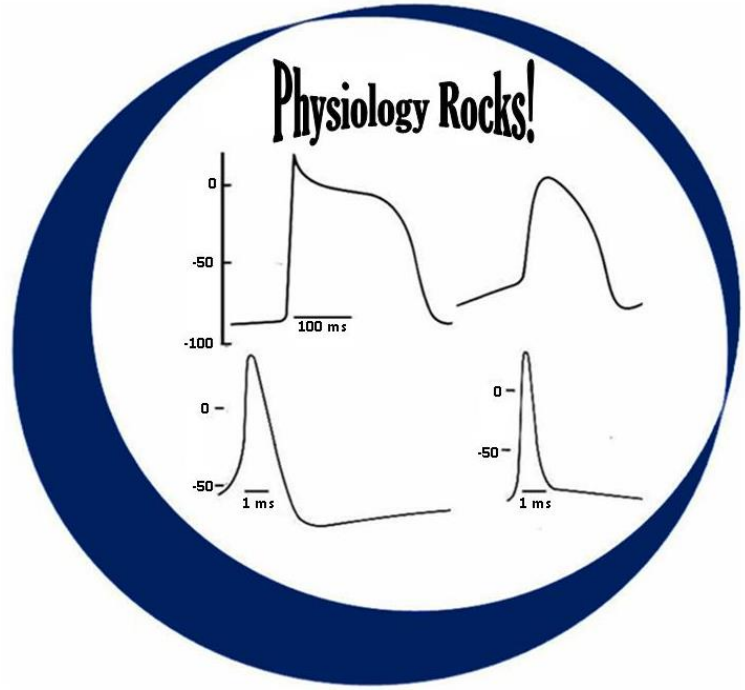
Lecture 4
Blood Flow, Pressure & Resistance - 1

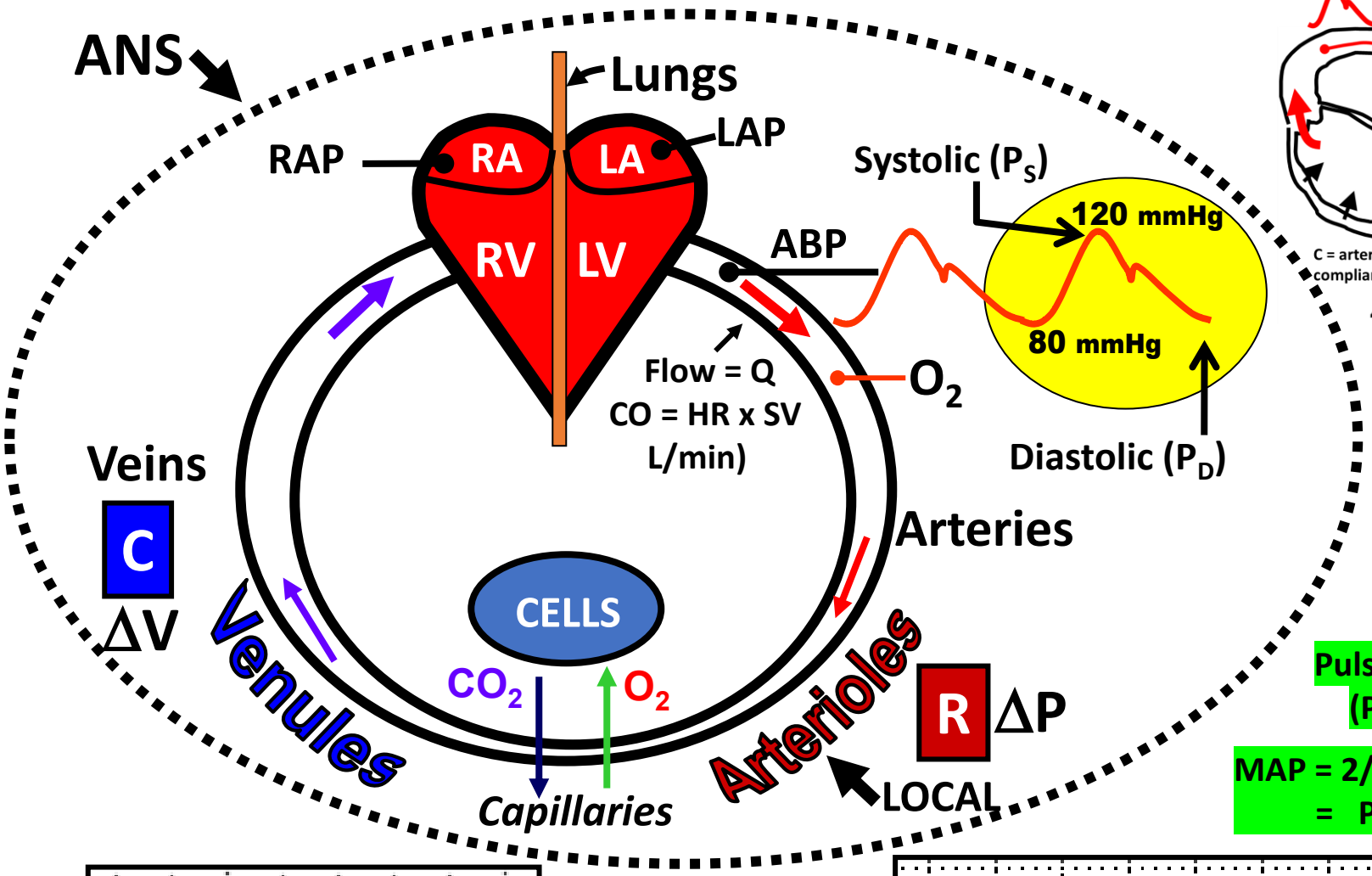


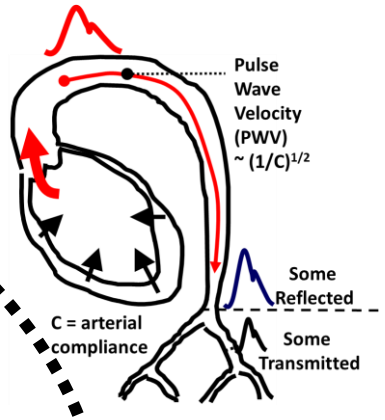
HN Mayrovitz PhD
mayrovit@nova.edu
mayrovitz.com

Topics

- Pressures and flow in the vascular circuit
- Vascular resistance
- Vascular patterns and arrangements
- Measuring blood pressure
- Blood pressure standards
- Measuring cardiac output
- Cardiac output distribution
- Blood pressure distribution
- Pulmonary pressures
- Interactive questions

