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Arterial stiffness.

Oral exam questions

- Arterial elasticity – significance
- Arterial pulse, pulse wave

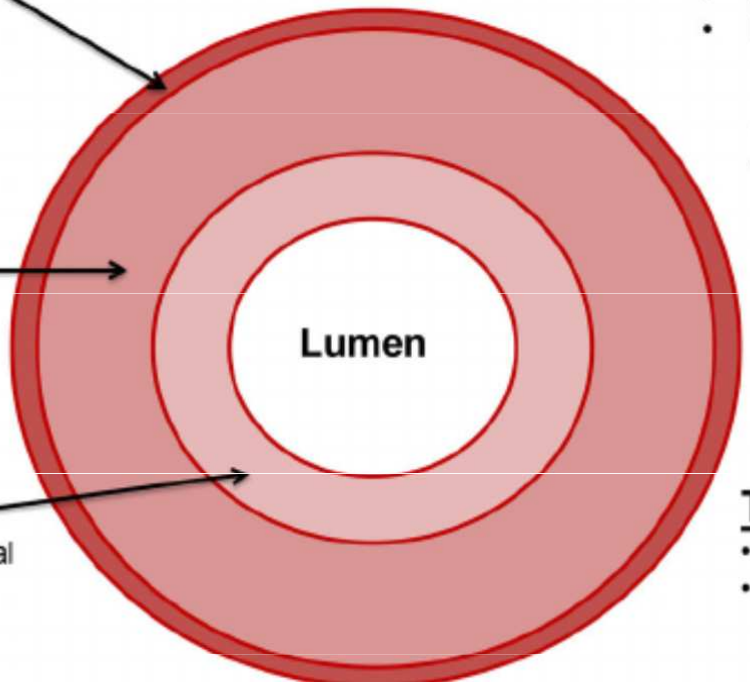
Factors of arterial stiffness changes

A. Vascular Structure

Tunica adventitia
- Fibroblasts
- Collagen-containing matrix
- External elastic lamina

Tunica media
- Smooth muscle cells
- Elastic fibers

Tunica intima
- Monolayer of endothelial cells
- Internal elastic lamina



B. Stiffness Pathology

Tunica adventitia
- Collagen deposition
- Increase in fibroblasts

Tunica media
- Collagen deposition
- Elastin degradation
- RAAS Signaling
  - AT1R & MR
- VSMC stiffness
  - Increase in α-SMA & β1-integrin

Tunica intima
- Endothelial dysfunction
- Oxidative stress

!
- Elastin degradation
- Collagen deposition
- Endothelial dysfunction

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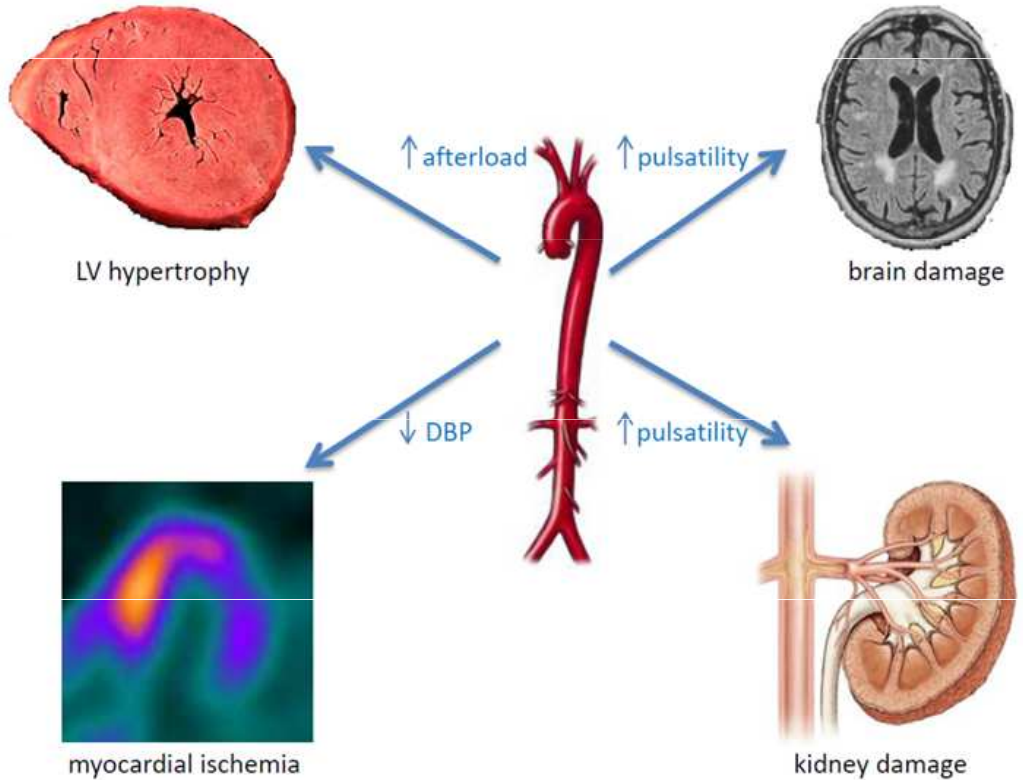
Complications of the higher arterial stiffness



