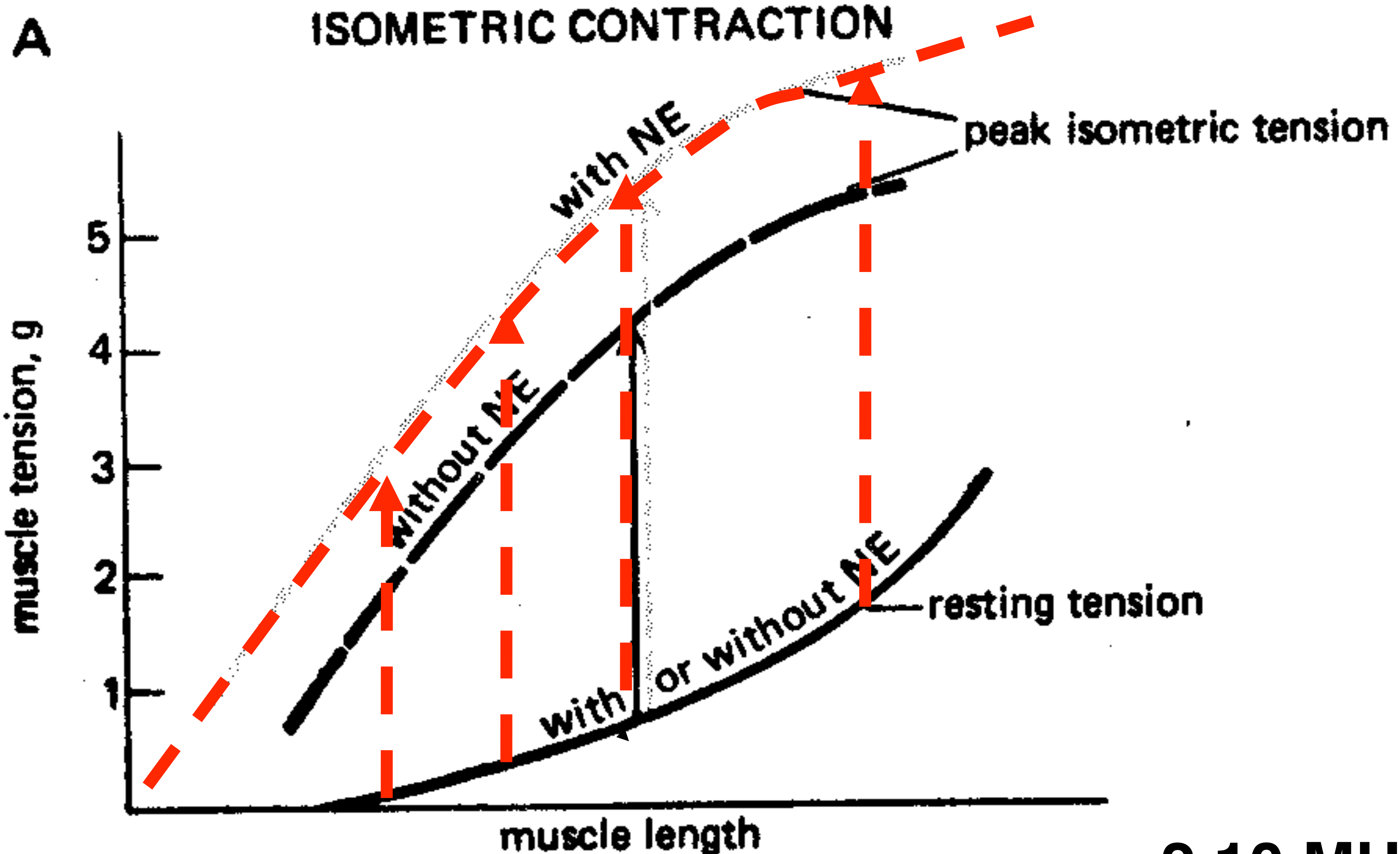
Contractility -- Property of heart muscle that accounts for changes in strength of contraction independent of preload and afterload.



Complex interactions so we will treat each separately with others held constant.

Increased Contractility = Positive Inotropic Effect

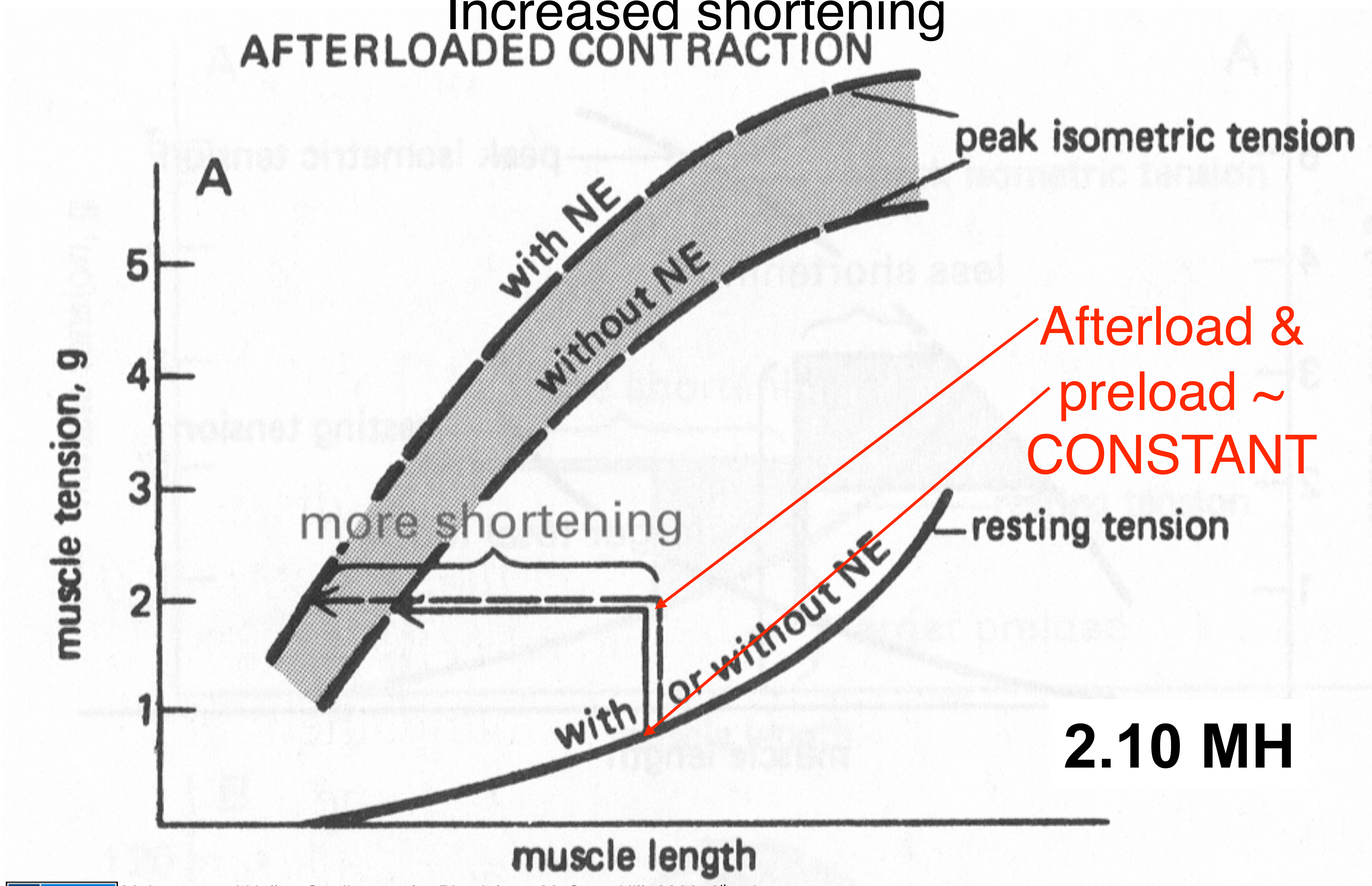
Increased peak isometric tension at each resting length.



 Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.

2.10 MH

Increased Contractility = Positive Inotropic Effect
Increased shortening

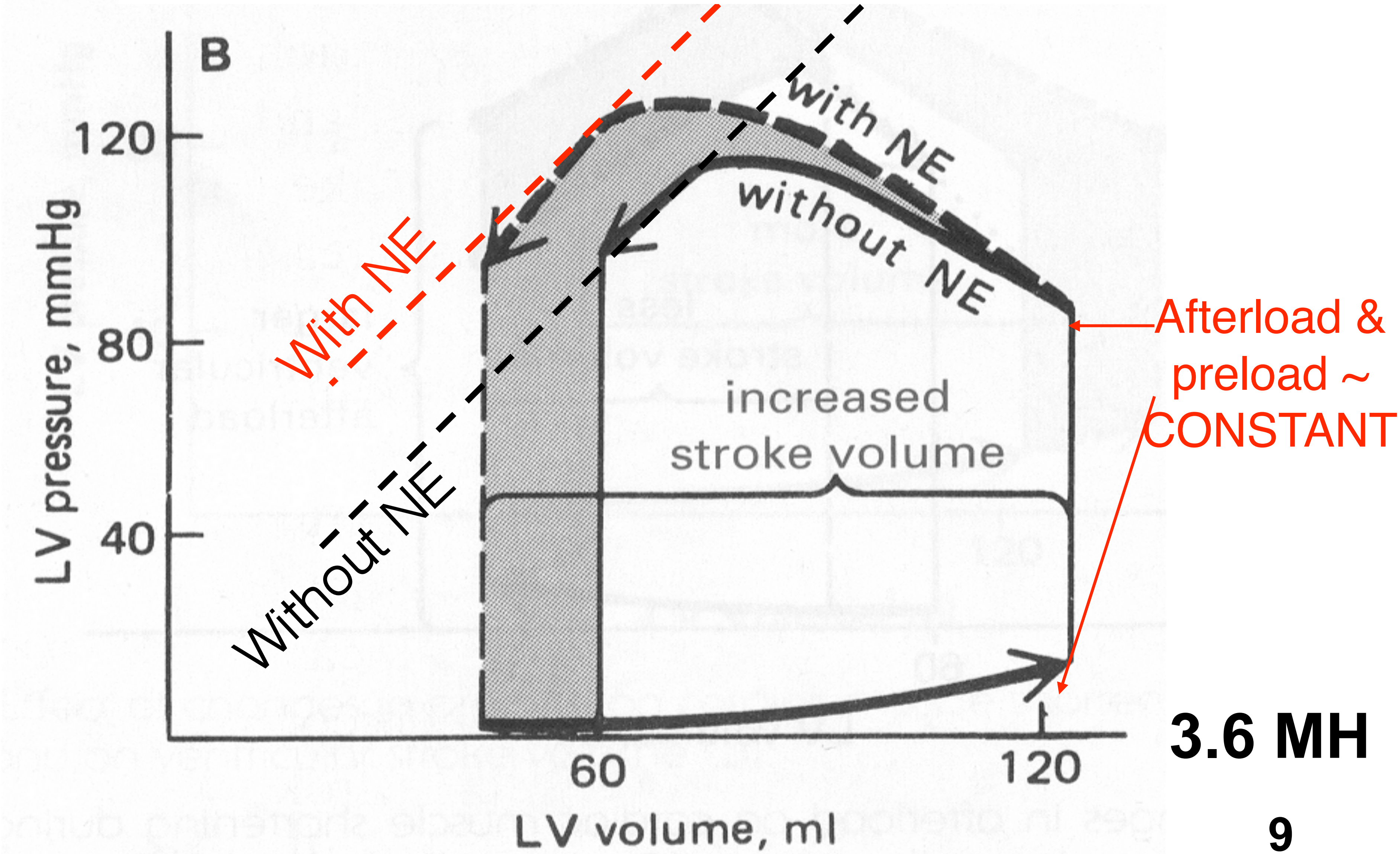


2.10 MH

 Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.