Vascular Circuit with Pressures and Flows Defined

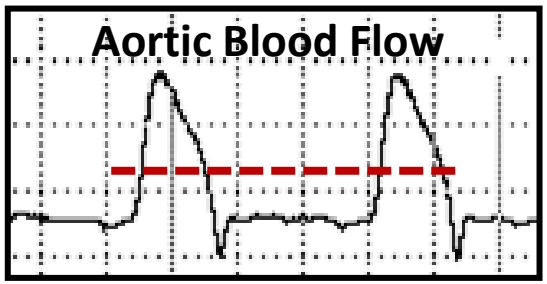




Pulse Pressure (PP)=P_S-P_D

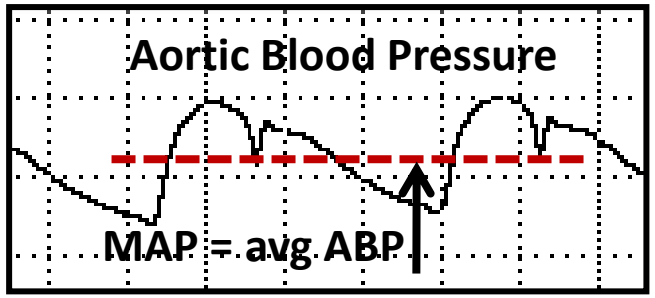
MAP = 2/3 P_D + 1/3 P_S = P_D + 1/3 PP

Q

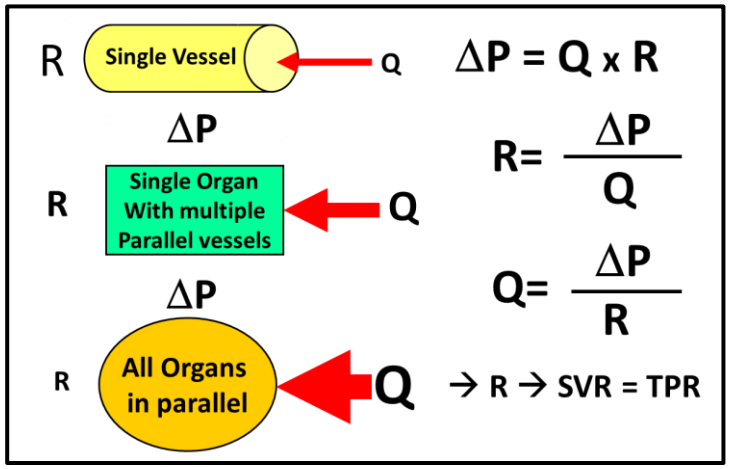


CO = avg Q

CO = SV x HR



Vascular Resistance Concept

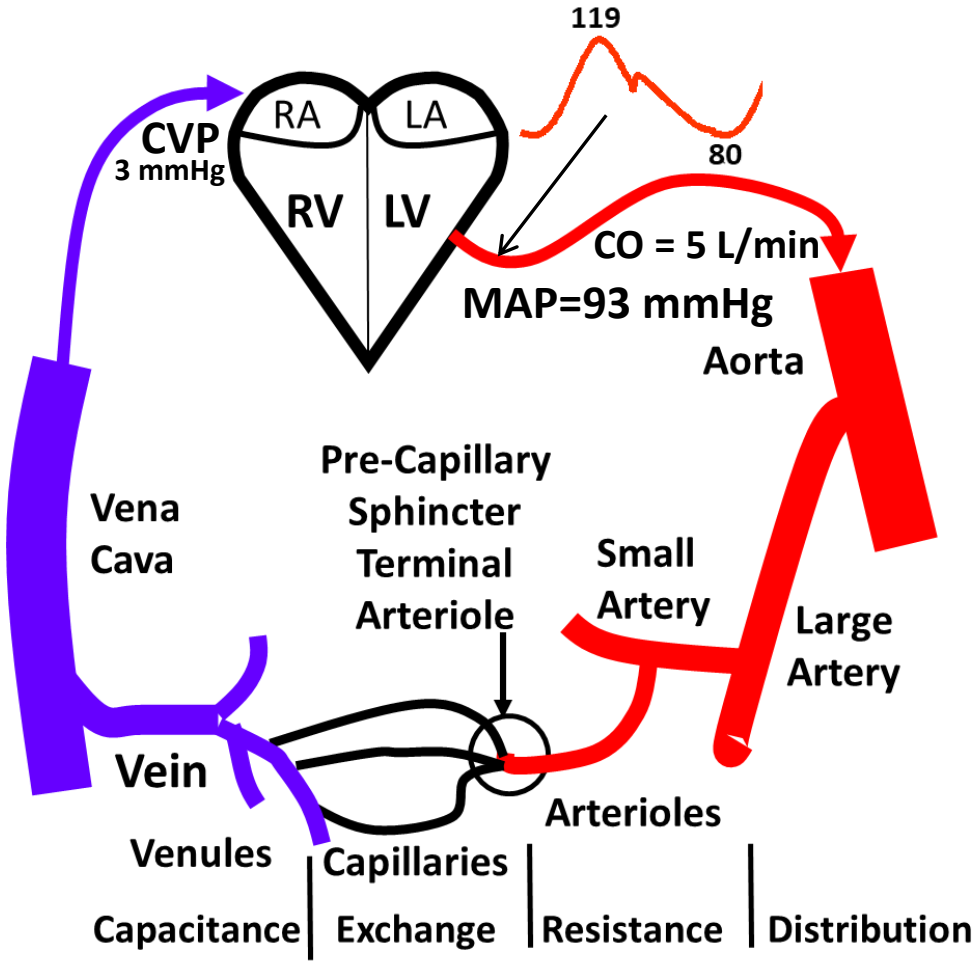


SVR = Systemic Vascular Resistance
TPR = Total Peripheral Resistance

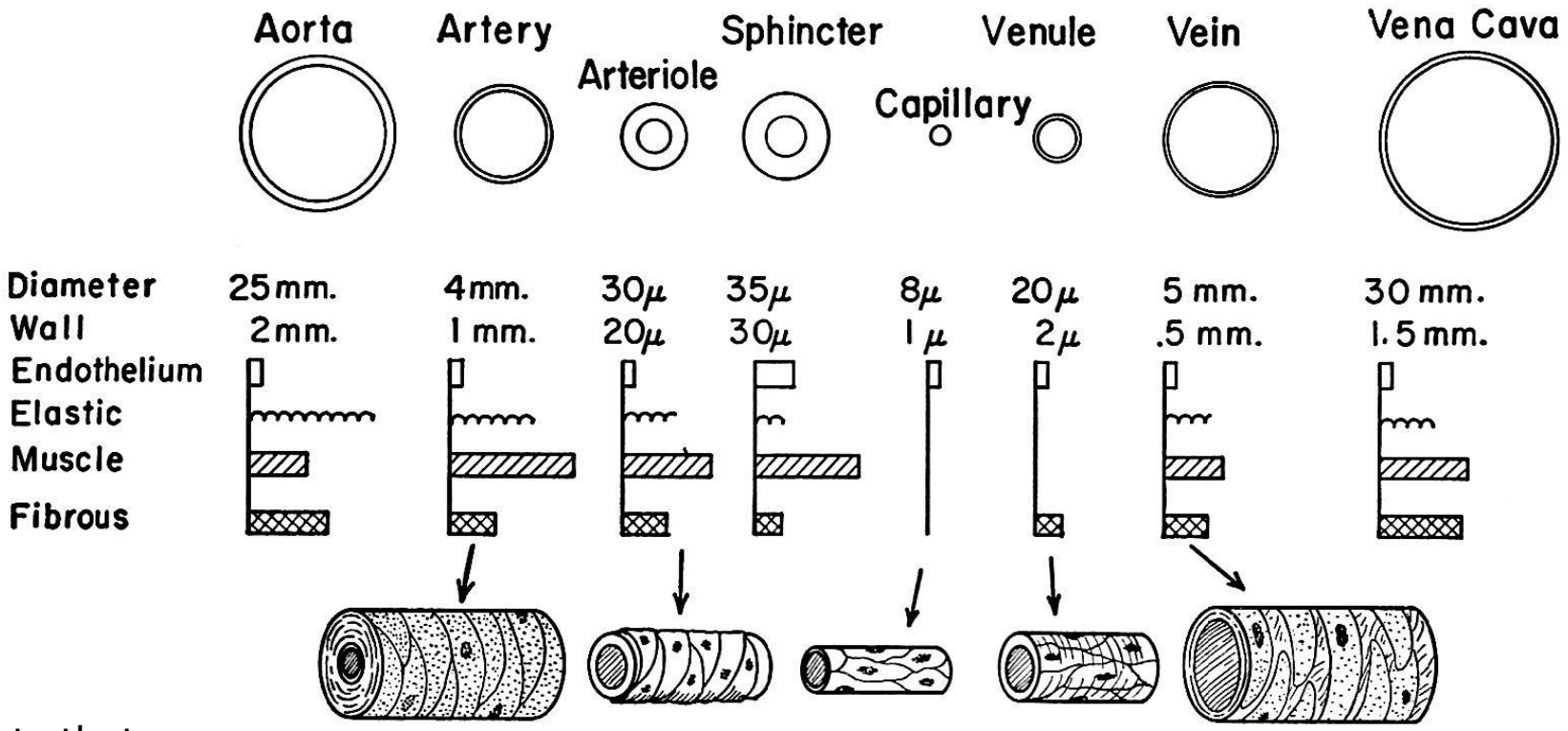
ΔP/CO = (MAP – CVP)/CO = (93 - 3 mmHg)/(5 L/min)
= 18 mmHg/L/min = 18 "Wood" units