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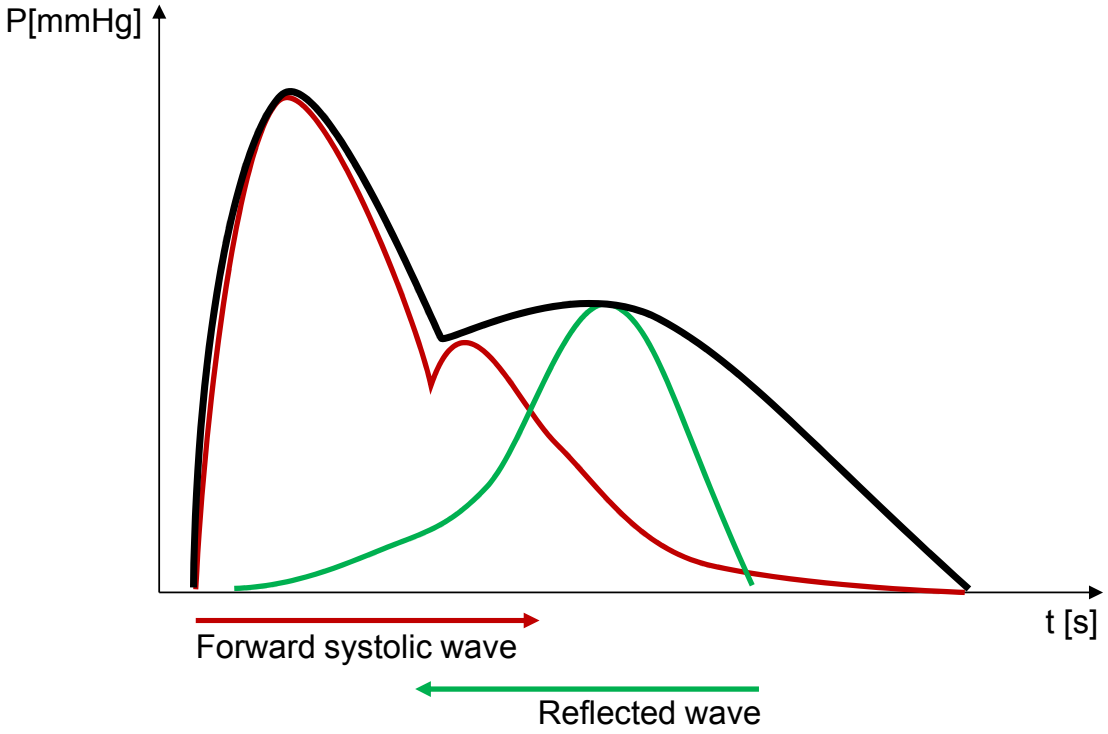
Pulse wave



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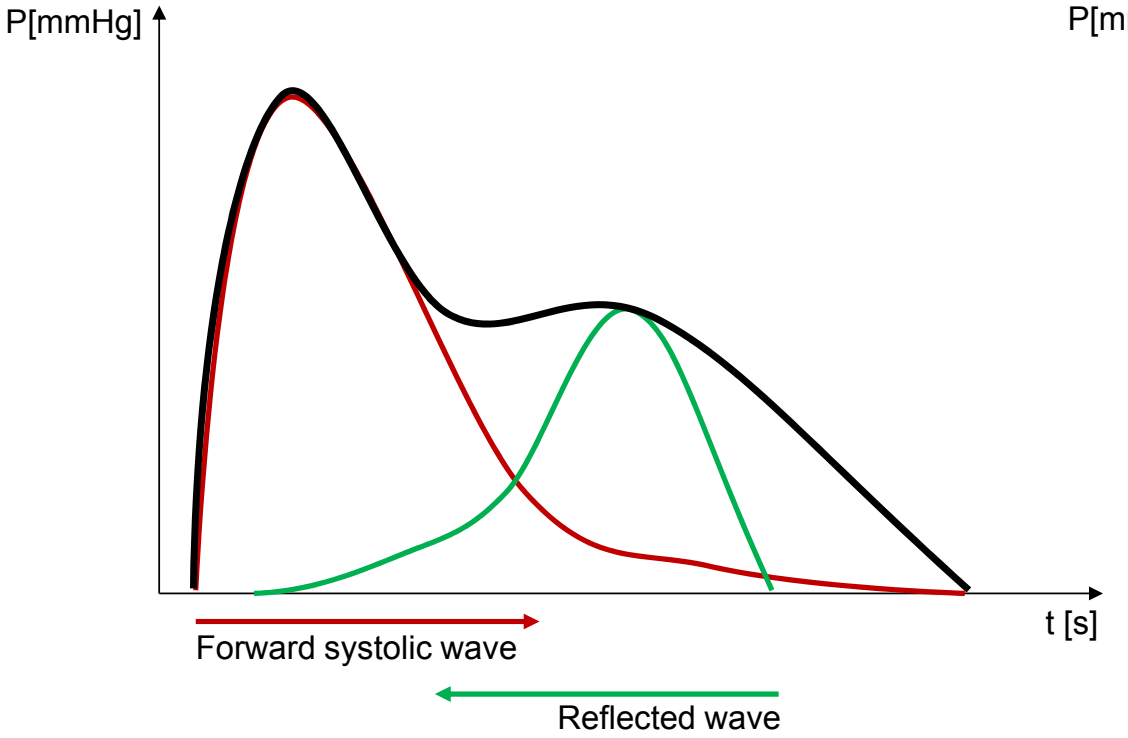
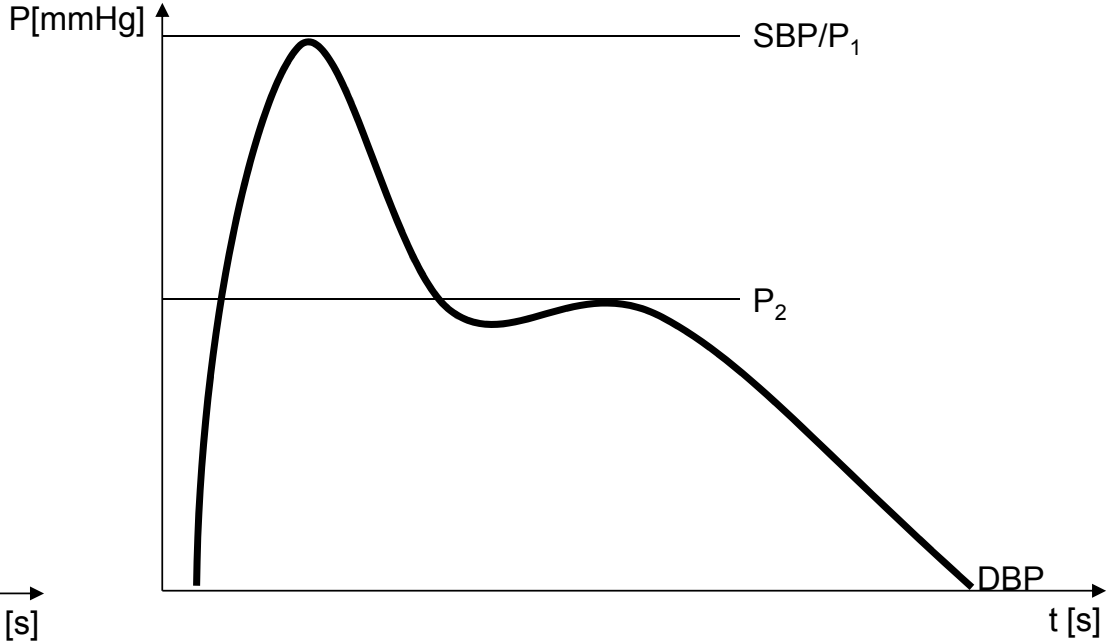
Pulse wave





