

**M U N I
M E D**

Arterial stiffness.

Oral exam questions

- Arterial elasticity – significance
- Arterial pulse, pulse wave

Factors of arterial stiffness changes

A. Vascular Structure

B. Stiffness Pathology

Tunica adventitia

- Fibroblasts
- Collagen-containing matrix
- External elastic lamina

Tunica adventitia

- Collagen deposition
- Increase in fibroblasts

Tunica media

- Smooth muscle cells
- Elastic fibers

Tunica media

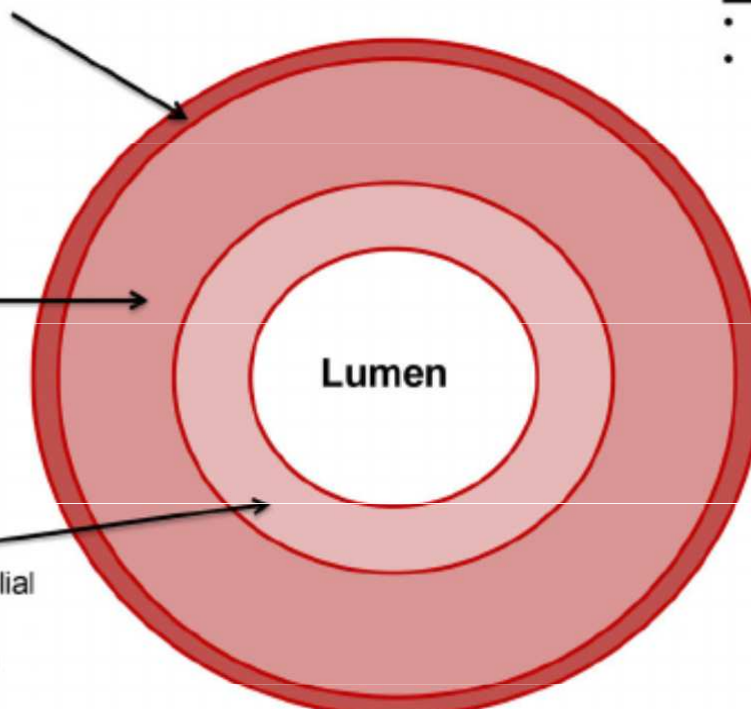
- Collagen deposition
- Elastin degradation
- RAAS Signaling
 - AT1R & MR
- VSMC stiffness
 - Increase in α -SMA & β 1-integrin