SVR = TPR = mmHg/(L/min) = Wood Unit
If mmHg/ml/min = PRU = Wood Unit/1000

"Normal" values
→ 15-20 Wood units
→ 0.015-0.020 PRU



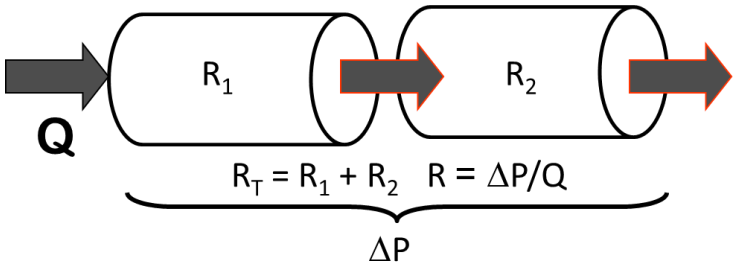
Vasculature: Vessel Types-Structure-Components



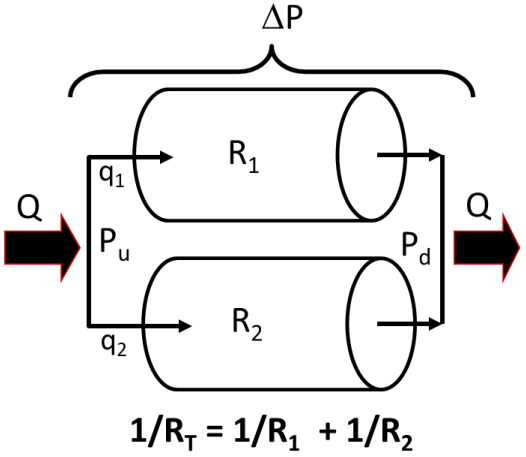
Note that:

- Smallest diameter is the **capillary** that has **no vascular smooth muscle** (VSM)
- What is called a "**precapillary sphincter**" refers to a **terminal arteriole** that immediately precedes the capillary network – **largest relative amount of VSM**
- The **larger arteries** have relatively more elastic material (**elastin > fibrous collagen**)
- Wall thickness to diameter is low in veins versus arteries → effects compliance

Vascular Resistances: Series vs. Parallel Arrangement

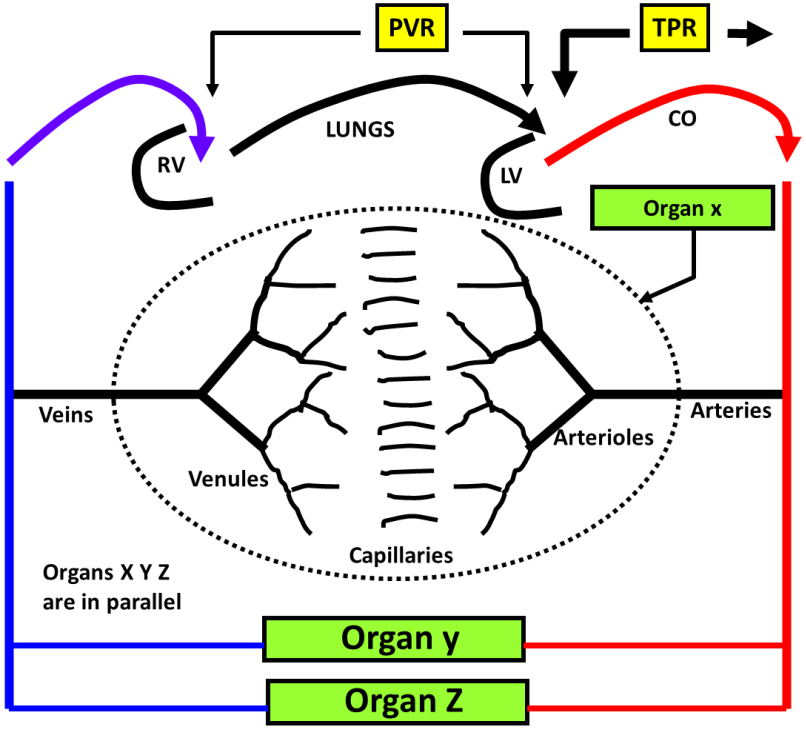


Organs or Vasculatures in SERIES
- **Flow same in series-coupled parts**
- **Resistances sum directly**
- **Total R greater than individual R**
- **Pressure is lost sequentially**



$1/R_T = 1/R_1 + 1/R_2$

Organs or Vasculatures in PARALLEL
- **Perfusion Pressures are the same**
- **Resistances sum reciprocally**
- **Total R is LESS than any individual R**

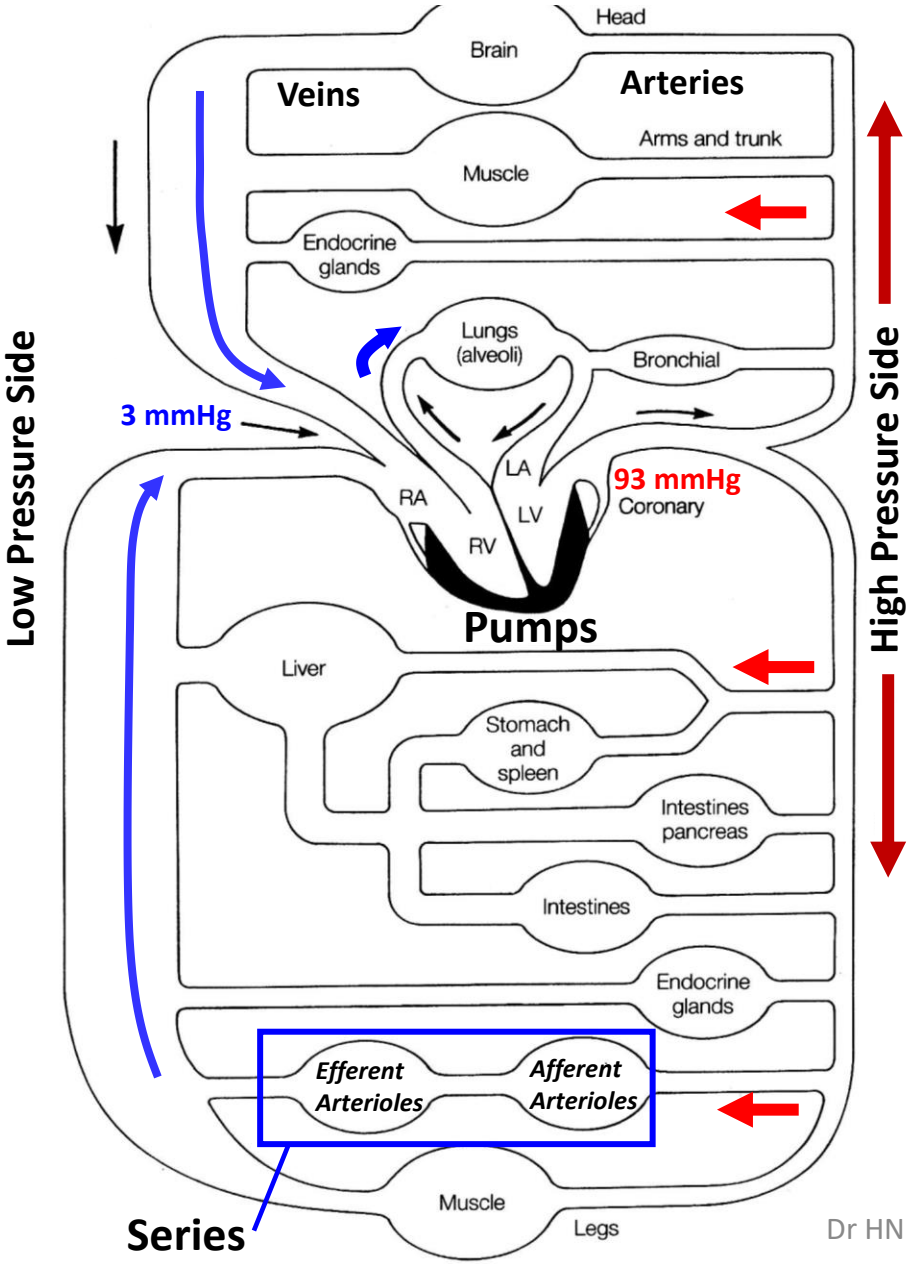


- **Organs are in parallel with other organs (x, y and z)**
- **So, flow to each organ depends on its vascular resistance since all have equal perfusion pressure**