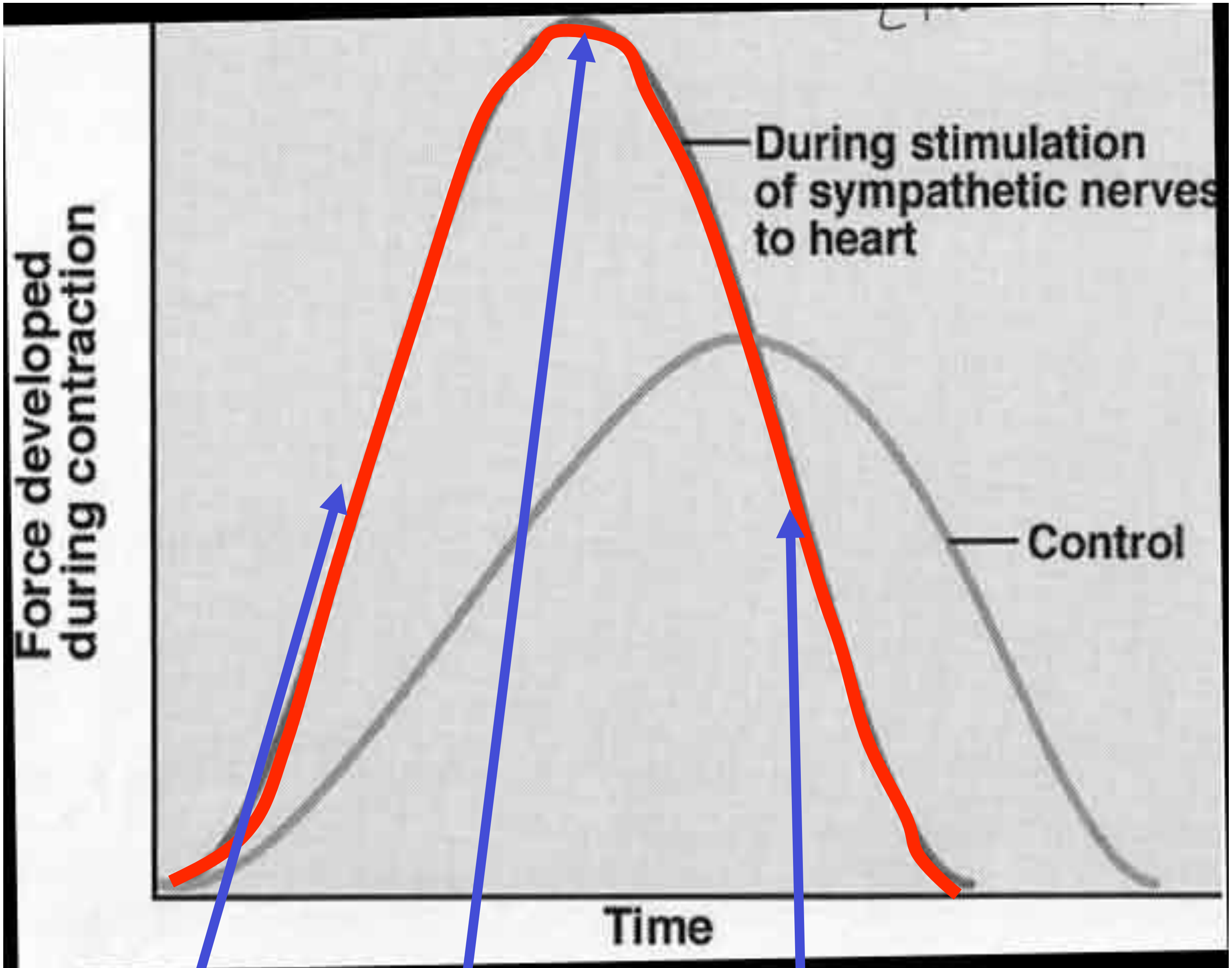
Increased Contractility = Positive Inotropic Effect

Increased stroke volume



3.6 MH

Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.



Beta adrenergic stimulation: increased force (faster and more) and faster relaxation.

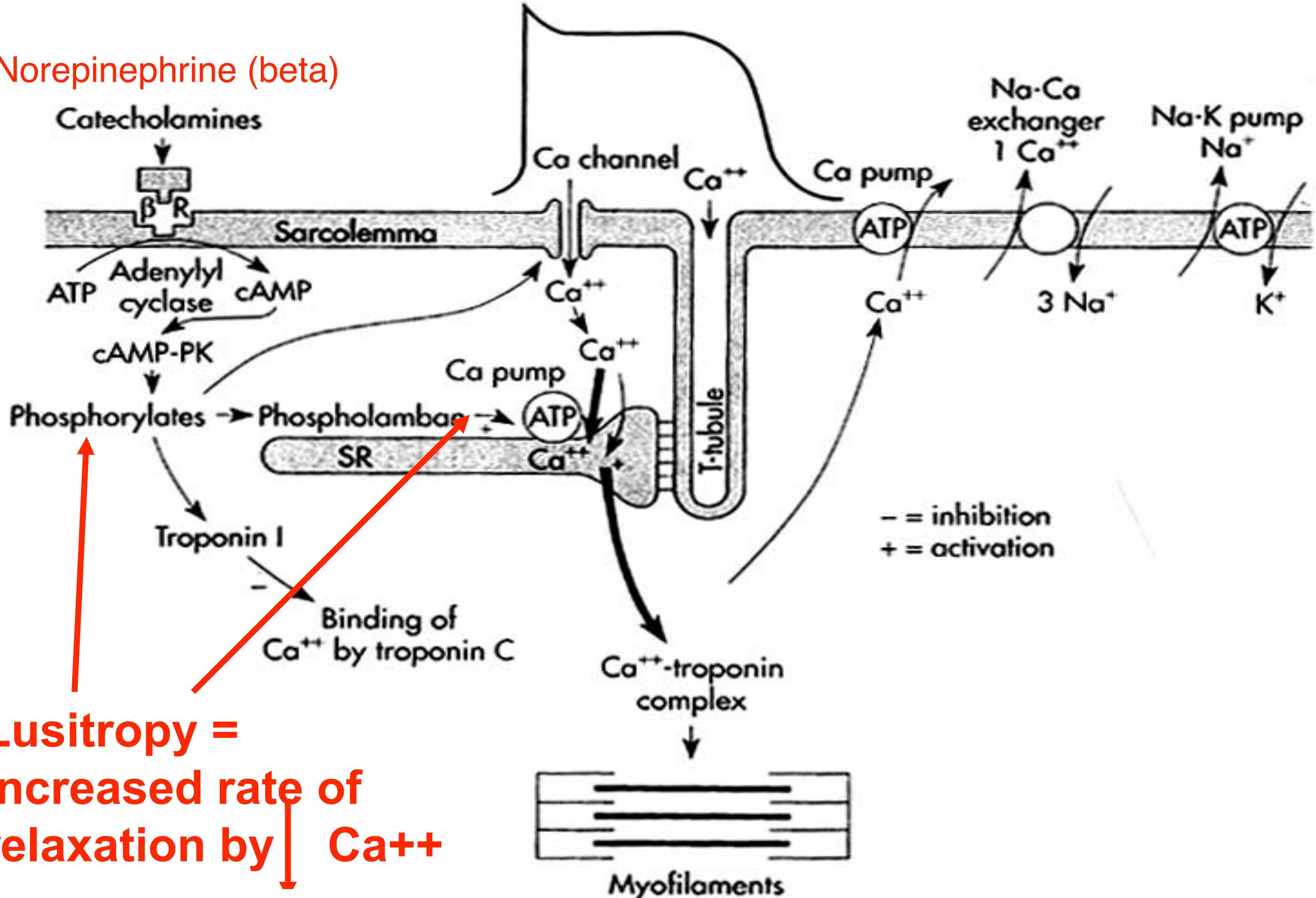
β (Beta) adrenergic effects

- Positive inotropic (strength) effect
- Positive lusitropic (rate of relaxation) effect
- Positive chronotropic (heart rate)effect
- Positive dromotropic (conduction velocity) effect
- Decreased duration (both AP and contraction)

Acetylcholine (cholinergic) has small negative inotropic effect.

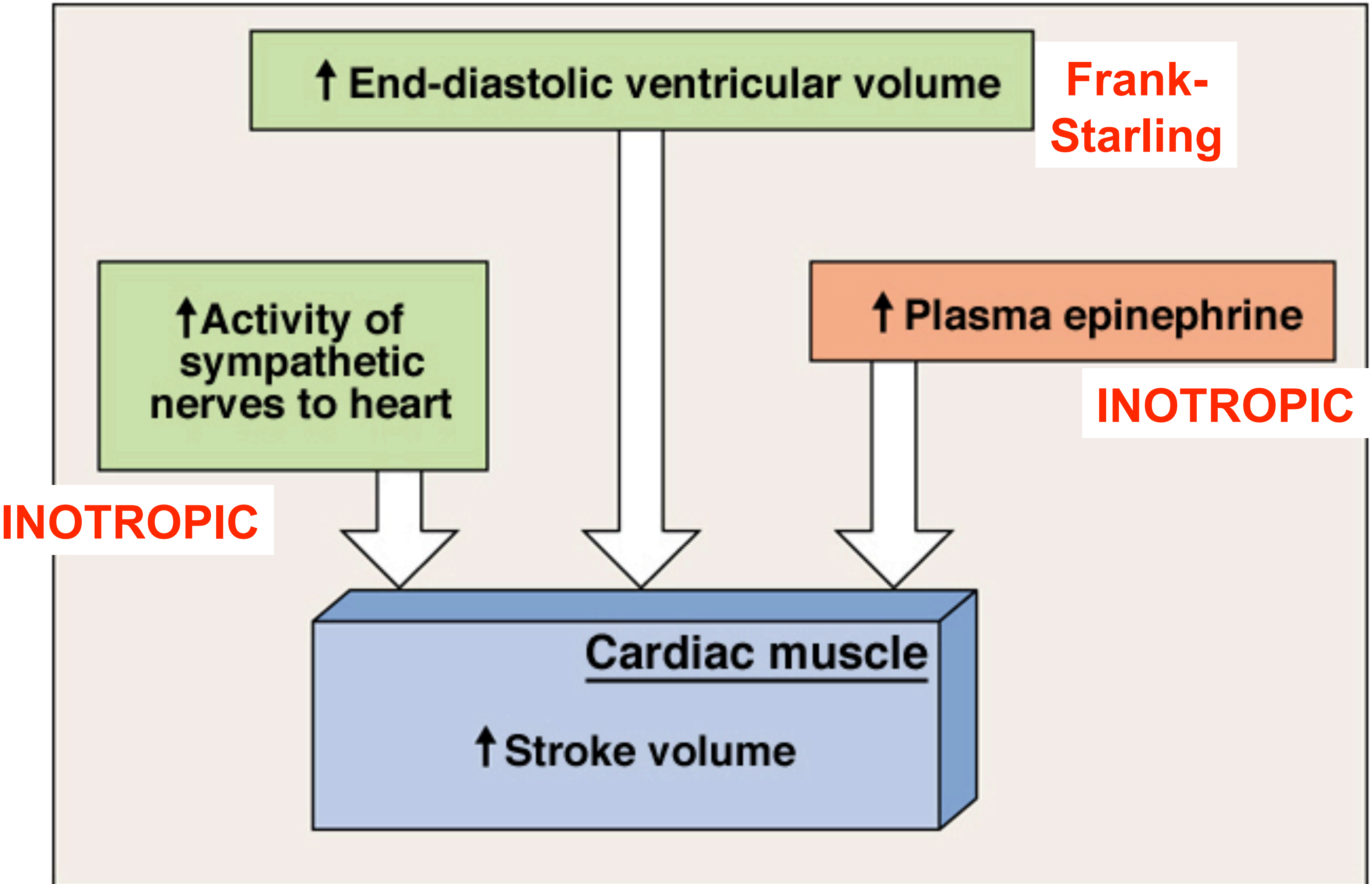
Cellular mechanism of positive inotropy and lusitropy