PP=SBP – DBP

mBP=DBP+1/3PP

AP=P_2 – P_1

SBP – systolic blood pressure, DBP – diastolic blood pressure, P_1 – pressure at peak of systolic flow, P_2 – pressure of the reflected wave, PP – pulse pressure, mBP – mean blood pressure, AP – augmented pressure

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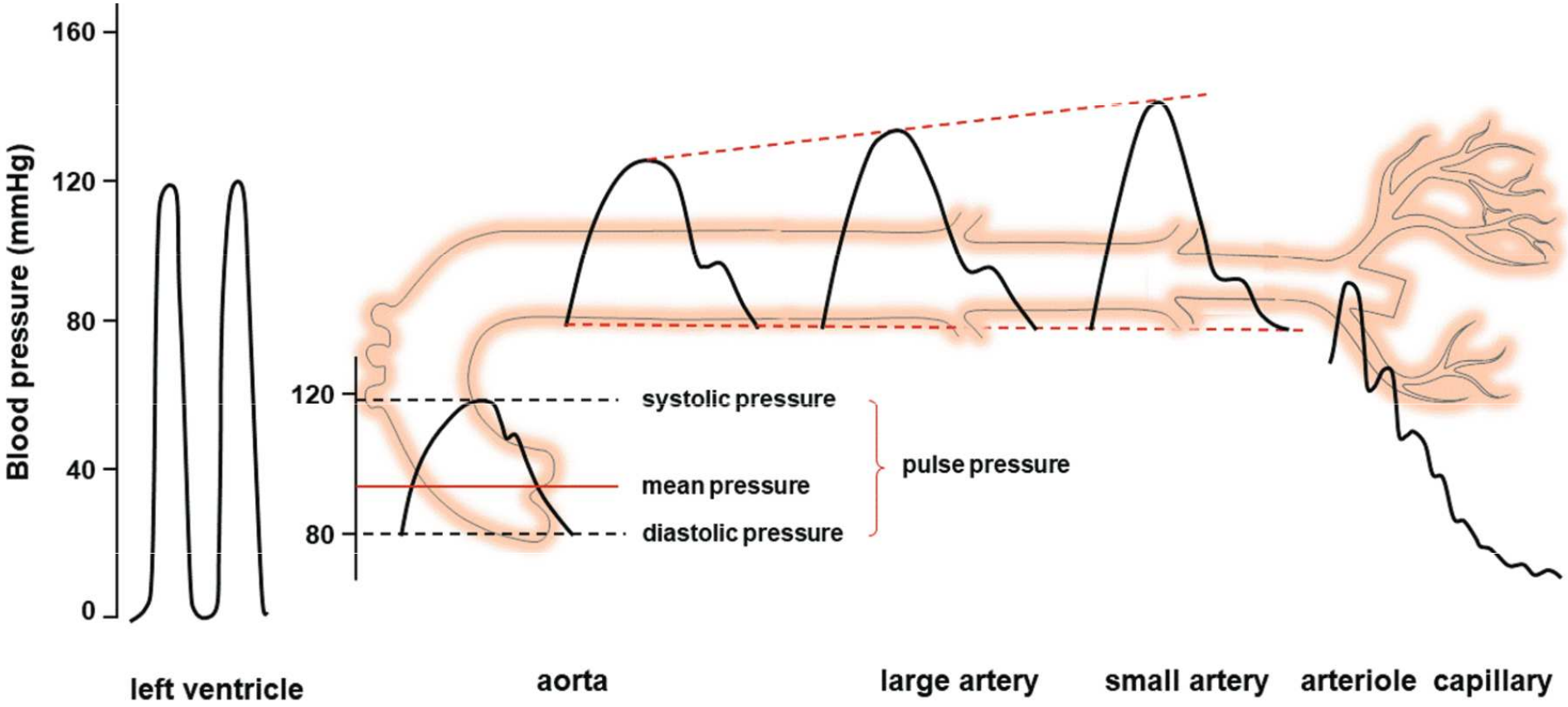
Pulse wave at different vascular segments



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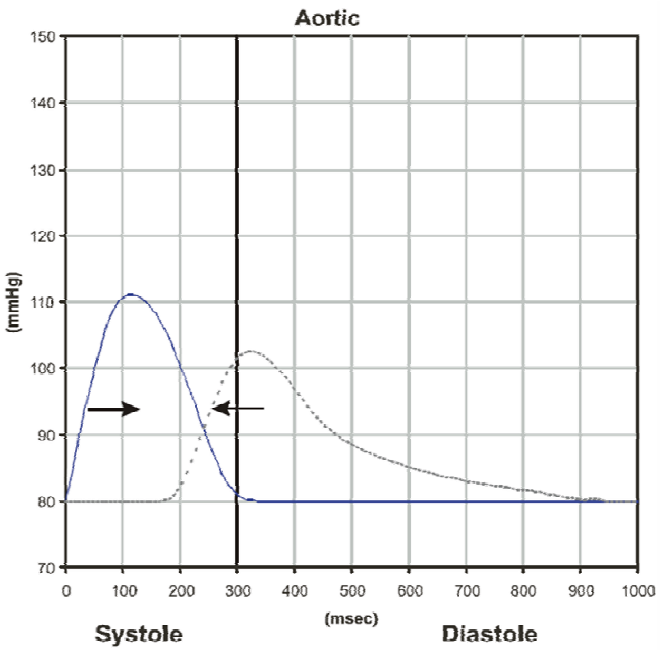
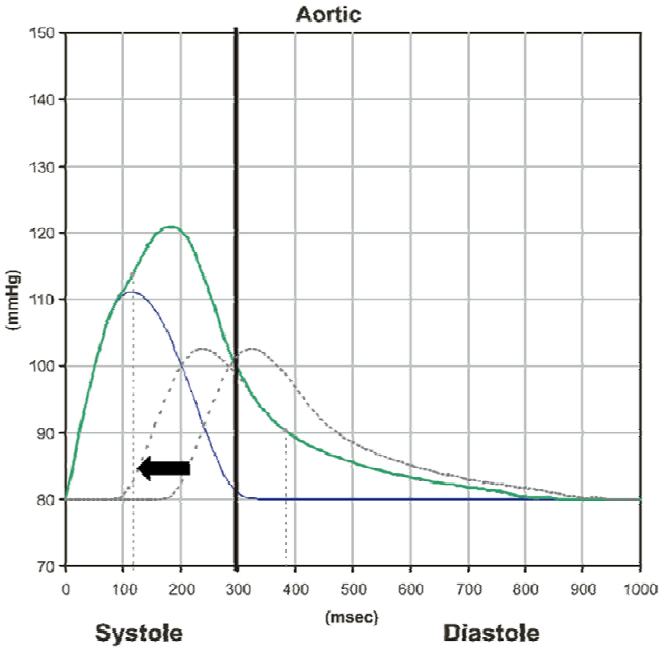
Sex differences in mechanisms of arterial stiffness