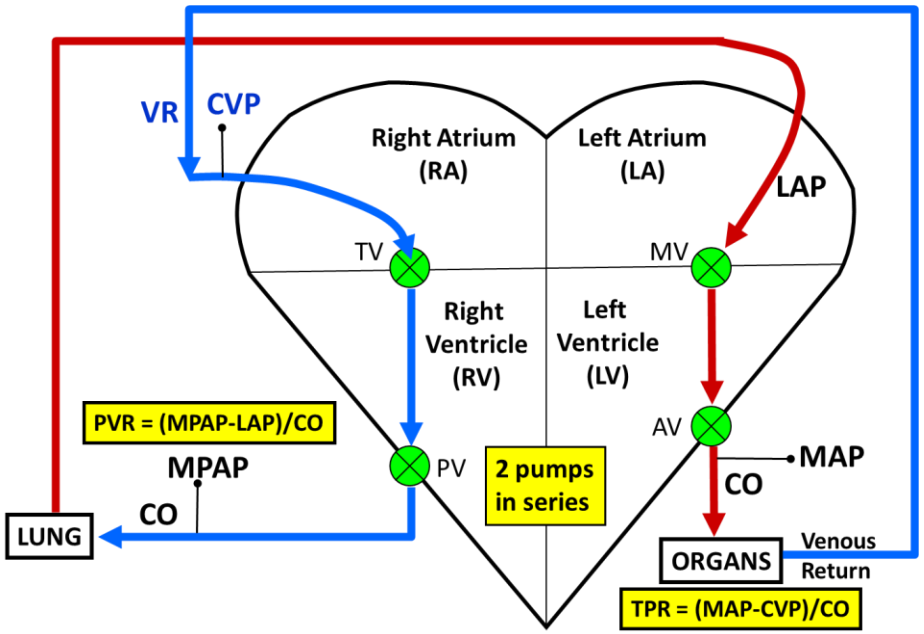
Within Organs
- **Arterioles are ≈ in parallel with arterioles**
- **Capillaries are ≈ in parallel with capillaries**

BUT
- **Segments are in series with the other segments**
- **Since in series pressure is lost across each segment**

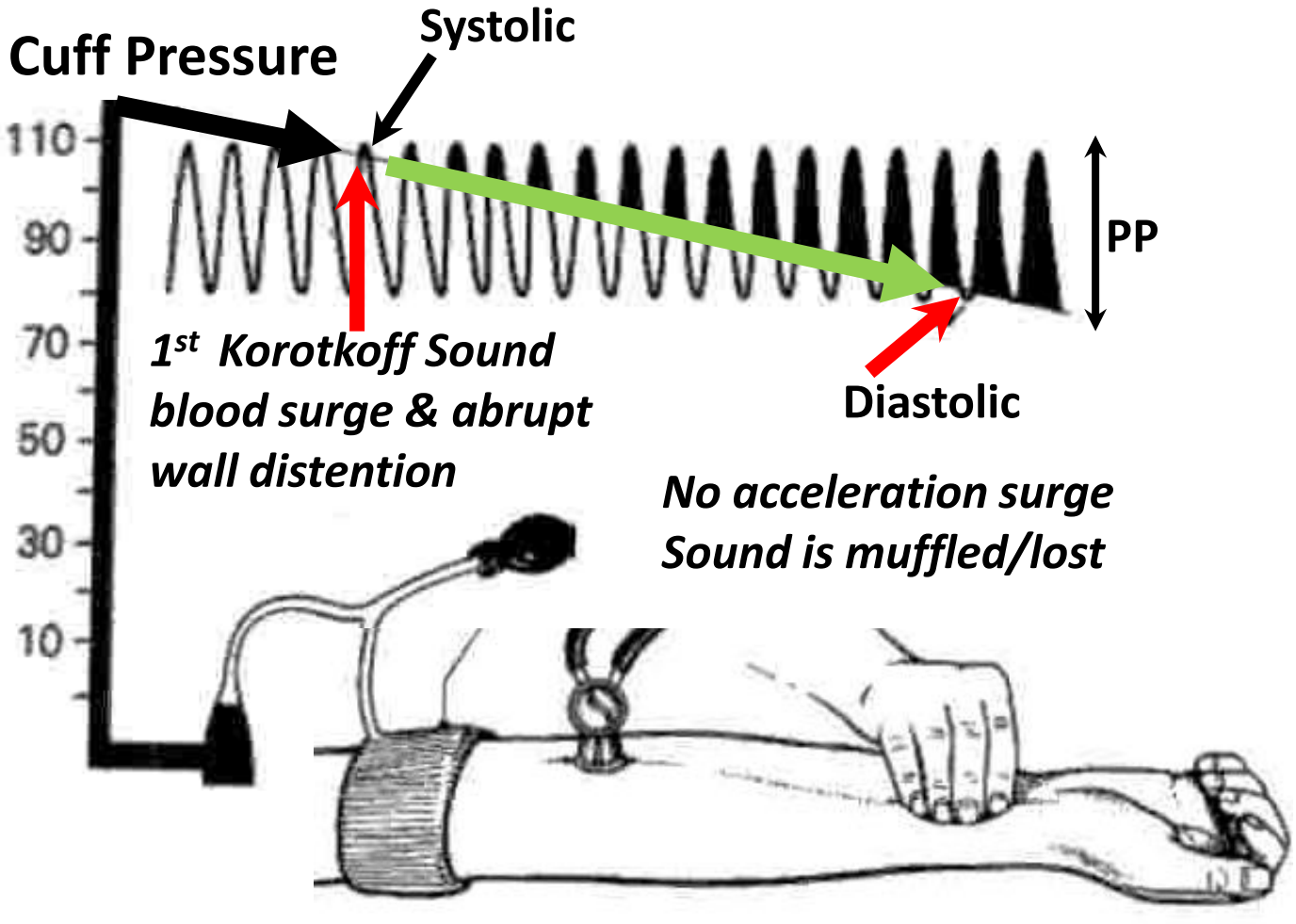
Cardiovascular Patterns and Arrangements