Norepinephrine (beta)

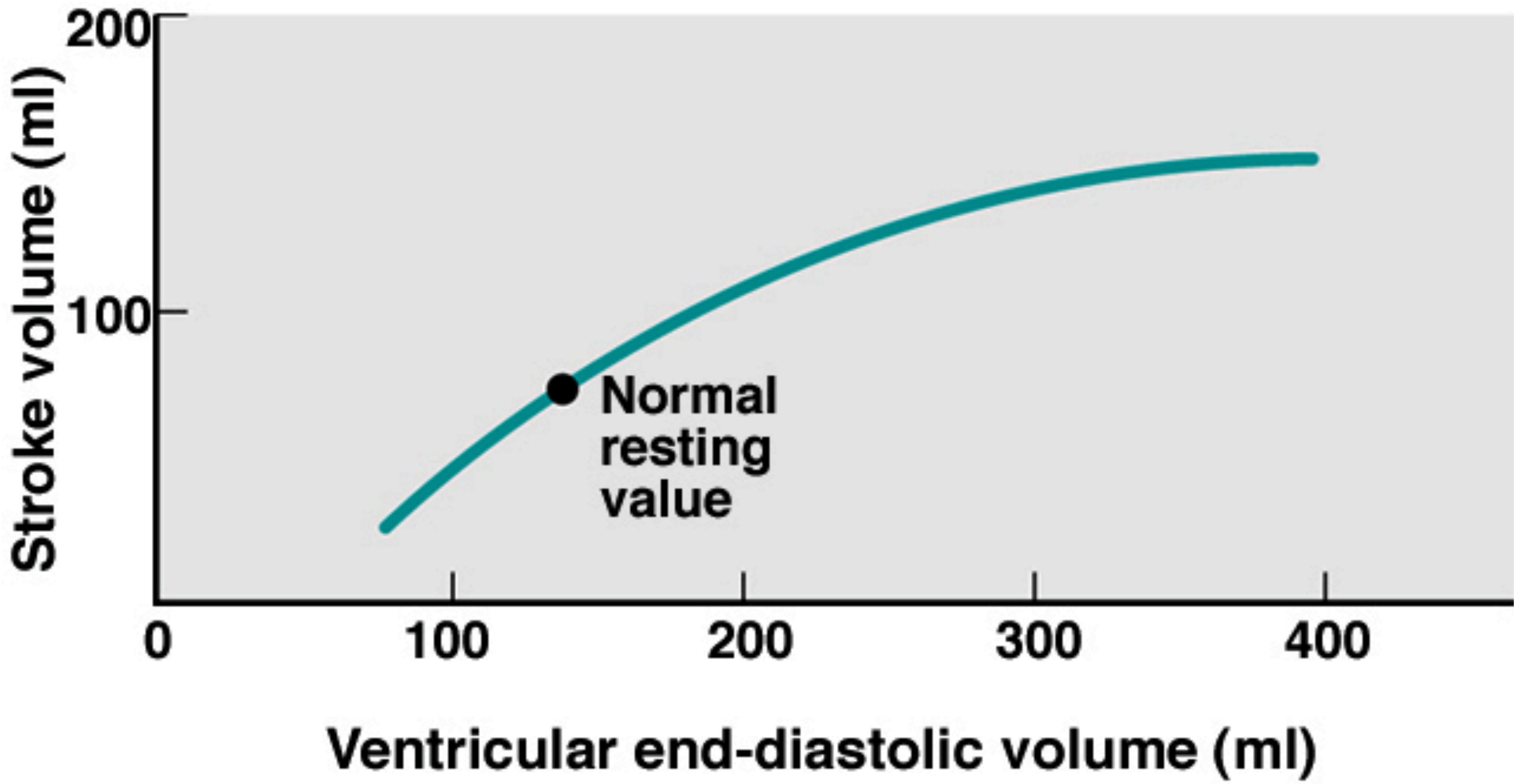


Lusitropy =
Increased rate of relaxation by ↓ Ca++

Controllers of stroke volume



Ventricular function curve



Ventricular function curve

SV

or

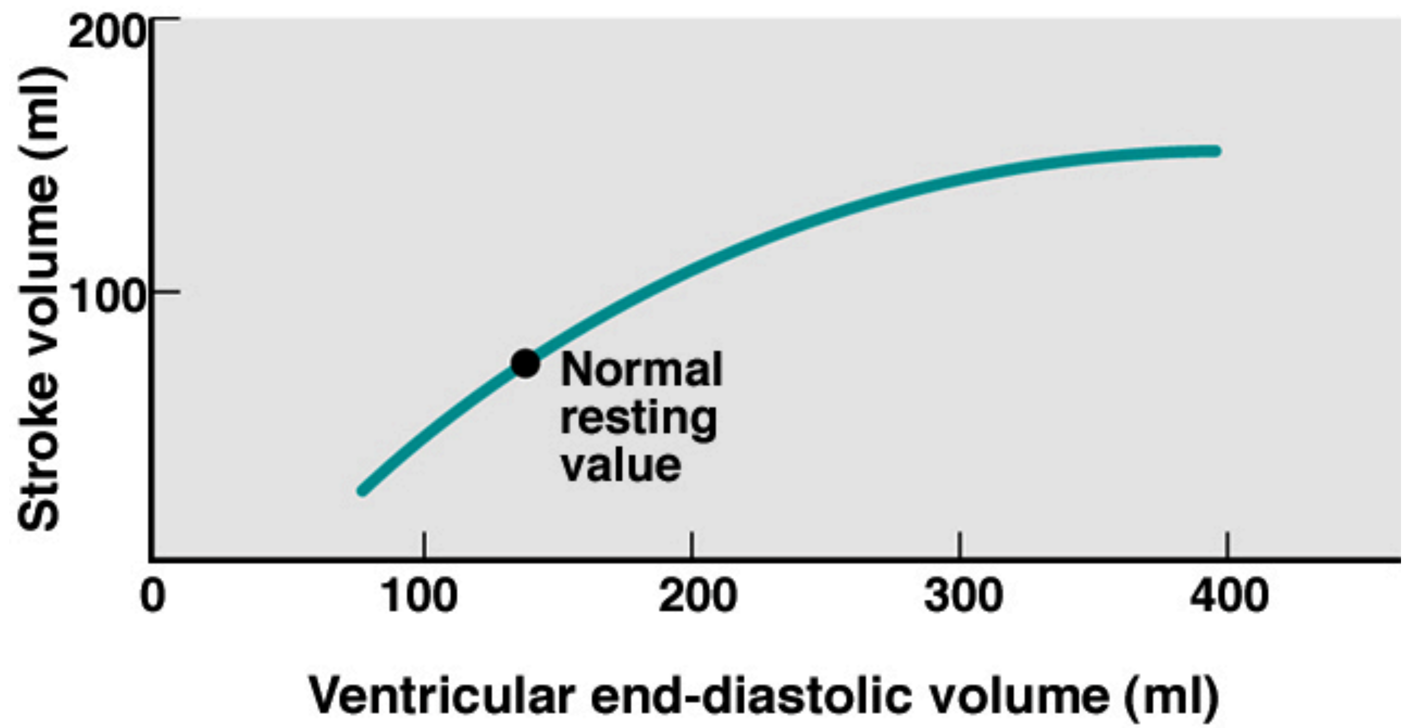
Tension

or

LVP

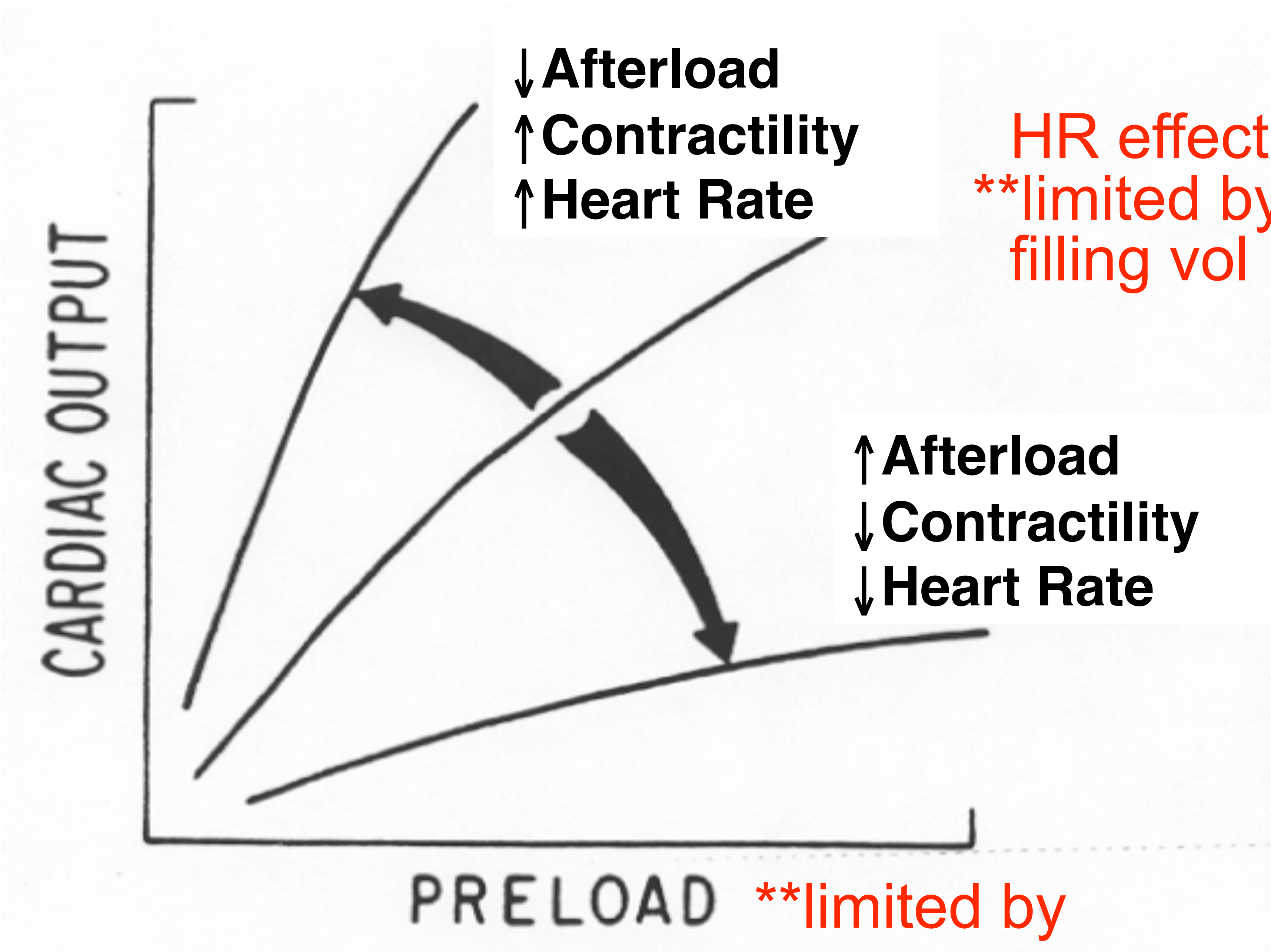
or

CO