	Males	Females
Mechanism	**Relevant pathways**	
ECM alterations	↑ Collagen ↓ Elastin	↑ Collagen
VSMC stiffening	↑ β1-integrin Rho kinase	Unknown
Oxidative stress	↑ Superoxide Mitochondrial-derived ROS NADPH-oxidase	↑ Superoxide eNOS uncoupling via BH(4) reductions
Inflammation	↑ NF-κB T-cell activation	↑ NF-κB
RAAS signalling	↑ SMC-MR AT1R activation	↑ EC-MR ENaC

ECM - extracellular matrix; VSMC - vascular smooth muscle cell; eNOS - endothelial NOS; NADPH - NAD phosphate oxidase; BH(4) - tetrahydrobiopterin; SMC-MR - smooth muscle cell mineralocorticoid receptor; AT1R - angiotensin II type 1 receptor; EC-MR - endothelial cell mineralocorticoid receptor; ENaC - epithelial sodium channel.

Pressure wave reflection





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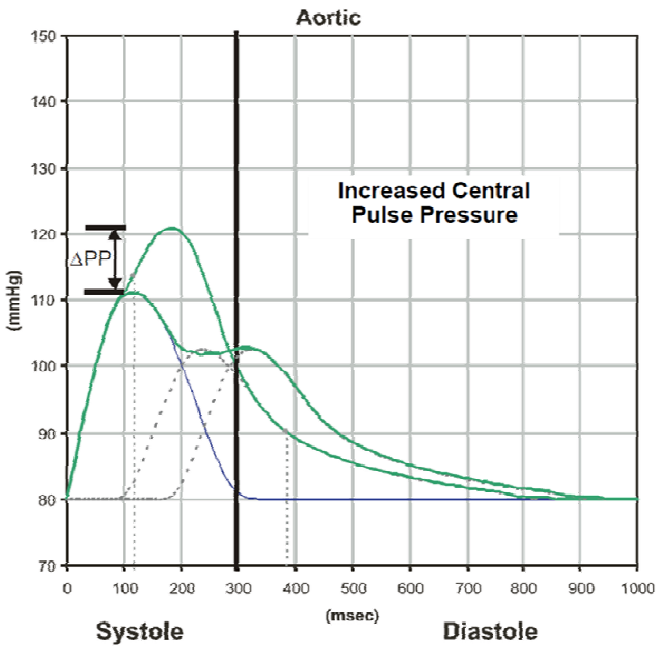
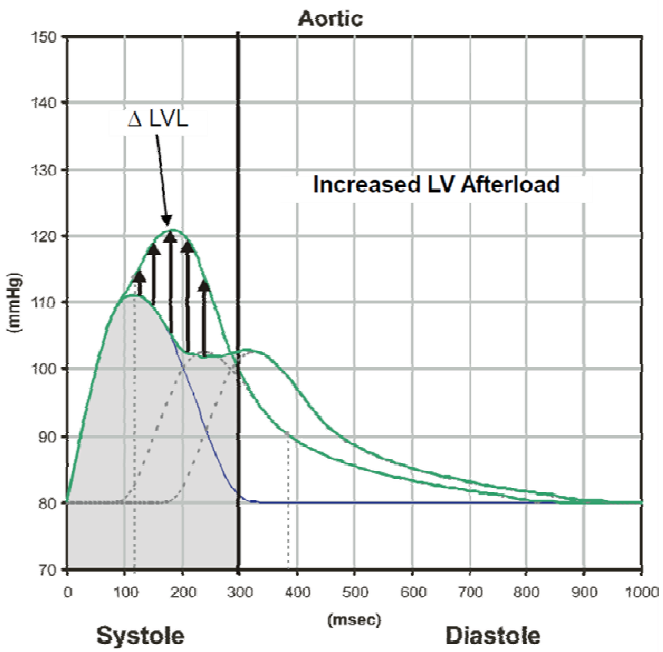
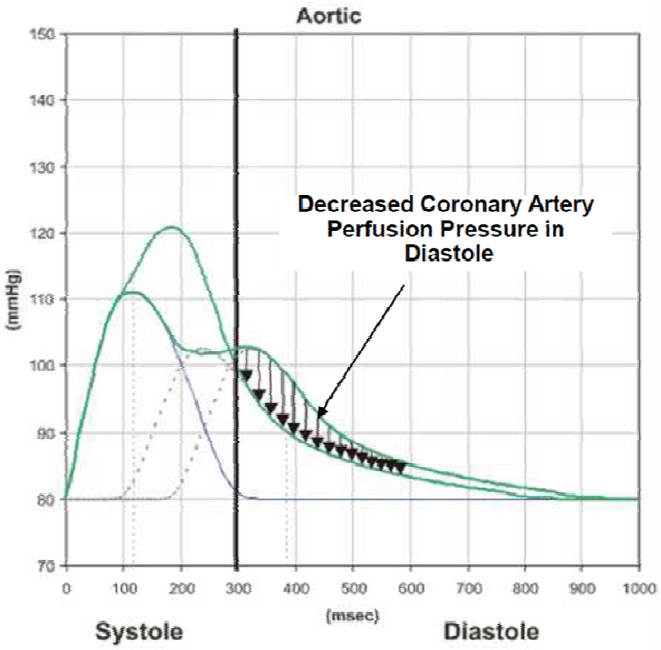
Pressure wave reflection