Simplified Functional View

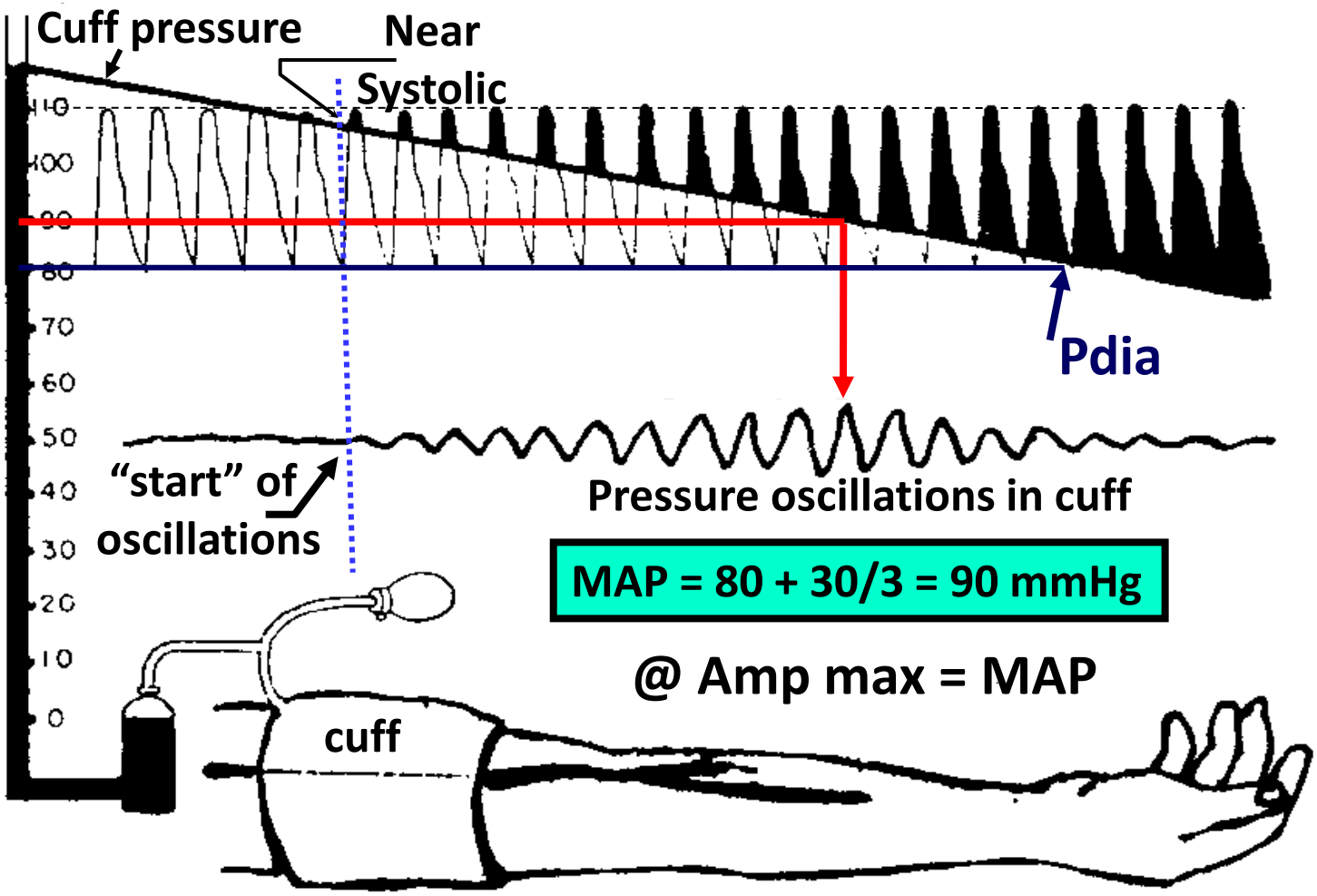


Measuring BP: Sphygmomanometer



Measuring BP: Oscillographic Method

Systolic & Diastolic via algorithm



Hypertension = High Blood Pressure

So ……. What's High?

Hypertension

BP CLASSIFICATION	SBP (mmHg)	DBP (mmHg)
Normal	< 120	AND <80
Elevated	120-129	AND < 80
Stage 1 Hypertension	130 - 139	OR 80 - 89
Stage 2 Hypertension	>= 140	OR >= 90
Hypertensive Crisis	> 180	AND/OR > 120

If DBP is normal but SBP is high then it may be called Isolated Systolic Hypertension (e.g. 145/75, also stage 2 HTN)

→ *Decreased Arterial Compliance*

Interactive Questions

Which (is) are normotensive?

Which (is) are stage 1 hypertension?

Which (is) are isolated systolic hypertension?

BP CLASSIFICATION	SBP (mmHg)	DBP (mmHg)
Normal	< 120	AND <80
Elevated	120-129	AND < 80
Stage 1 Hypertension	130 - 139	OR 80 - 89
Stage 2 Hypertension	>= 140	OR >= 90
Hypertensive Crisis	> 180	AND/OR > 120

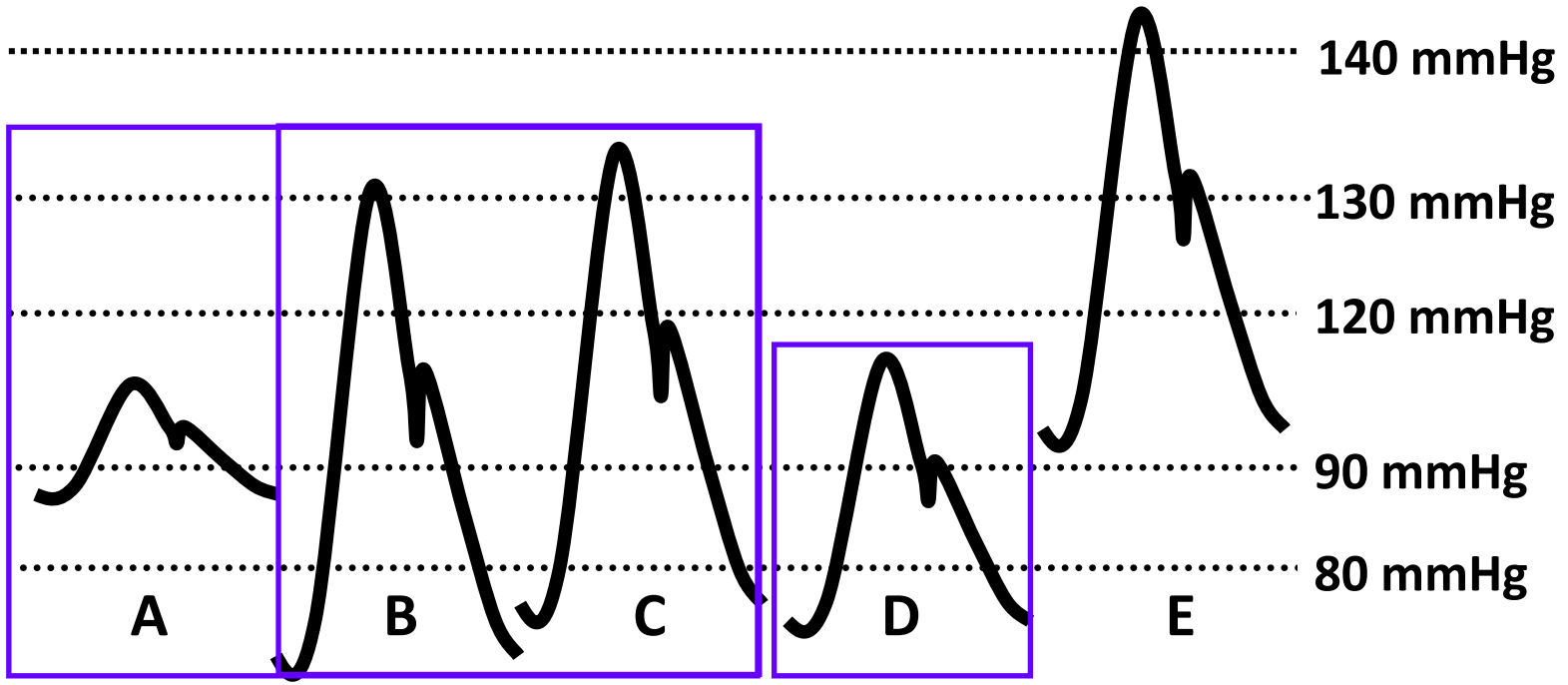
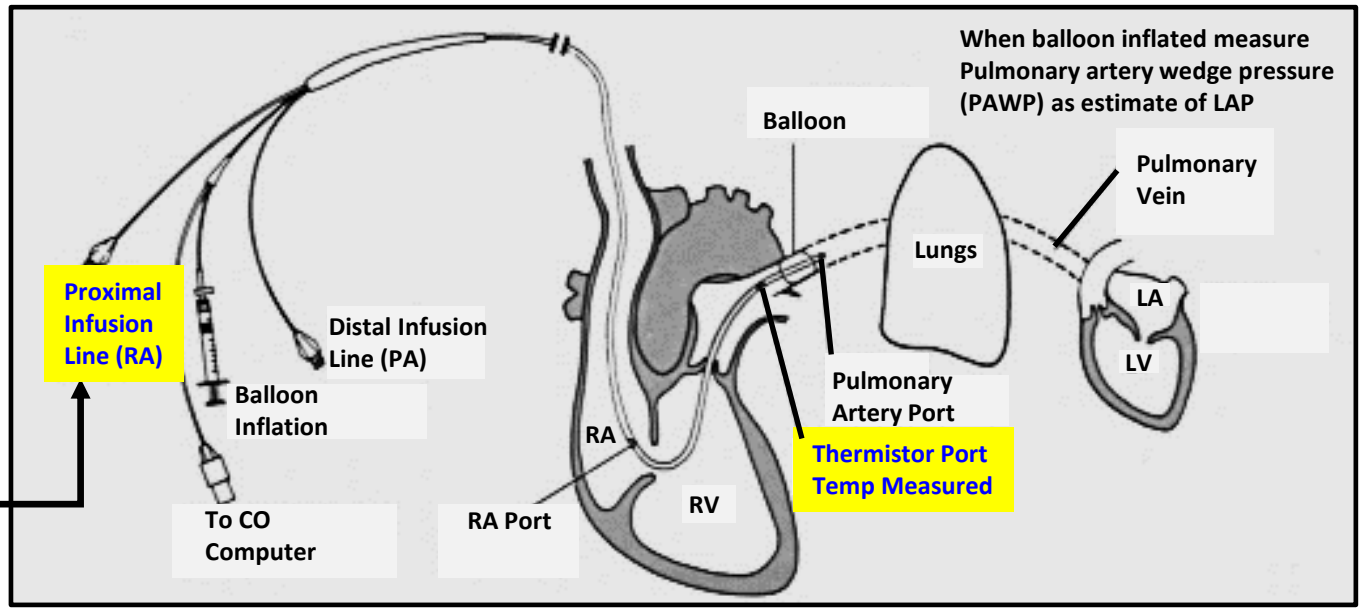