LVEDV or LVEDP or

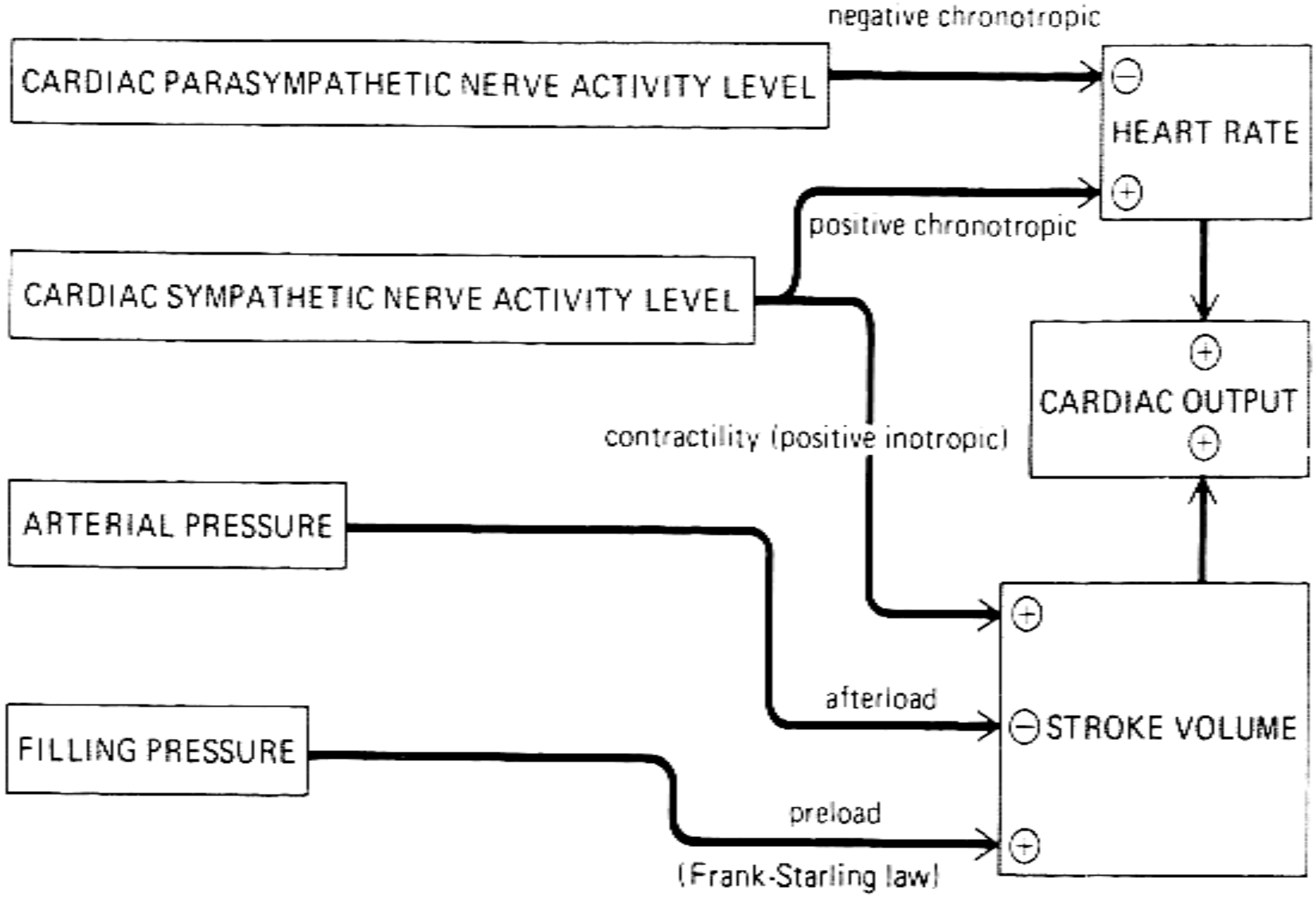
Length or **Preload**



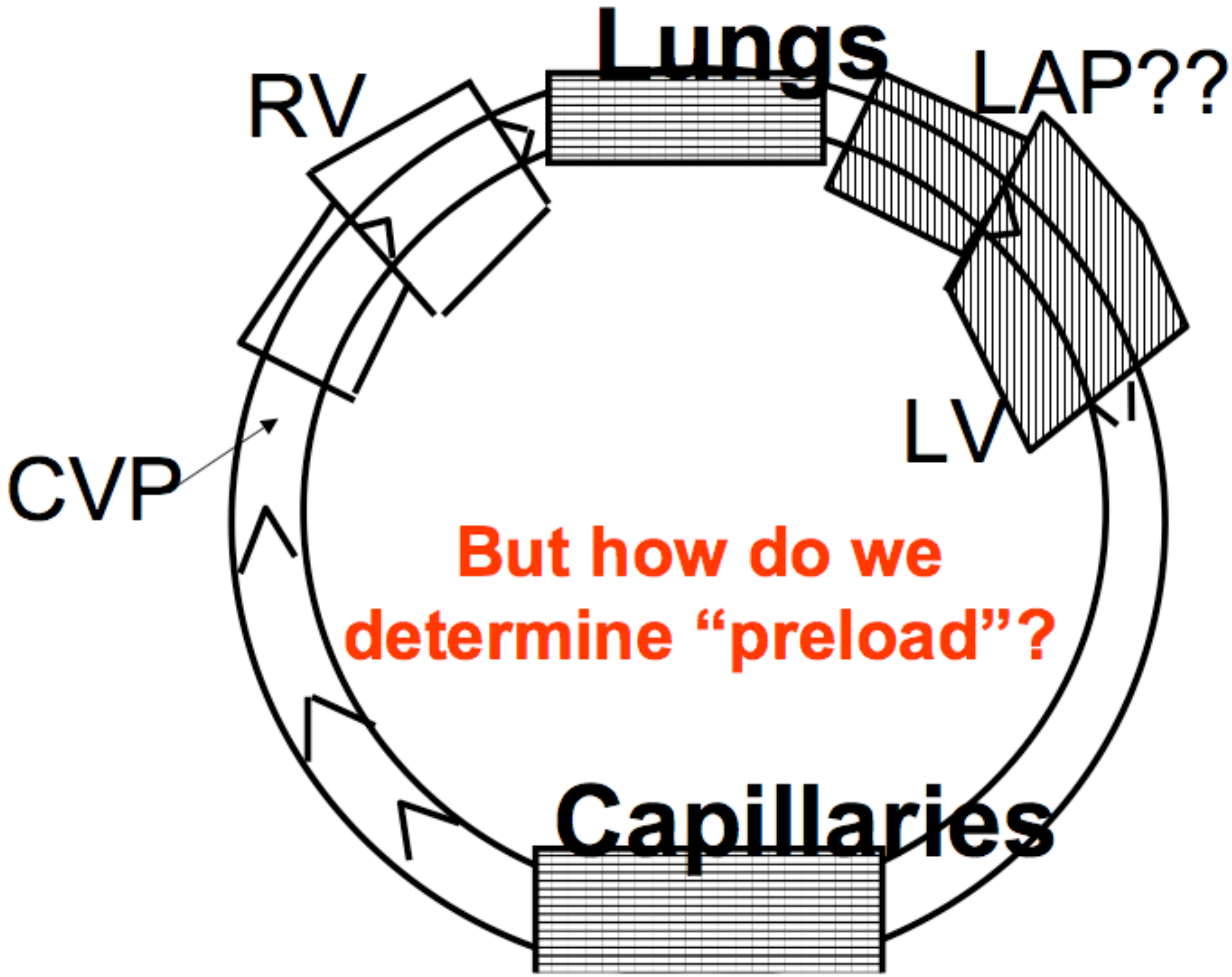
HR effect
**limited by filling vol

**limited by fiber overlap

M & H 3 -7 Summary of Determinants of CO

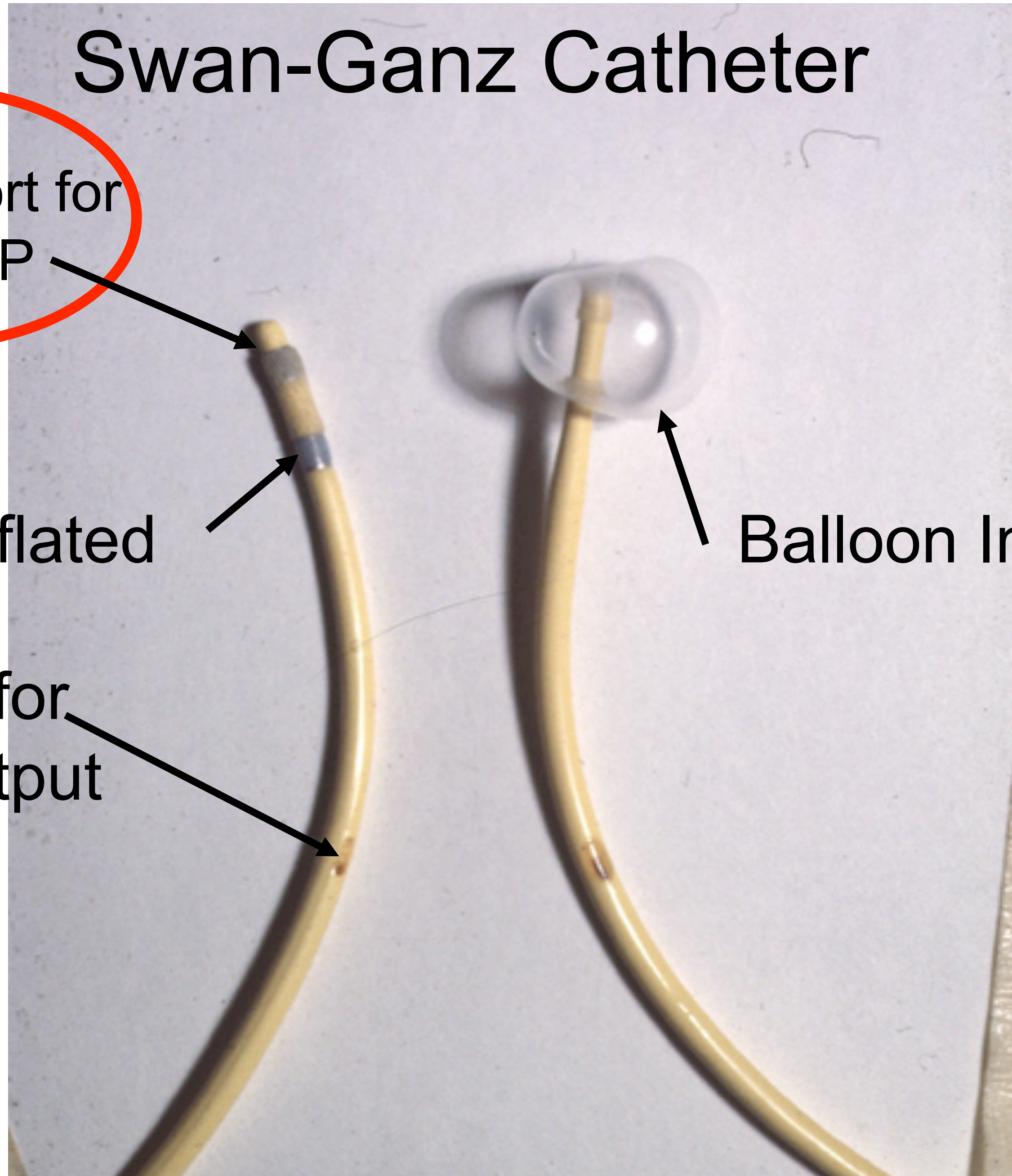


 Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.