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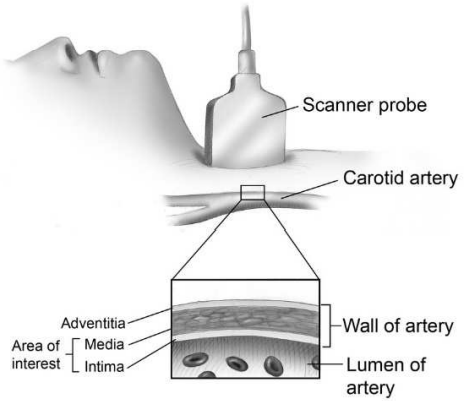
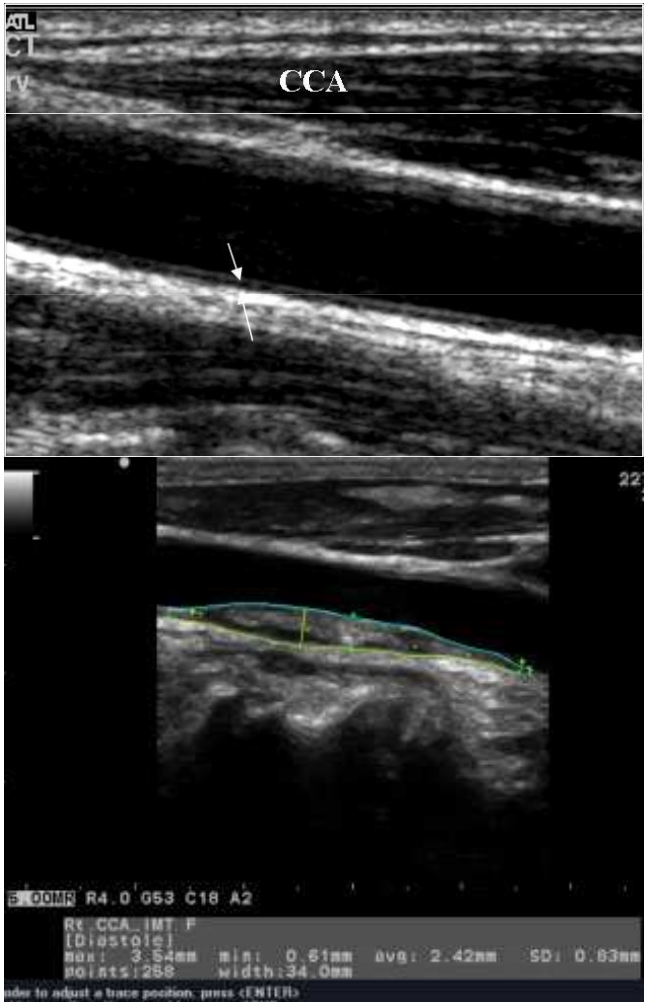
Ultrasound measurement





age		IMT_R (mm)	IMT_L (mm)
25-35	Mean	0.39±0.07	0.40±0.07
	V%	18.26	17.37
	CI	0.36<x<0.42	0.38<x<0.42
35-45	Mean	0.43±0.07	0.46±0.09
	V%	15.15	18.59
	CI	0.41<x<0.45	0.43<x<0.49
45-55	Mean	0.47±0.08	0.50±0.11
	V%	17.49	21.18
	CI	0.44<x<0.50	0.47<x<0.54
55-65	Mean	0.52±0.11	0.54±0.11
	V%	21.01	20.89
	CI	0.48<x<0.56	0.50<x<0.58
65-75	Mean	0.55±0.09	0.57±0.09
	V%	16.65	14.60
	CI	0.53<x<0.59	0.55<x<0.61

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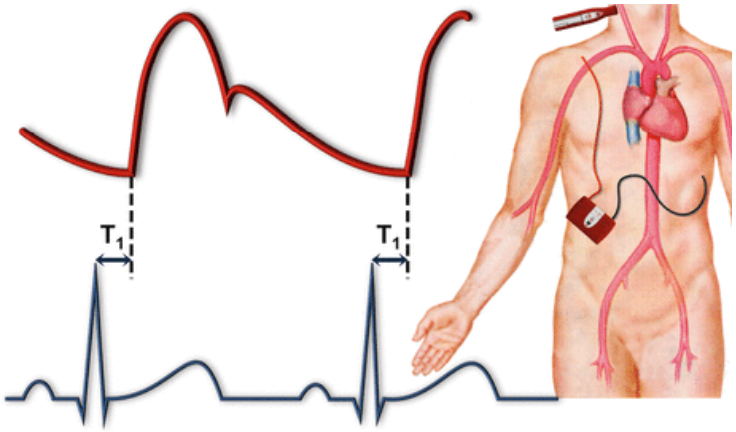
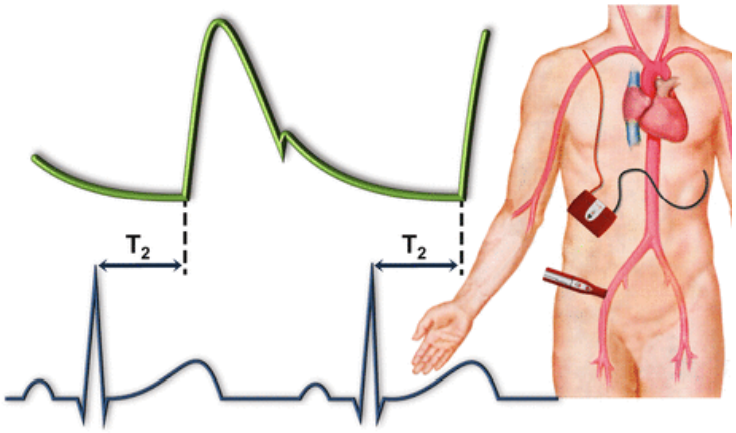
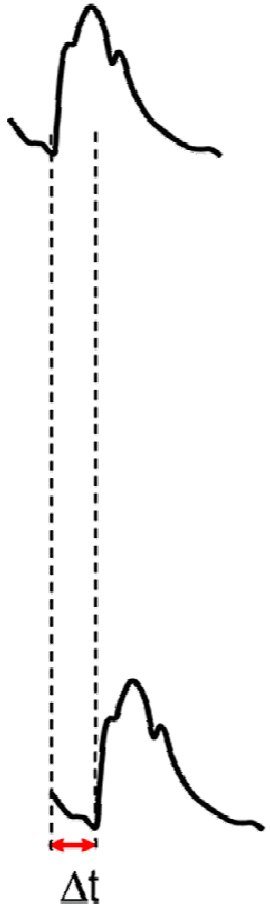
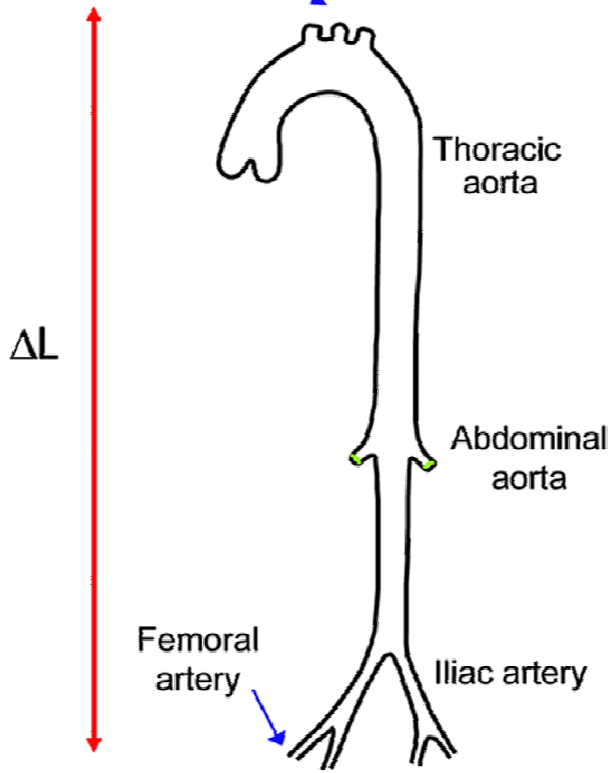
PWV measurement