Figure shows artery Pulses of 5 patients

Determining CO via Thermodilution Method

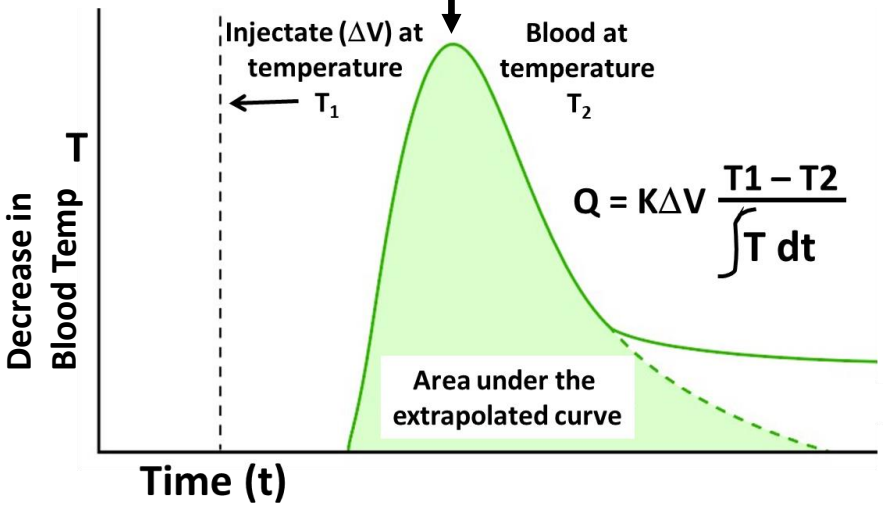
Thermodilution Swan-Ganz catheter with a thermistor placed into pulmonary artery via peripheral vein insertion



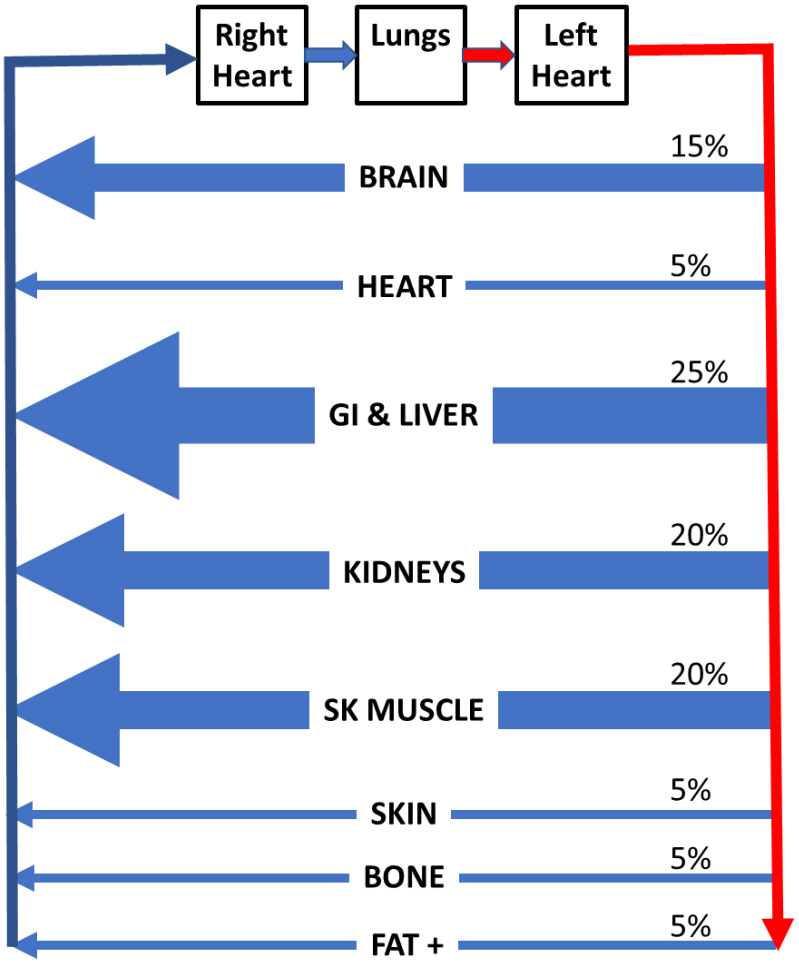
- **Cold saline injected into right atrium at the end of expiration**

- **Temperature change at the thermistor is sensed and recorded**

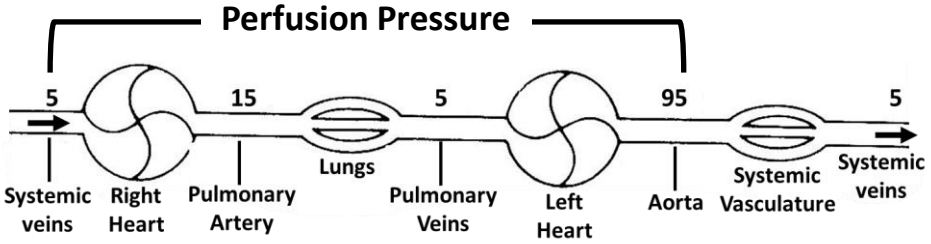
- **Blood flow (cardiac output, CO) is determined from the temperature profile**