But how do we determine "preload"?

Swan-Ganz Catheter

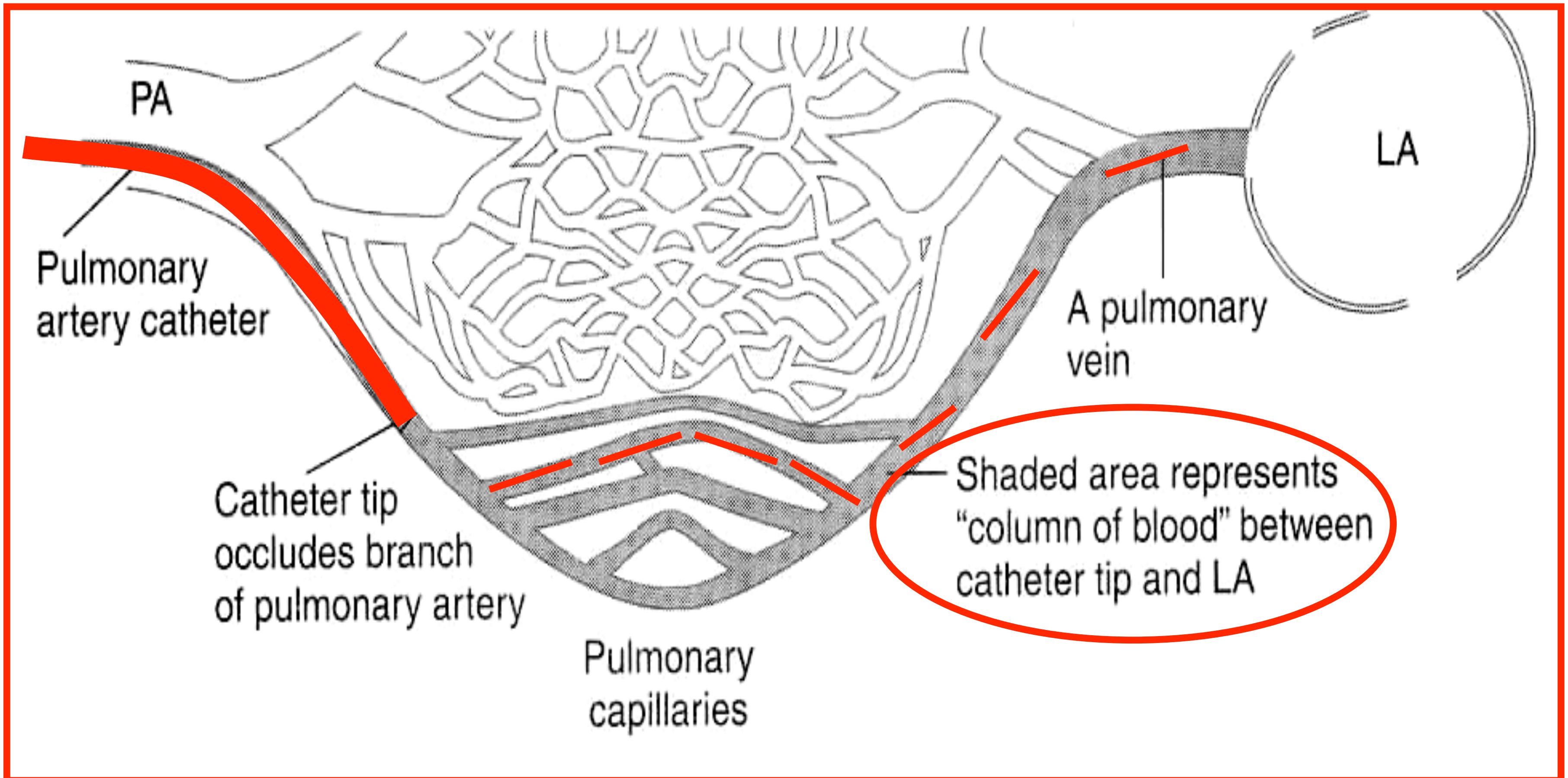


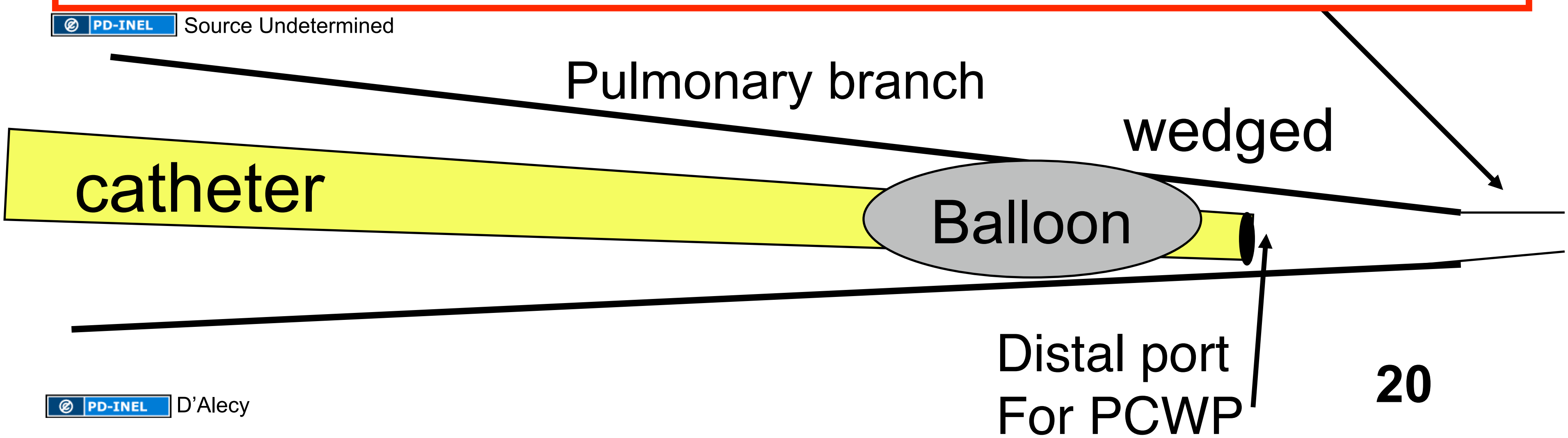
Distal Port for PCWP

Balloon Deflated

Balloon Inflated

Thermistor for Cardiac Output


PA
LA
Pulmonary artery catheter
A pulmonary vein
Catheter tip occludes branch of pulmonary artery
Shaded area represents "column of blood" between catheter tip and LA
Pulmonary capillaries