$$PWV = \frac{\Delta L}{\Delta t}$$



A highly compliant aorta has a relatively low PWV (< 6 m/s)

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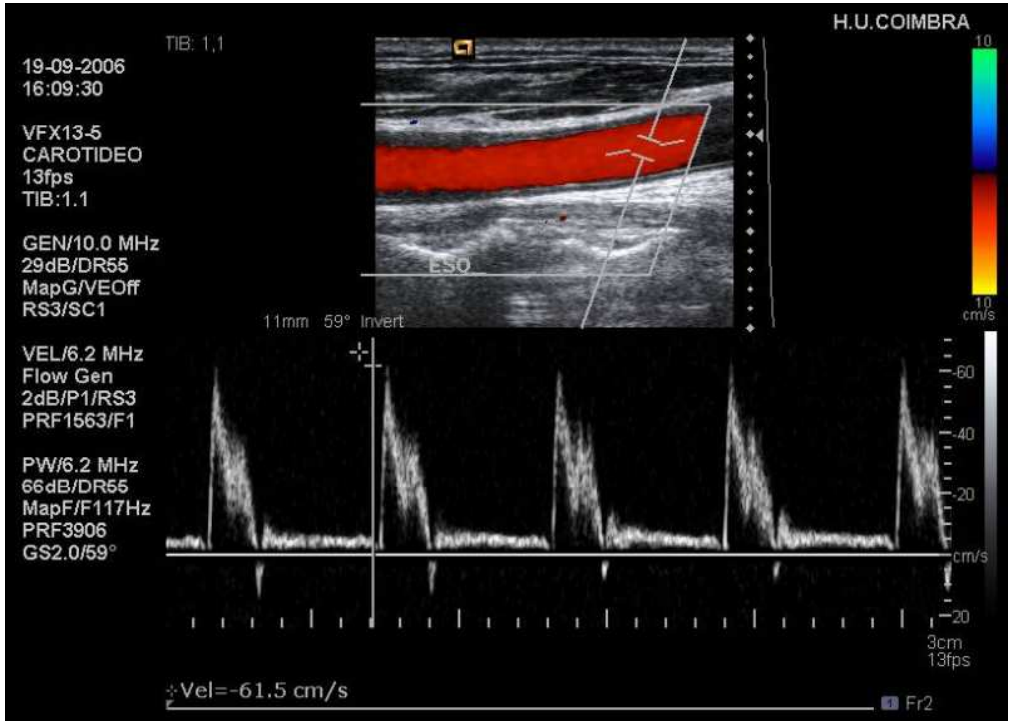
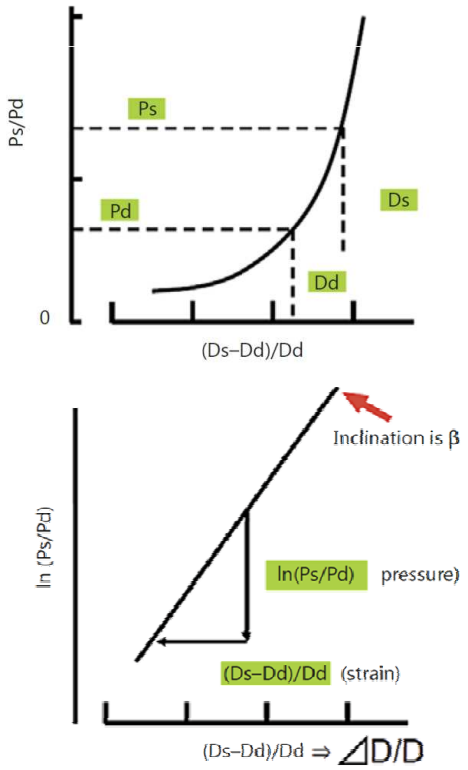
Ultrasound measurement (β – index).