Resting Cardiac Output Distribution



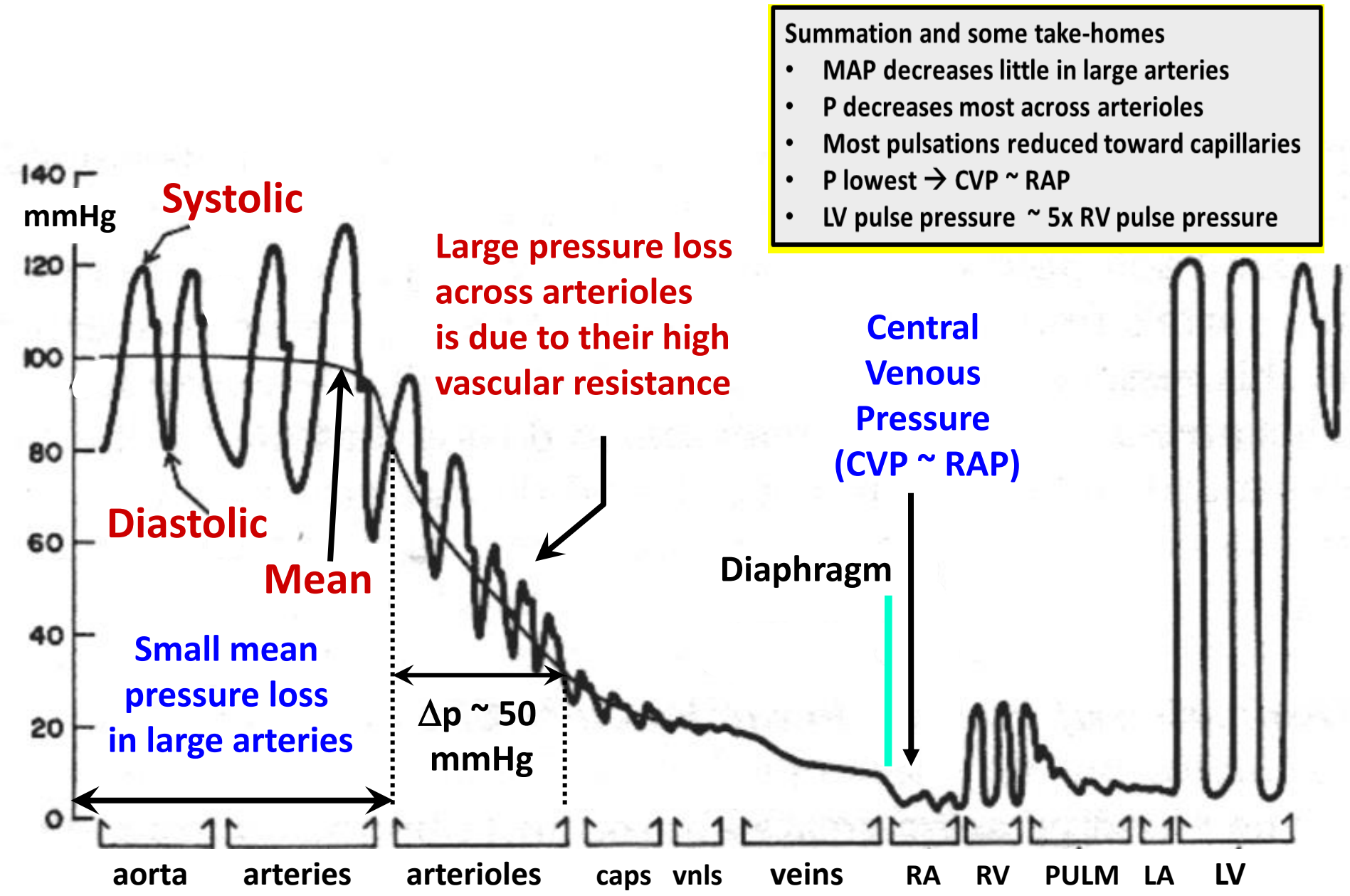
- Percentages are approximate; vary by person
- **Absolute cardiac output** (CO, L/min) varies by age, gender, weight, and other factors
- **Cardiac Index** (CO/BSA, L/min/m^2) helps minimize variance also (**SVI = SV/BSA**)
- For a fixed perfusion pressure, flow (Q) to organs depends on their vascular resistance; **Q = ΔP/R**
- The diagram below shows pressures in mmHg and illustrates normal average values at the different locations



The above figure shows approximate percentages of cardiac output distribution. If CO were 6 L/min then absolute flow to the kidneys would be 1.2 L/min.

Perfusion pressure = ΔP = 95-5 = 90 mmHg
If cardiac output were 6 L/min, then
TPR = 90/6 = 15 Wood units and
PVR = 10/6 = 1.67 Wood units