Pulmonary branch
wedged
catheter
Balloon
Distal port
For PCWP

Bartlett, Critical Care Physiology: Fig 2-3

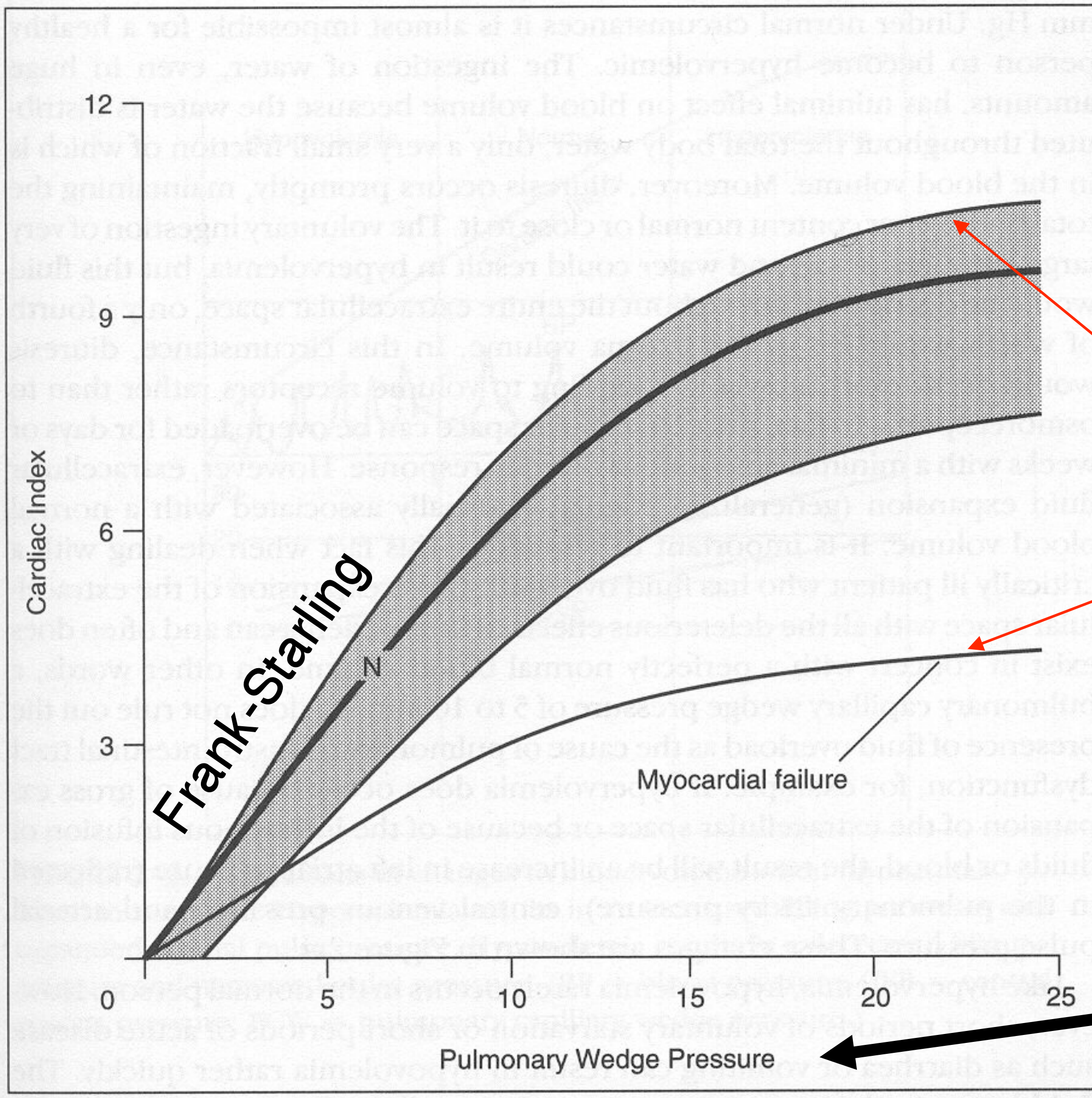
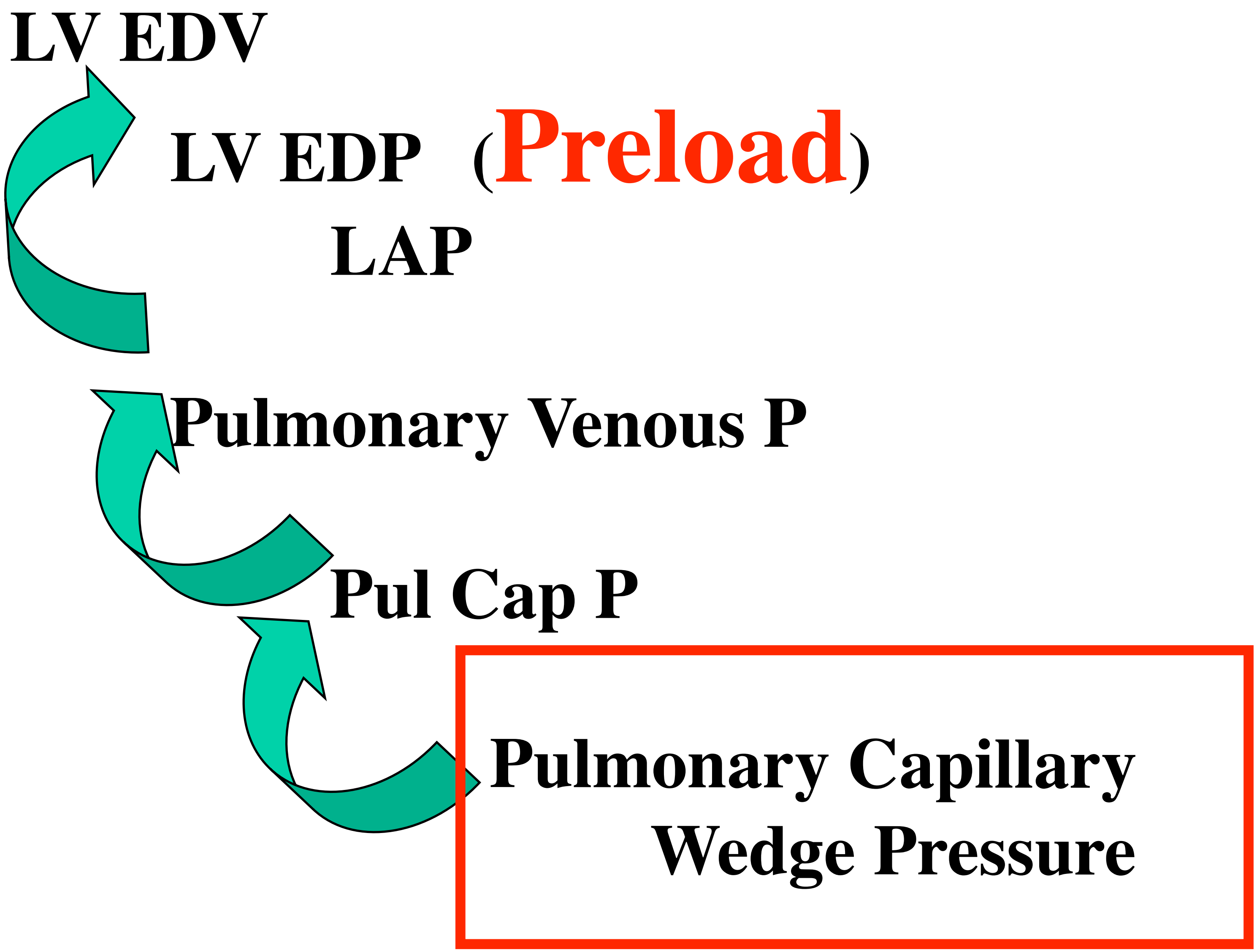


FIGURE 2-3. Frank-Starling curve describing cardiac function. The normal (N) relationships are in the shaded area.

No More Frank-Starling Left !!

LVEDP or
LV Preload or
PCWP

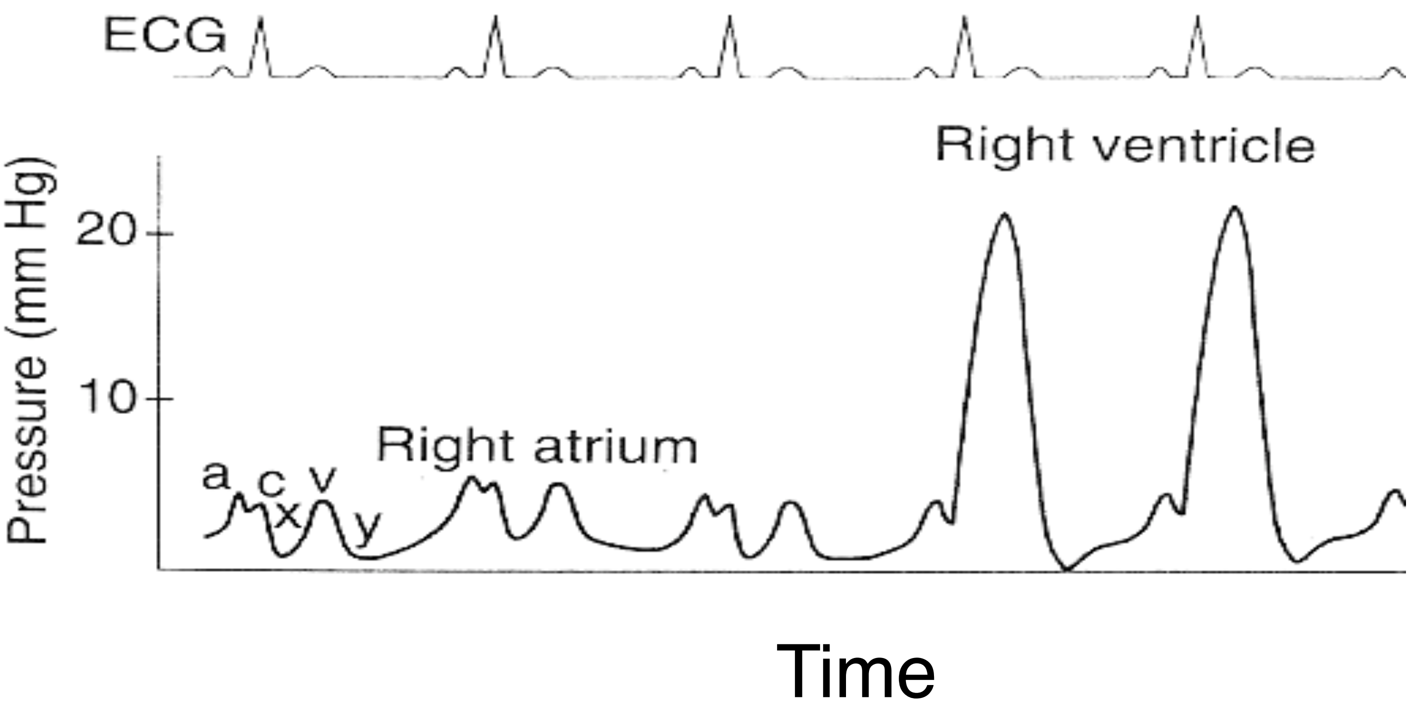
 Bartlett, Critical Care Physiology. Figure 2-3