Tunica intima

- Monolayer of endothelial cells
- Internal elastic lamina

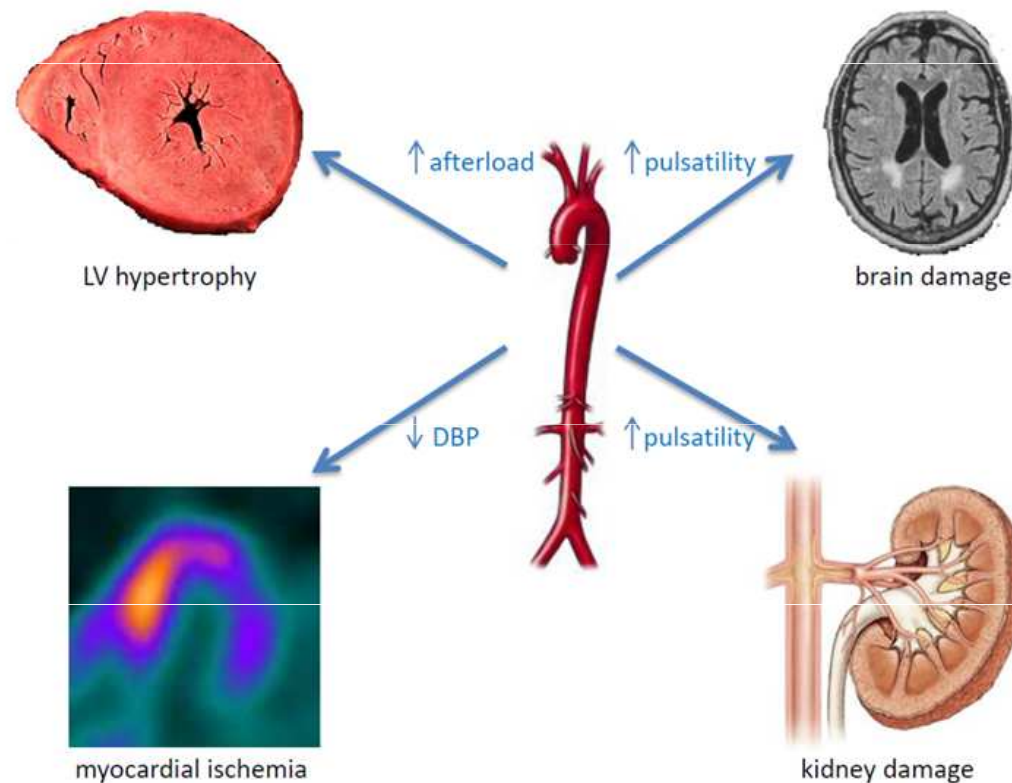
Tunica intima

- Endothelial dysfunction
- Oxidative stress

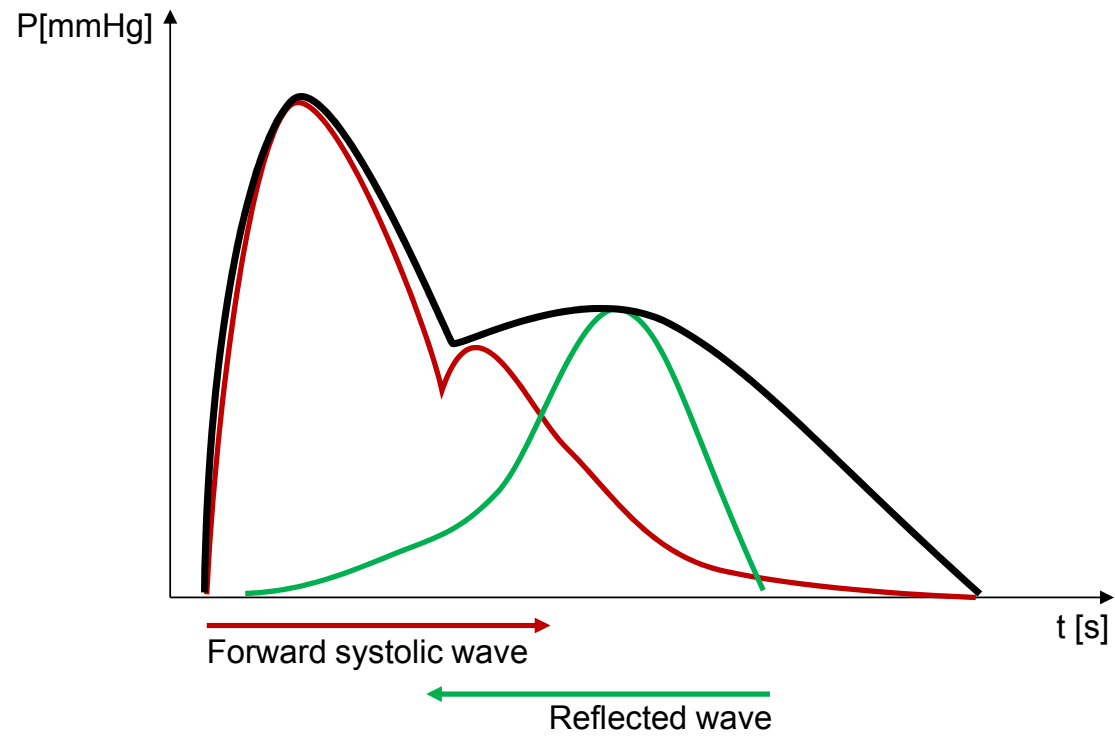