$$\beta = \left(\ln \frac{P_s}{P_d}\right)\left(\frac{D}{\Delta D}\right)$$





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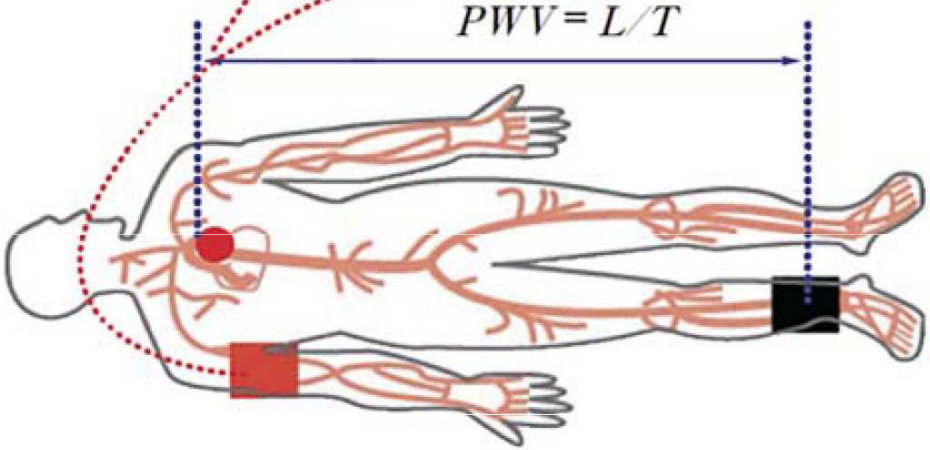
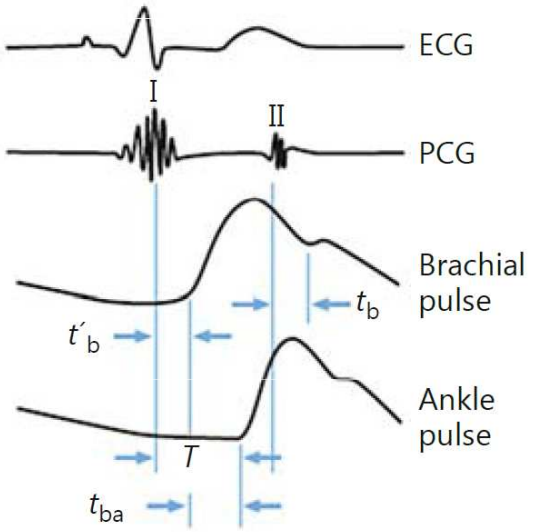
CAVI measurement

$$CAVI = a\left[\frac{2\rho}{\Delta P}\left[\ln\frac{Ps}{Pd}\right]PWV^2\right]+b$$

$$PWV = L/T$$





● Reference value of CAVI

CAVI<8.0	Normal range
8.0≦CAVI<9.0	Borderline
9.0≦CAVI	Arteriosclerosis suspected

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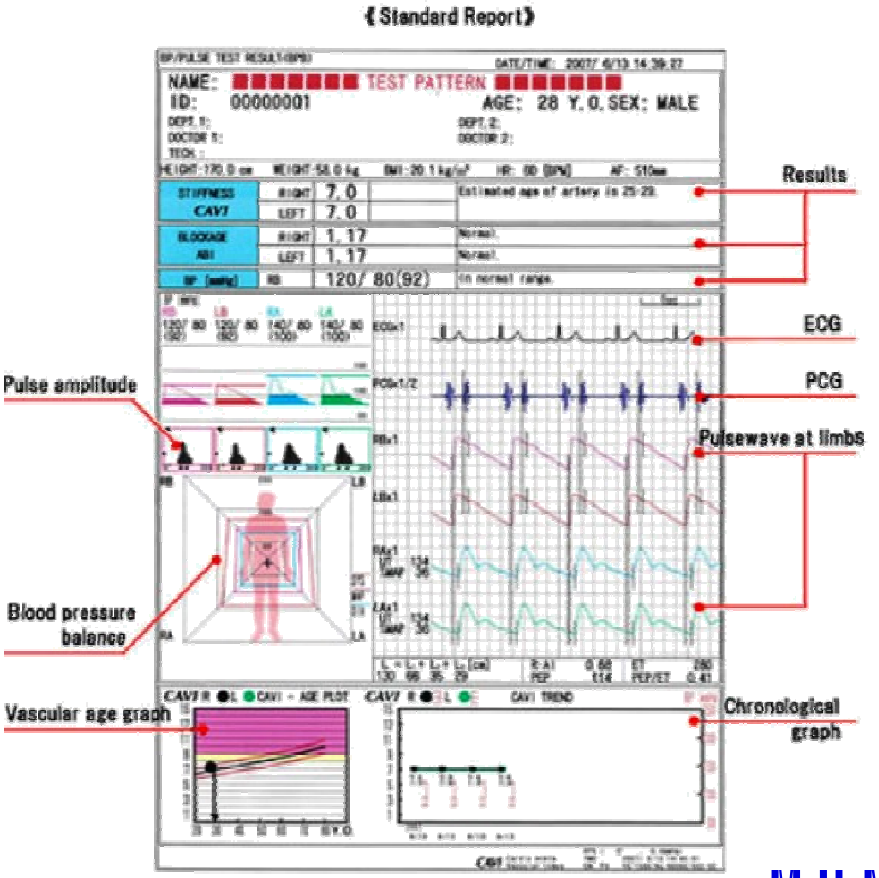
CAVI measurement