PCWP is used as an index of LV EDP

PRELOAD

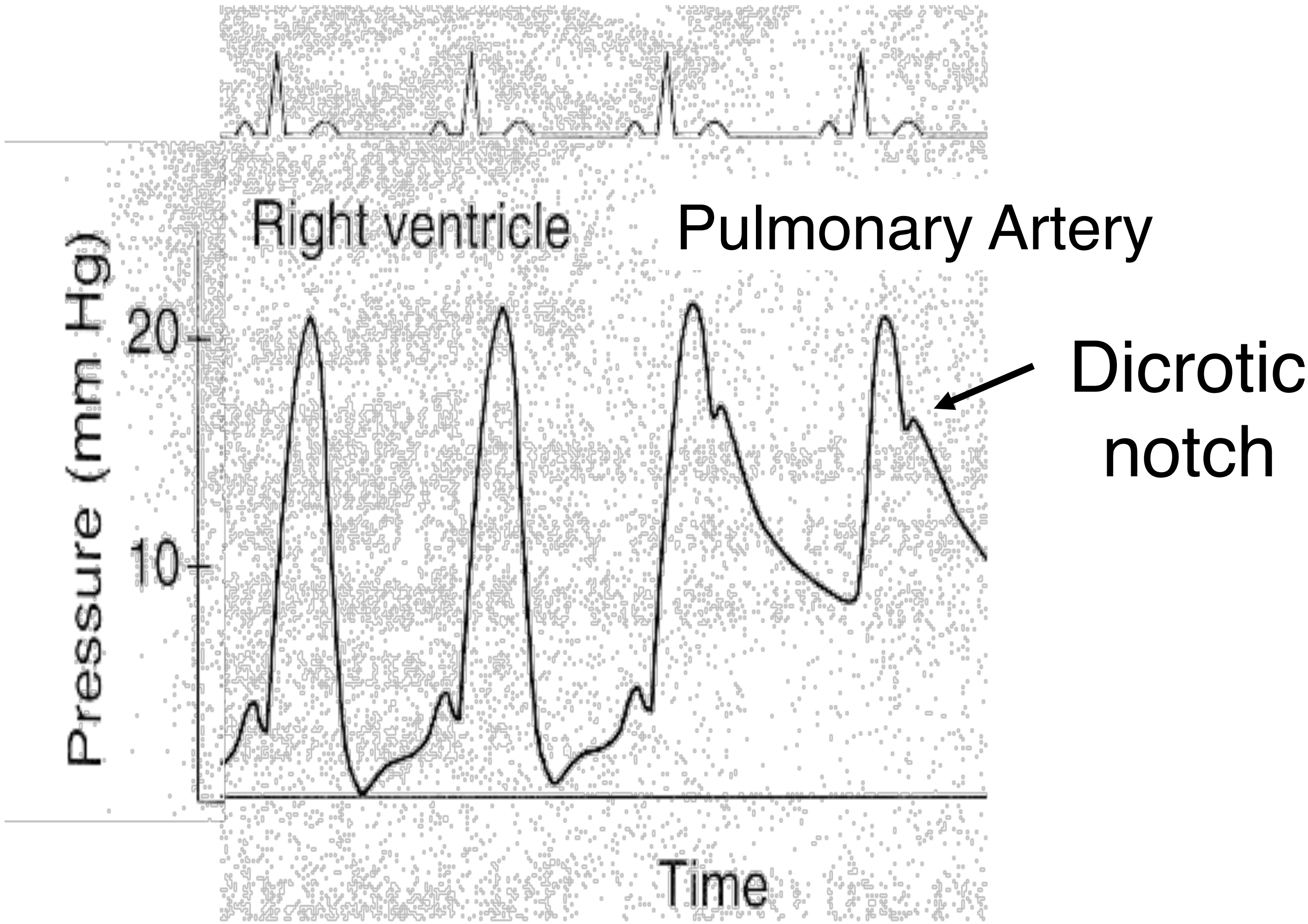
Lilly Box 3.1



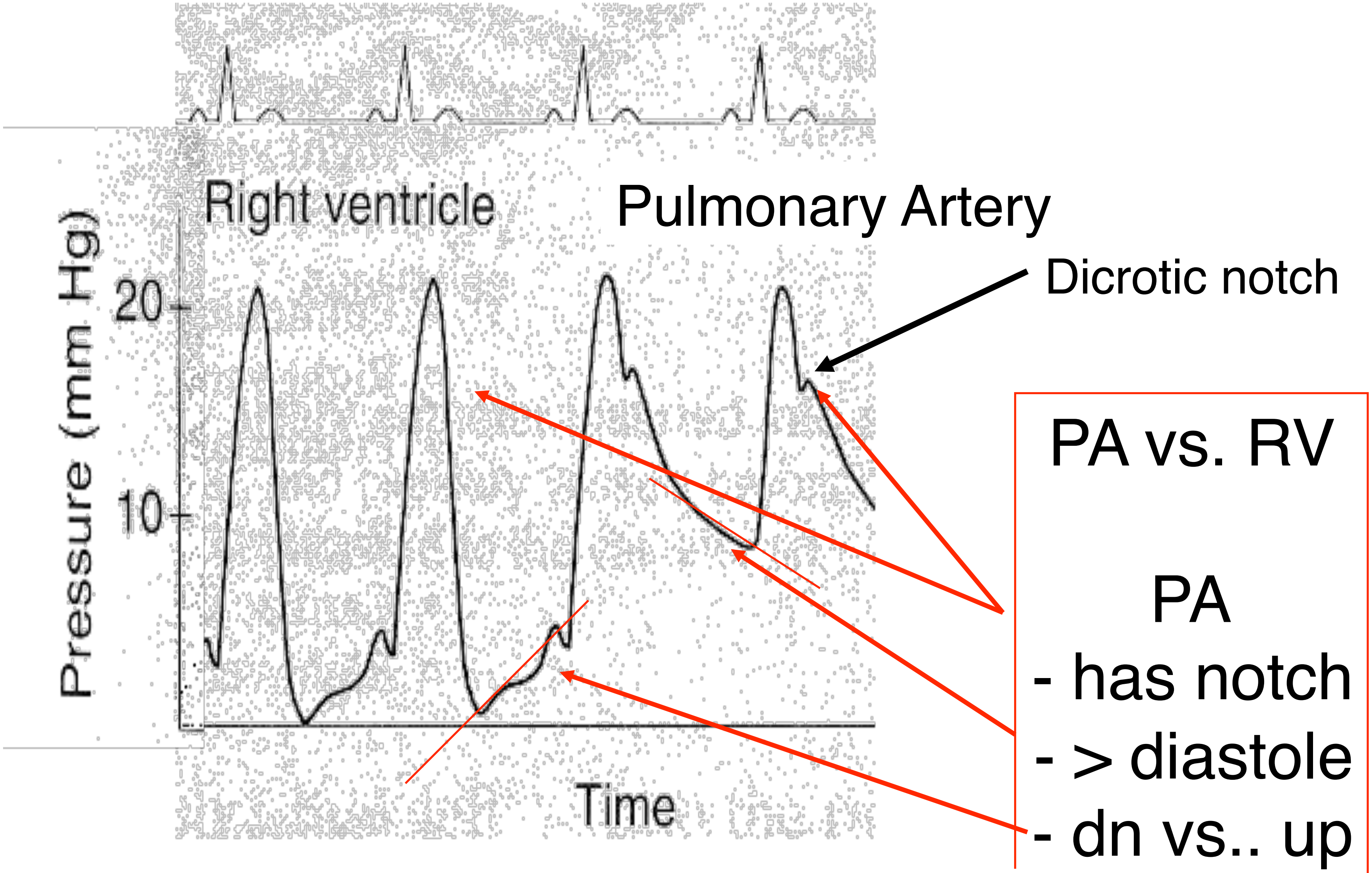
PD-INEL Lilly, L. Pathophysiology of Heart Disease. Lippincott, 2007. 4th ed. Figure 3.1

Pressure Changes as Catheter Moves

Through Right Heart



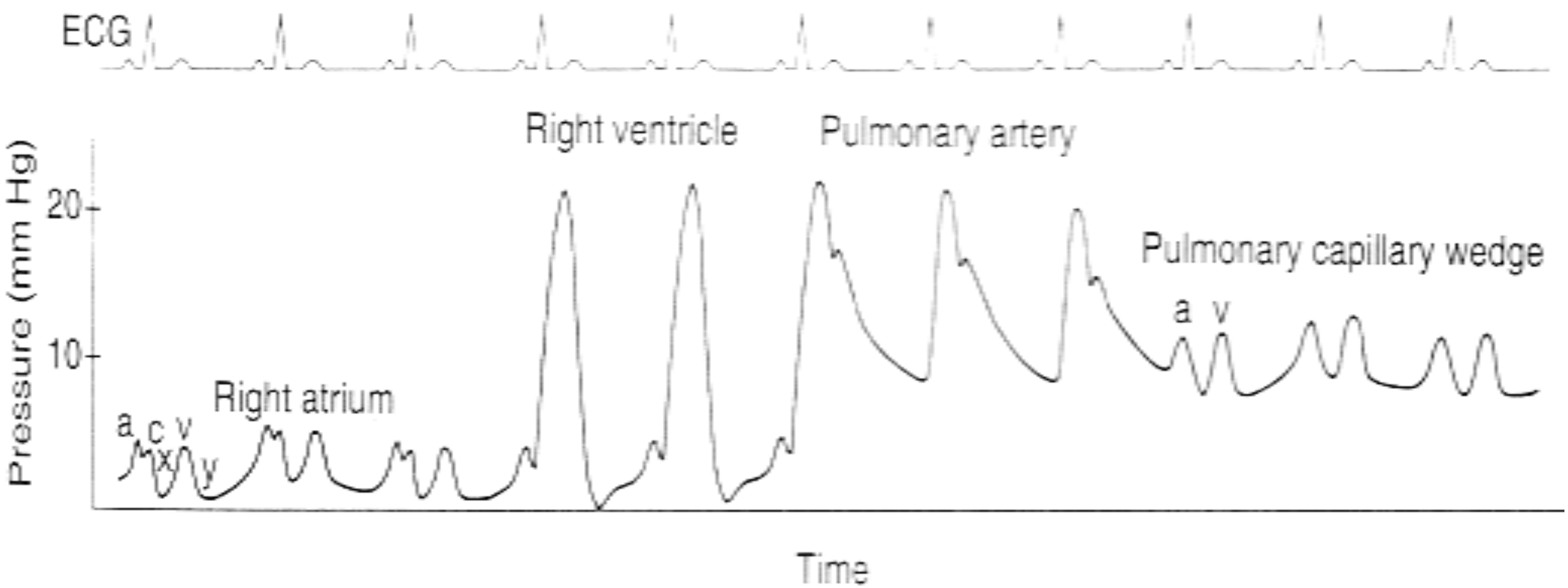
 Lilly, L. Pathophysiology of Heart Disease. Lippincott, 2007. 4th ed. Figure 3.1



 Lilly, L. Pathophysiology of Heart Disease. Lippincott, 2007. 4th ed. Figure 3.1

Pressure wave difference between PA and RV

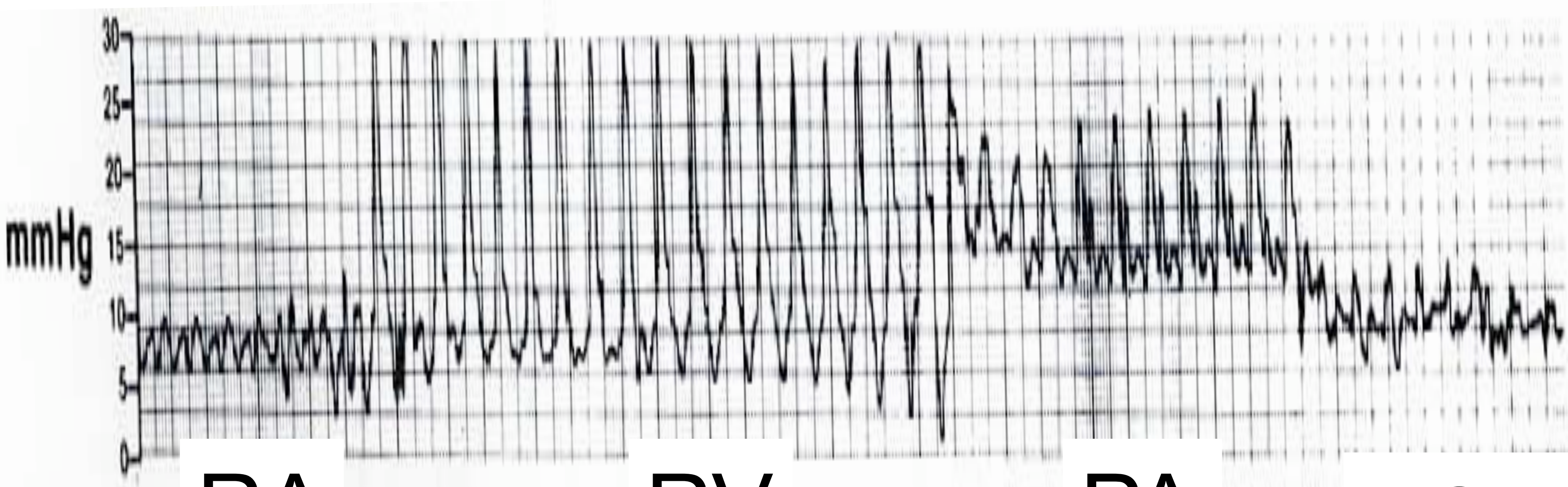
Box 3.1



 Lilly, L. Pathophysiology of Heart Disease. Lippincott, 2007. 4th ed. Figure 3.1

Pressure Changes as Catheter Moves

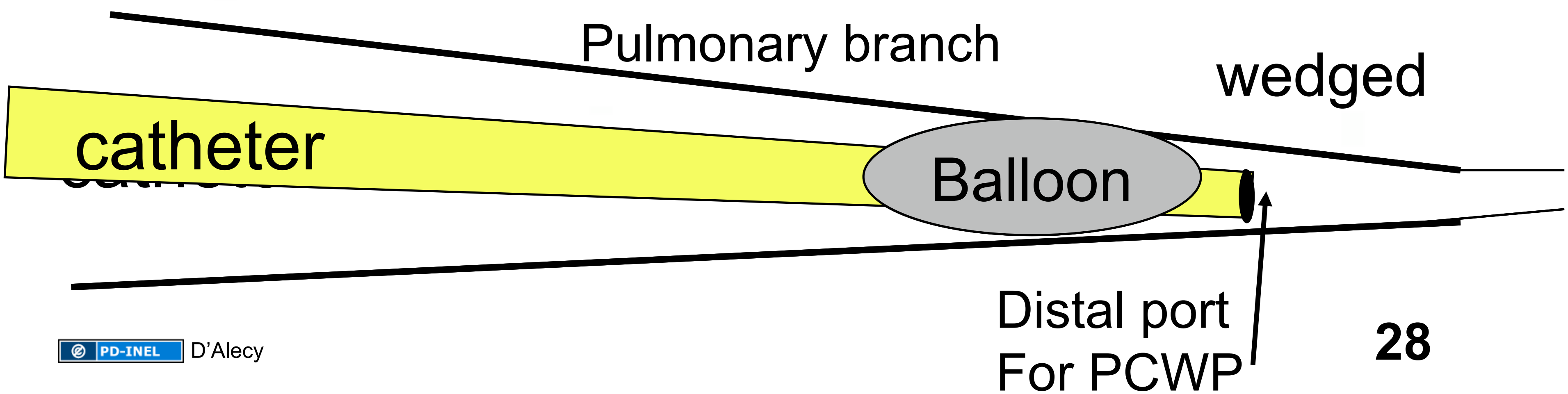
Through Right Heart to PA & PCWP



Pressure Changes as Catheter Moves Through Right Heart

Swan-Ganz Catheter Pressure Recording

Right Ventricle Pulmonary Artery Pul. Cap Wedge



LV EDV

LV EDP (Preload)