- Elastin degradation
- Collagen deposition
- Endothelial dysfunction

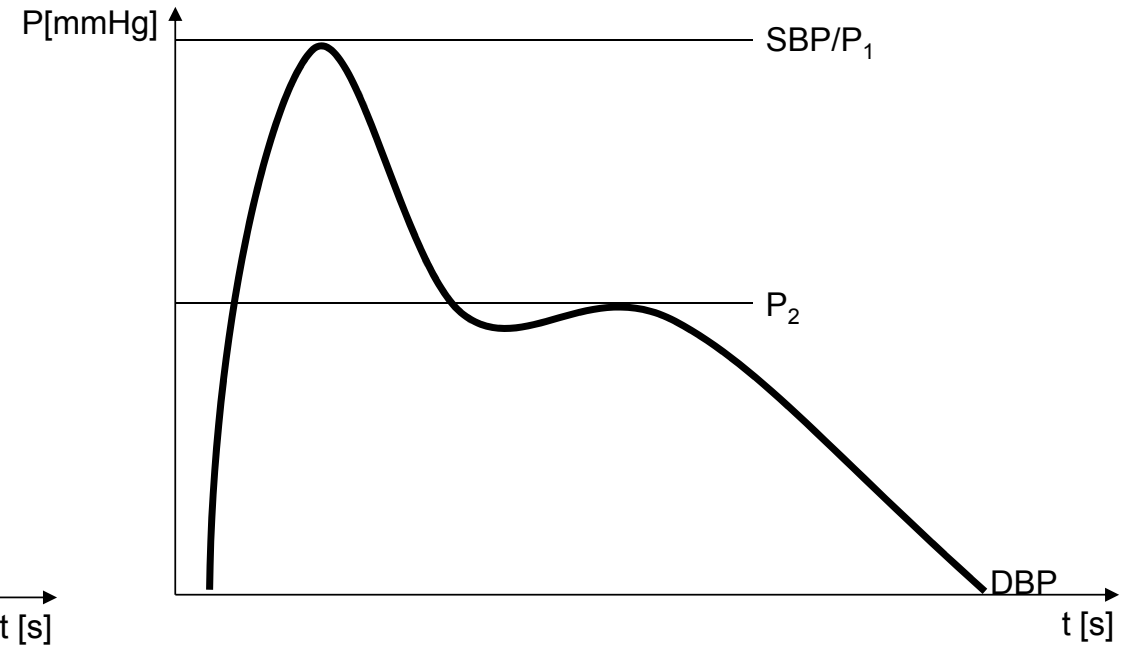
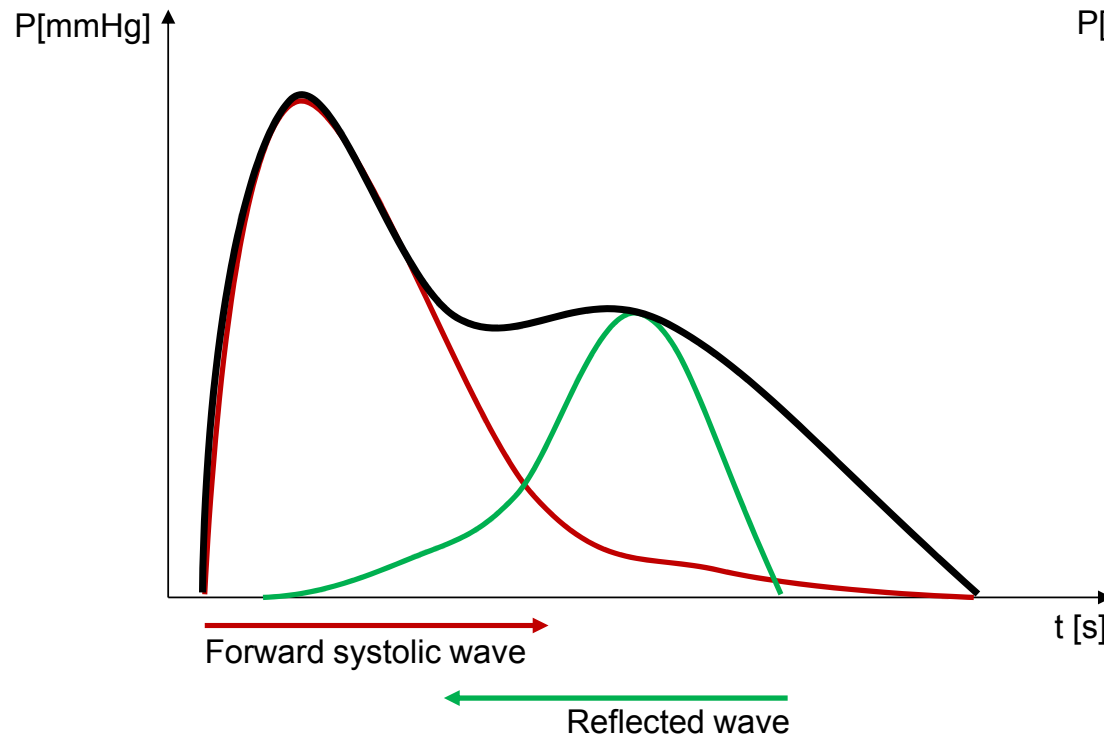
Complications of the higher arterial stiffness