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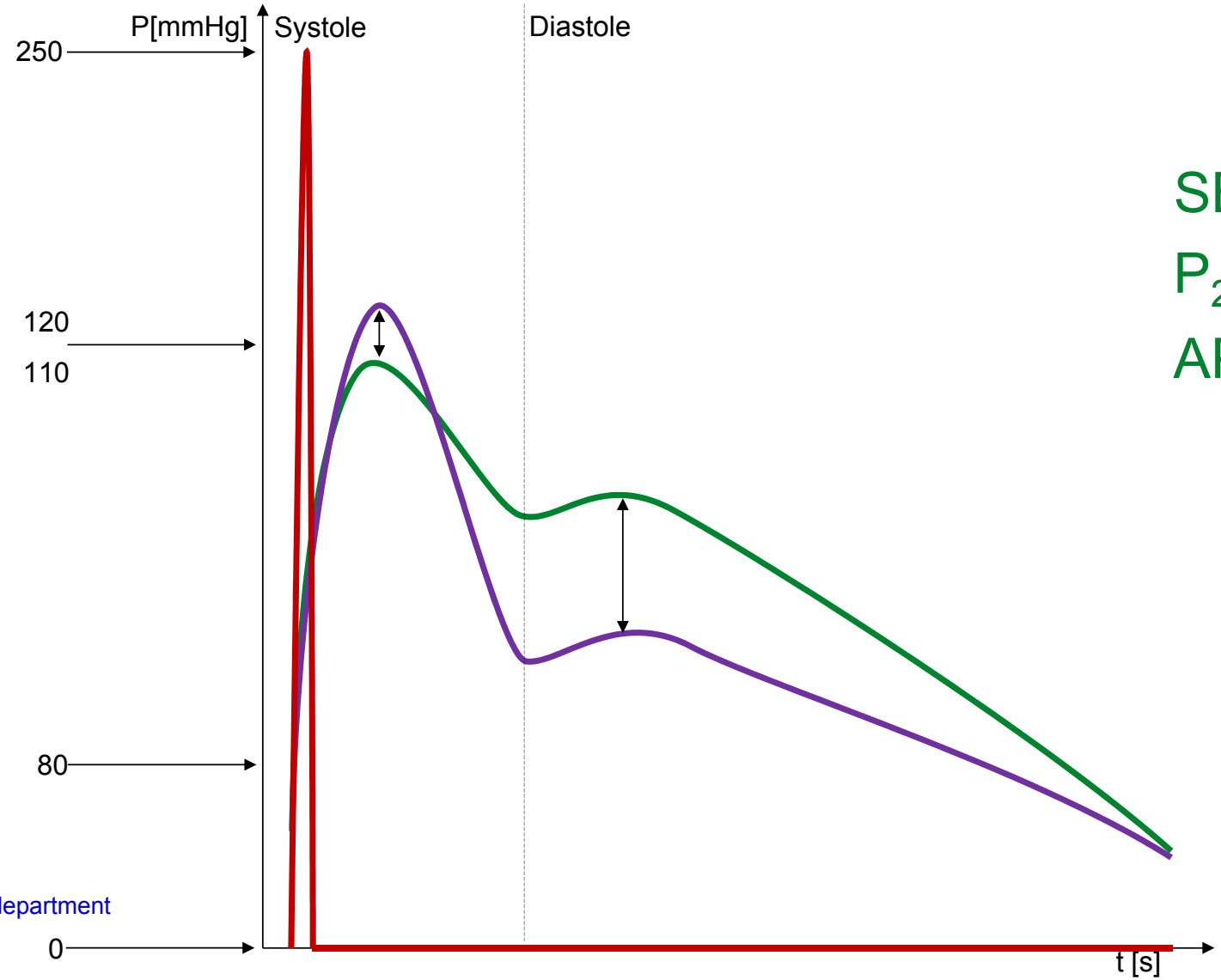

SBP<SBP

P_2>P_2

AP<AP

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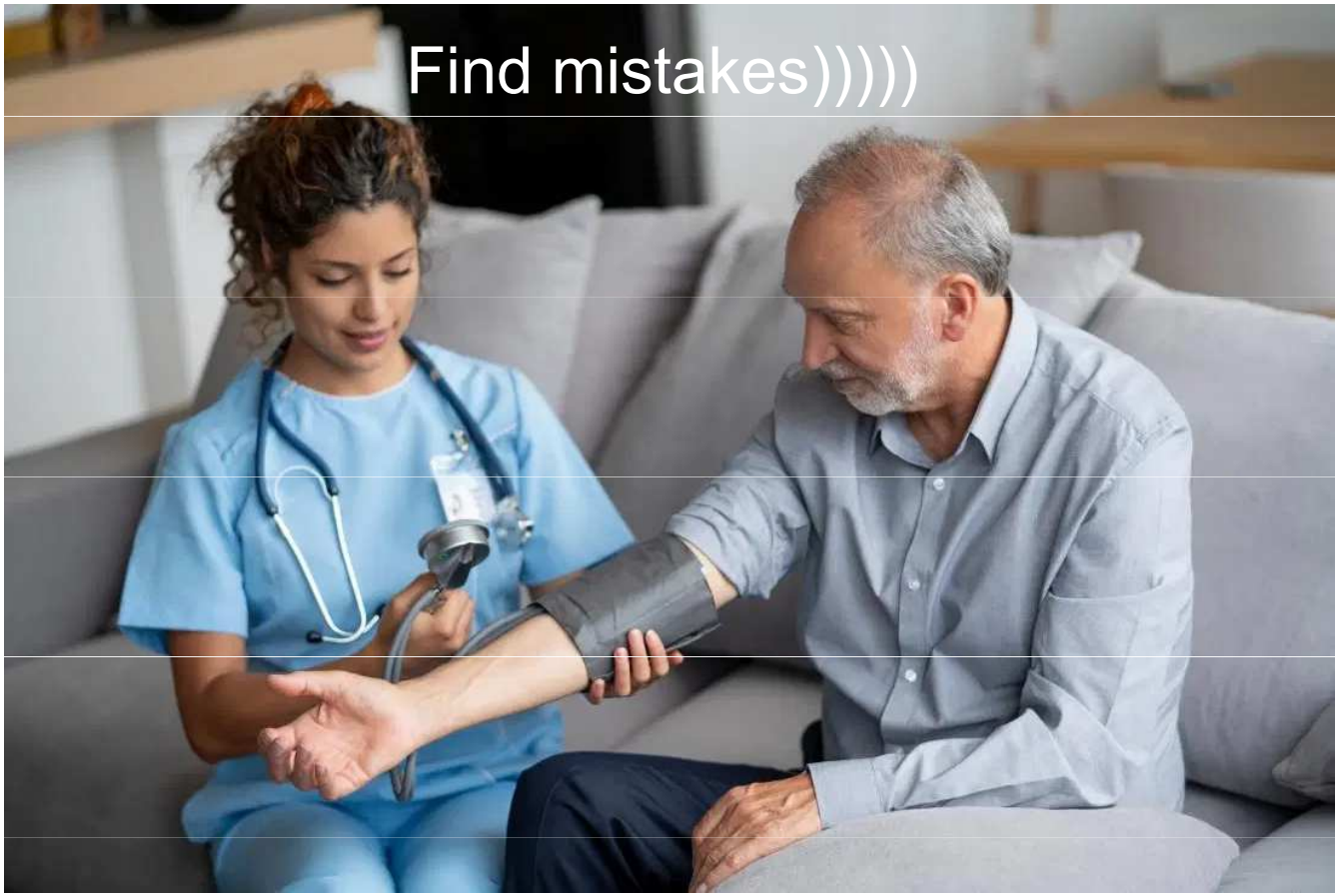
Thank you for your attention



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