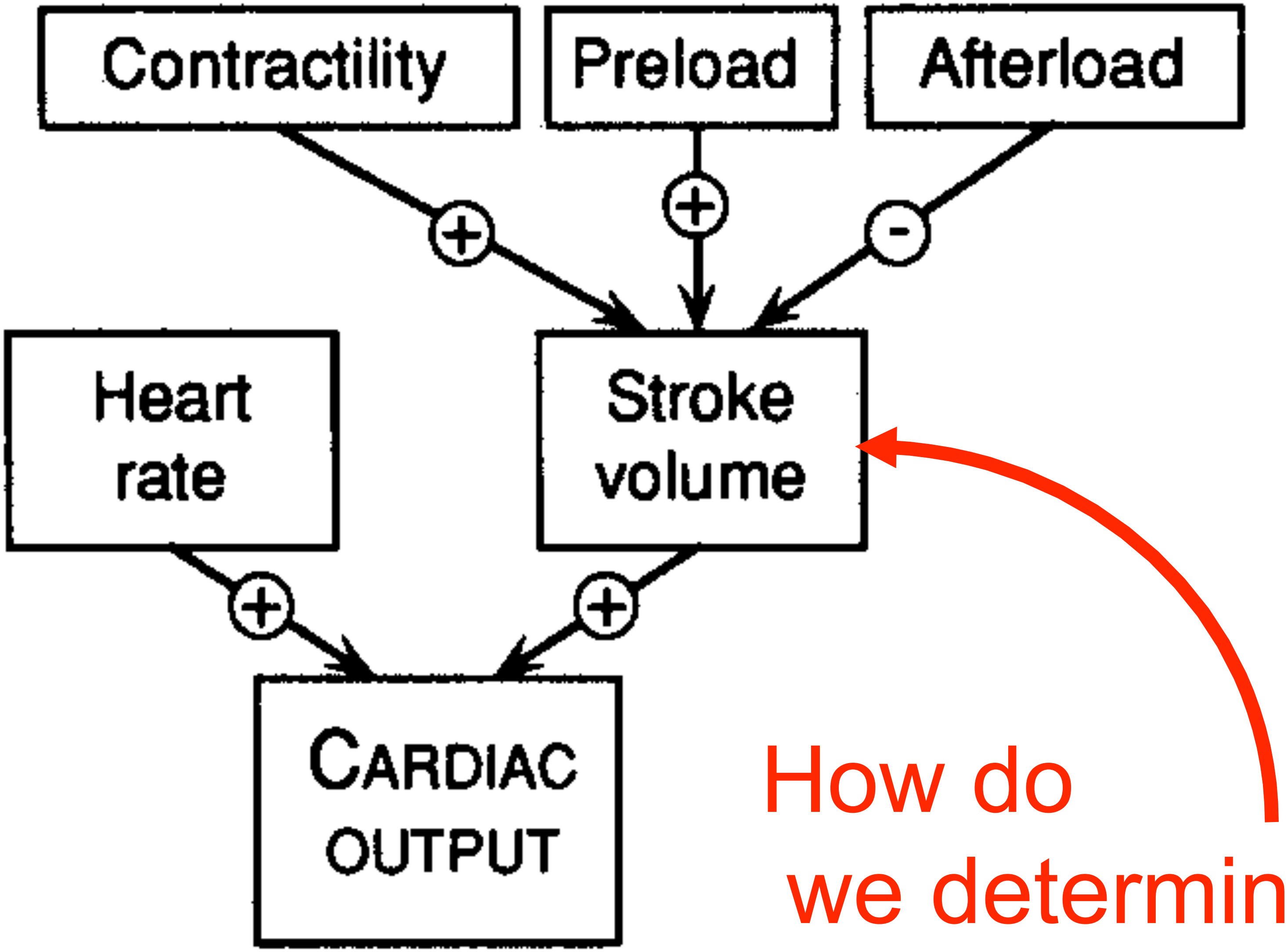
LAP

Pulmonary Venous P

Pul Cap P

Pulmonary Capillary Wedge Pressure

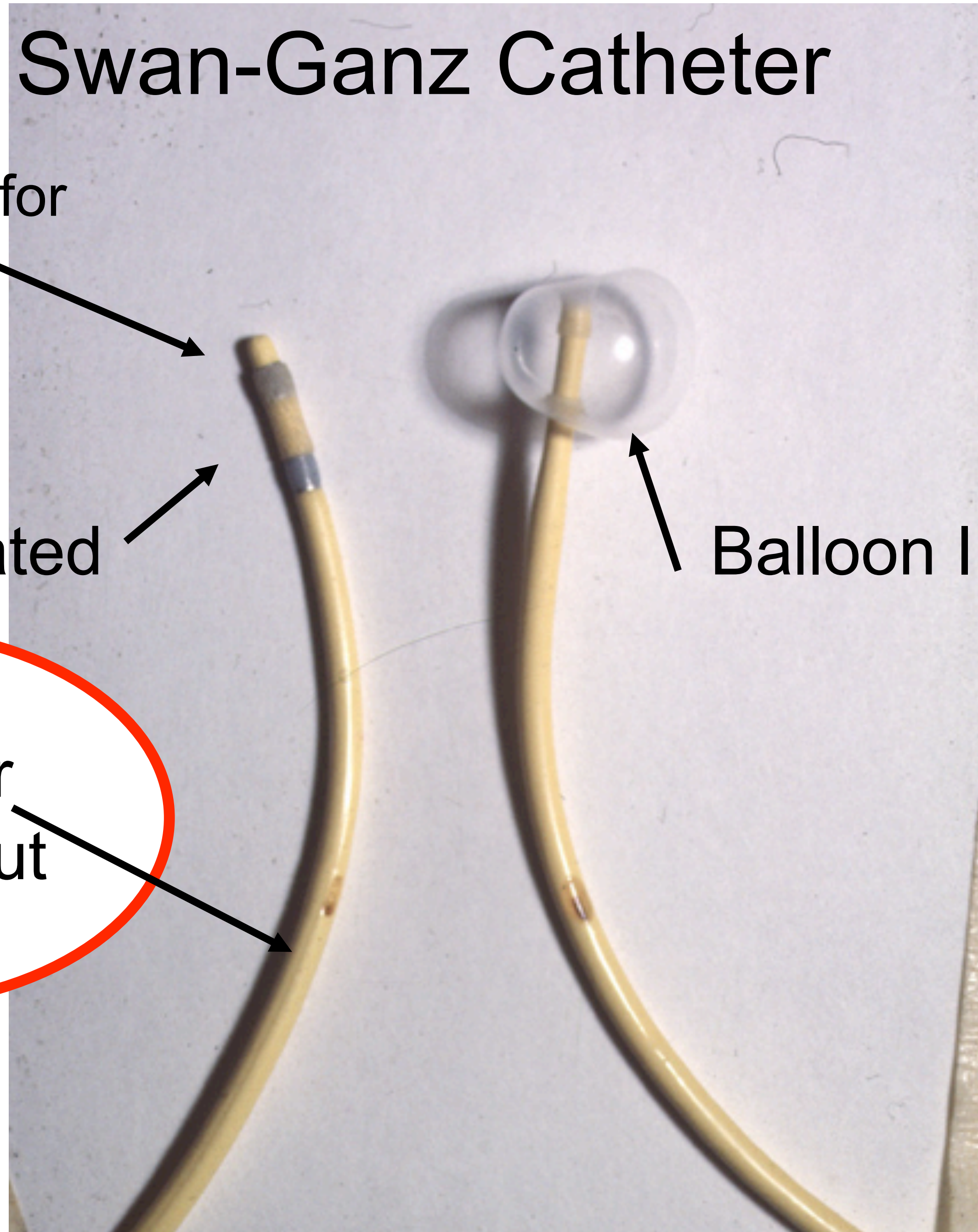
PCWP is used as an index of LV EDP PRELOAD



How do we determine??

?Transesophageal Echocardiogram?

Swan-Ganz Catheter



Heart Rate X Stroke Volume = Cardiac Output

Measure

Cardiac Output by Thermal Dilution

Calculate SV

HR X SV = CO

b/min X mL/b = mL/min

Cardiovascular System Central Pressures (mmHg)		
	RANGE	TYPICAL
1 Right Atrium	-1 to +7	+3
2 Rt. Ventricle		
Systolic	15 to 30	24
Diastolic	0 to 8	4
3 Pulmonary Artery (PAP)		
Systolic	15 to 30	24
Diastolic	8 to 15	9
Mean	10 to 20	15
4 Pulmonary Capillary Wedge Pressure	8 to 12	10
5 Left Ventricle		
Systolic	90 to 140	130
Diastolic	5 to 12	9
6 Aorta (Systemic Art.)		
Systolic	90 to 140	125
Diastolic	60 to 90	70
Mean	70 to 108	90

Additional Source Information

for more information see: http://open.umich.edu/wiki/CitationPolicy

Slide 7: Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.
Slide 8: Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.
Slide 9: Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.
Slide 10: Source Undetermined
Slide 12: Source Undetermined
Slide 13: McGraw-Hill
Slide 14: McGraw-Hill
Slide 15: McGraw-Hill
Slide 16: Source Undetermined
Slide 17: Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.
Slide 18: D'Alecy
Slide 19: Source Undetermined
Slide 20: Source Undetermined; D'Alecy
Slide 21: Bartlett, Critical Care Physiology. Figure 2-3
Slide 23: Lilly, L. Pathophysiology of Heart Disease. Lippincott, 2007. 4th ed. Figure 3.1
Slide 24: Lilly, L. Pathophysiology of Heart Disease. Lippincott, 2007. 4th ed. Figure 3.1
Slide 25: Lilly, L. Pathophysiology of Heart Disease. Lippincott, 2007. 4th ed. Figure 3.1
Slide 26: Lilly, L. Pathophysiology of Heart Disease. Lippincott, 2007. 4th ed. Figure 3.1
Slide 27: Source Undetermined
Slide 28: Source Undetermined; D'Alecy
Slide 30: Source Undetermined
Slide 31: Source Undetermined