Pulse wave



Pulse wave

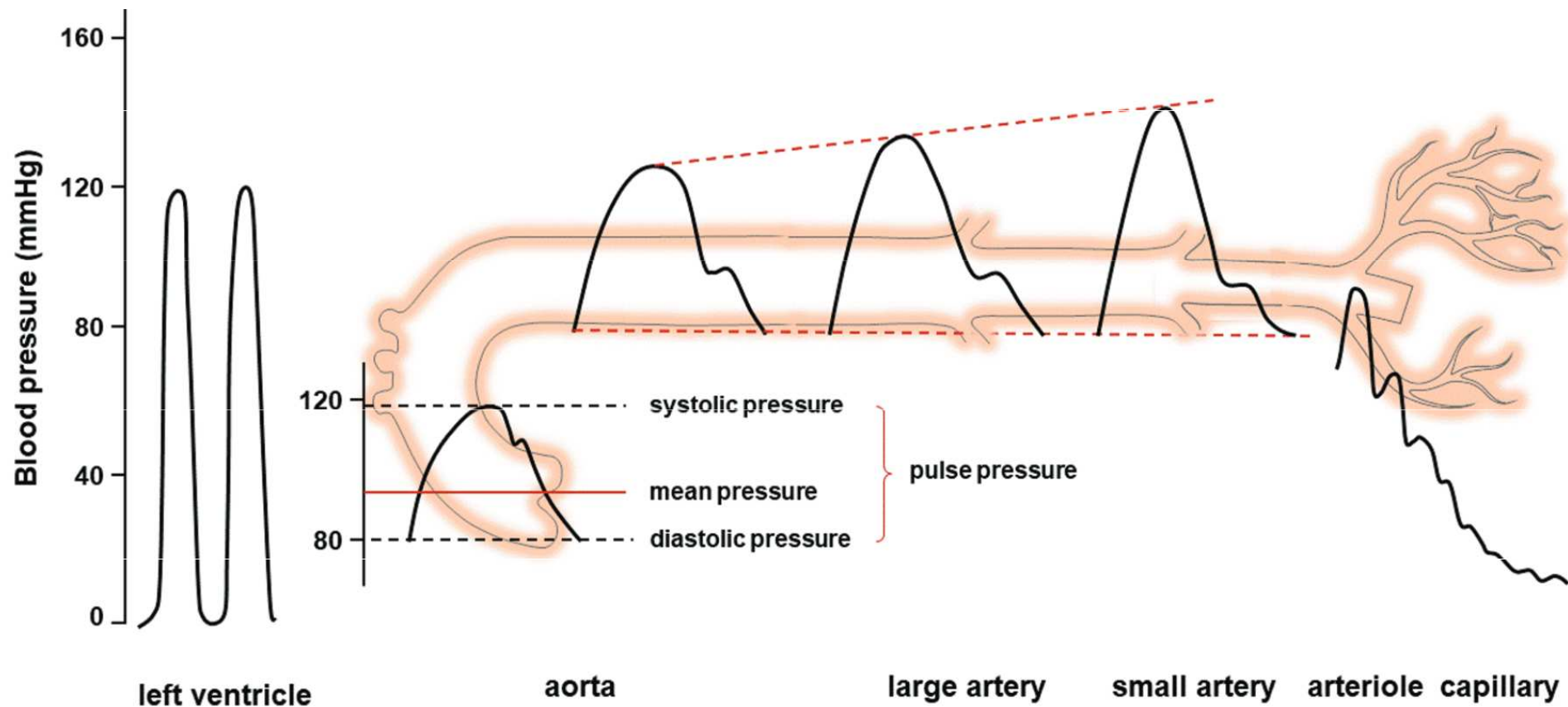


$$PP = SBP - DBP$$

$$mBP = DBP + 1/3PP$$

$$AP = P_2 - P_1$$