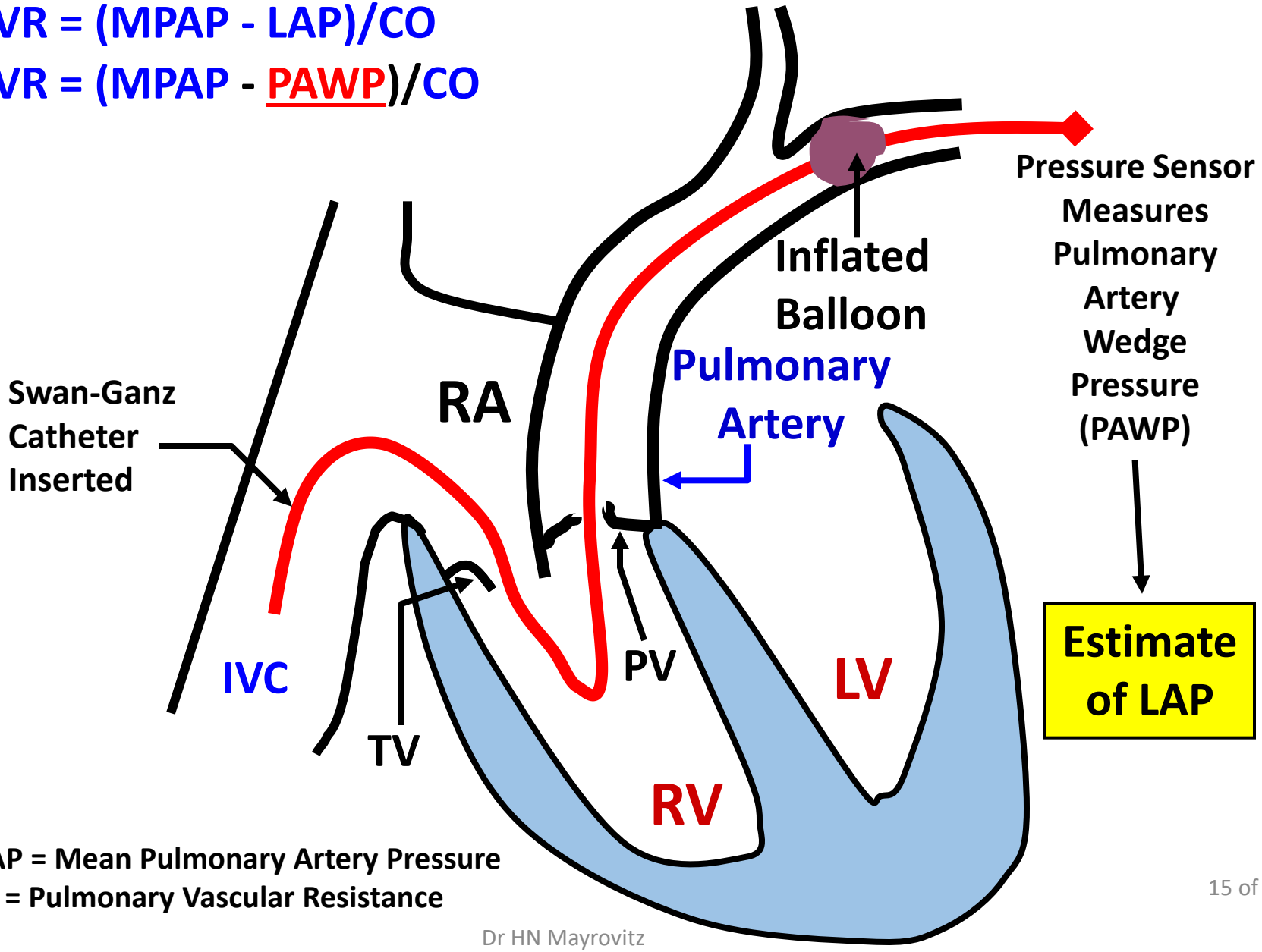
Cardiovascular Pressure Variations



Determining Pulmonary Artery Wedge Pressure

PVR = (MPAP - LAP)/CO

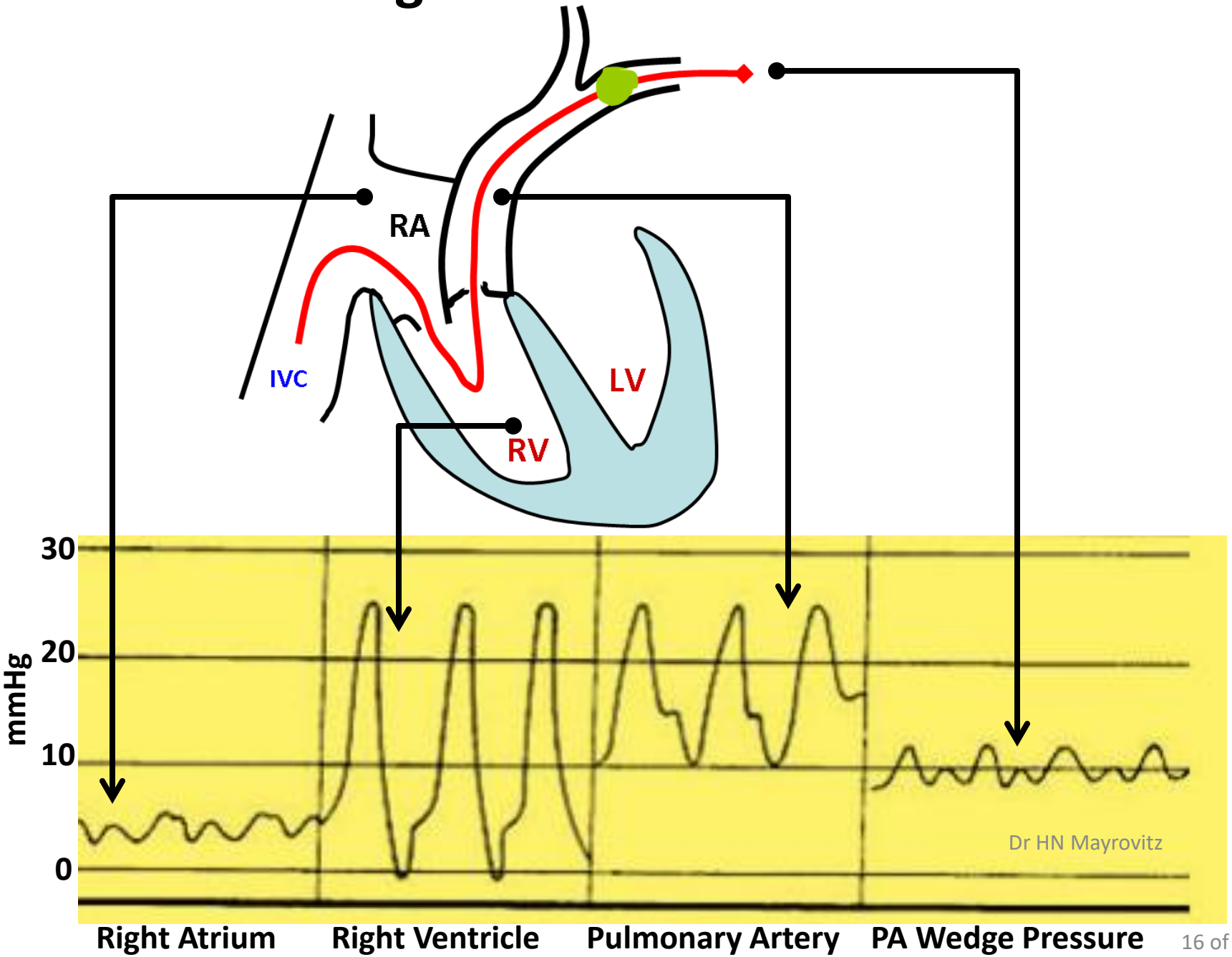
PVR = (MPAP - PAWP)/CO



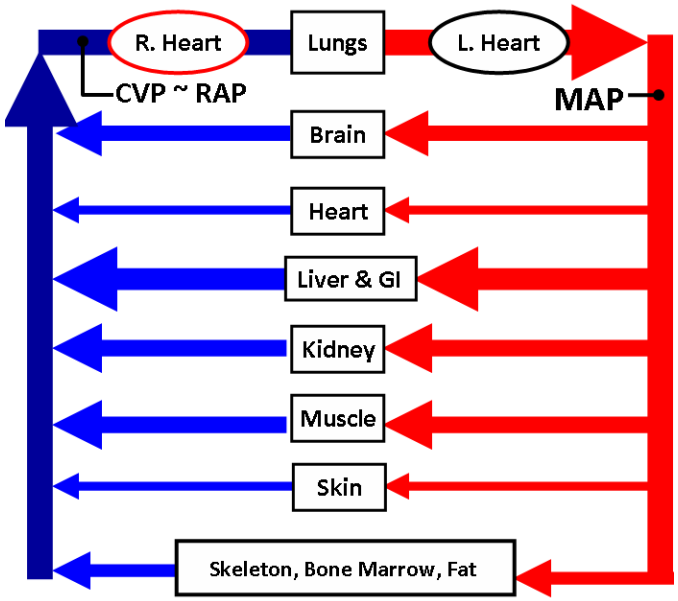
MPAP = Mean Pulmonary Artery Pressure

PVR = Pulmonary Vascular Resistance

Right Sided Pressures



Interactive Question



Bill has the following hemodynamic data
ABP = 150/60 mmHg
CVP = 3 mmHg
SV = 100 ml
HR = 60

What is his TPR in Wood units? One minute!

Interactive Question

Which of the following best describes conditions within a vascular bed of an organ? 30 s

A. All capillaries of the same type are effectively in parallel with each other

B. All arterioles of the same type are effectively in parallel with capillaries they supply

C. The greatest pressure loss is attributable to the small lumen of the capillaries

D. All arterioles of the same type are effectively in series with each other

E. A decrease in the number of arterioles leads to a decrease in organ resistance

Interactive Question

If all arterioles of an organ vasoconstrict then: 30 s

A. Blood flow to the organ increases

B. Blood pressure in the organ's capillaries decreases

C. Total resistance of the organ decreases

D. Blood flow within arterioles increases

E. Total peripheral resistance decreases

Interactive Question

Which one of the following is not normally a major function or attribute of systemic arterioles?

A. Control of the amount of blood flow that enters an organ

B. Control of the amount of blood pressure in the capillaries

C. Control of the vascular resistance of an organ

D. Control of the systemic blood pressure

E. Control of the systemic blood volume

Interactive Question

Which of the following features is numerically similar in the systemic and pulmonary circulations? 30 sec

A. Systolic blood pressure

B. Diastolic blood pressure

C. Mean blood pressure

D. Total blood flow

E. Ventricular maximum pressure

Interactive Question

Which one of the statements correctly describes one or more aspects of the cardiovascular system?

A. The left and right ventricles pump blood in parallel with each other

B. Capillaries within most organs are essentially in series with each other

C. The network of capillaries in an organ is essentially in series with the network of arterioles

D. In the kidney, the afferent and efferent arterioles are in parallel with each other

E. In systemic capillaries, the amount of vascular smooth muscle is about the same as in arterioles

End CV Physiology Lecture 4