Pulse wave at different vascular segments

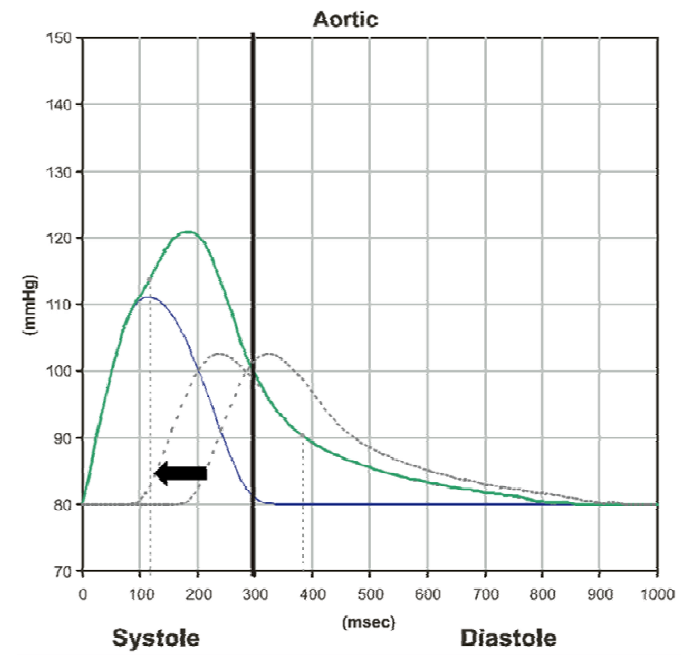
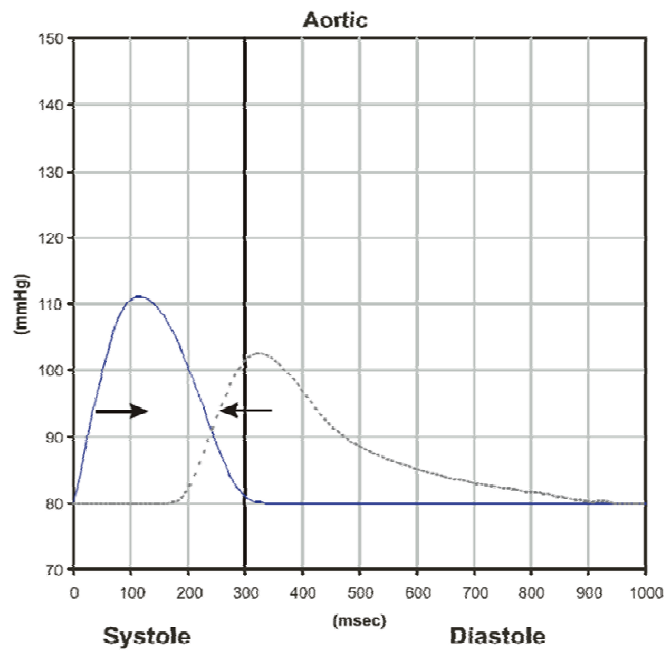


Sex differences in mechanisms of arterial stiffness

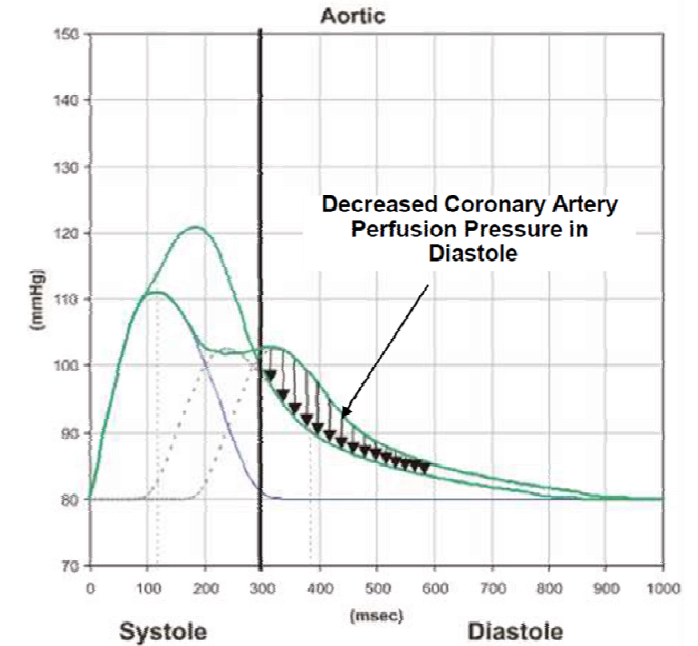
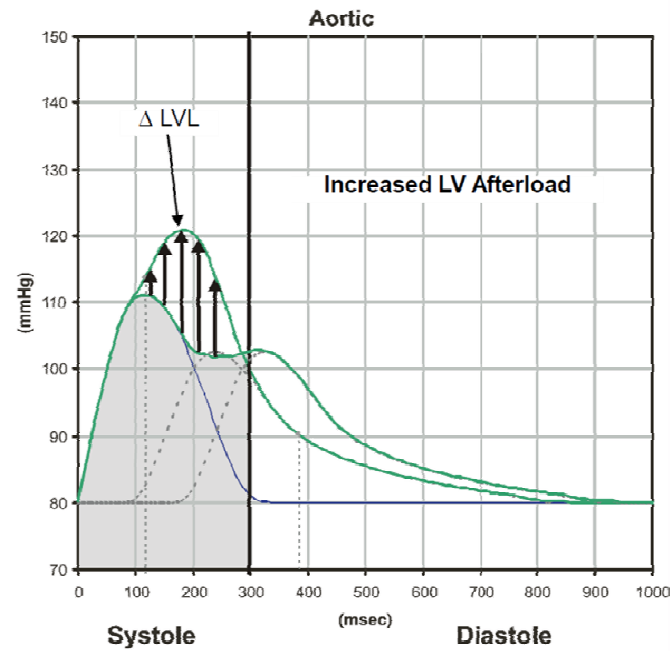
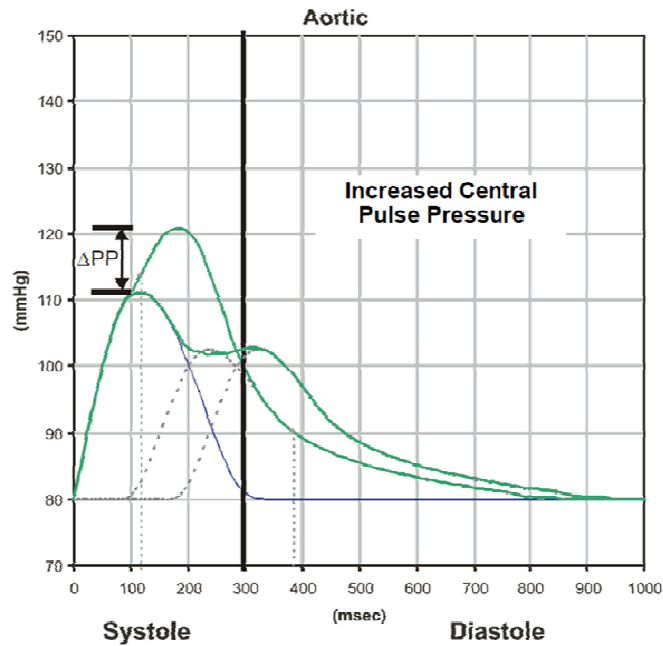
	Males	Females
Mechanism	Relevant pathways	
ECM alterations	↑ Collagen ↓ Elastin	↑ Collagen
VSMC stiffening	↑ β1-integrin ↑ Rho kinase	Unknown
Oxidative stress	↑ Superoxide ↑ Mitochondrial-derived ROS ↑ NADPH-oxidase	↑ Superoxide ↑ eNOS uncoupling via BH(4) reductions
Inflammation	↑ NF-κB ↑ T-cell activation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

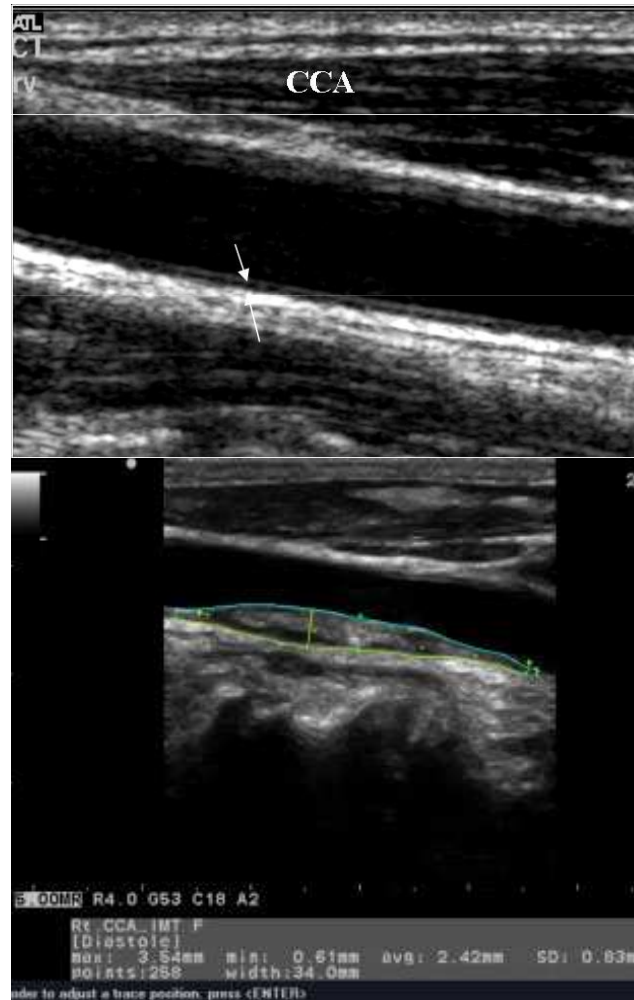
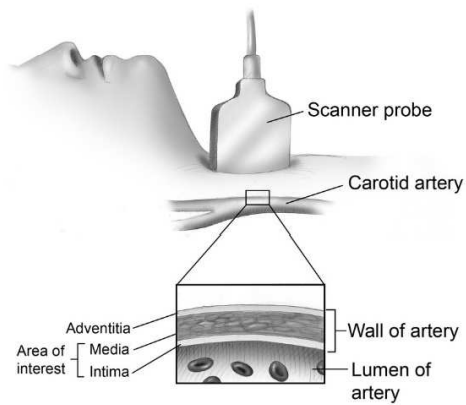
Pressure wave reflection



Pressure wave reflection

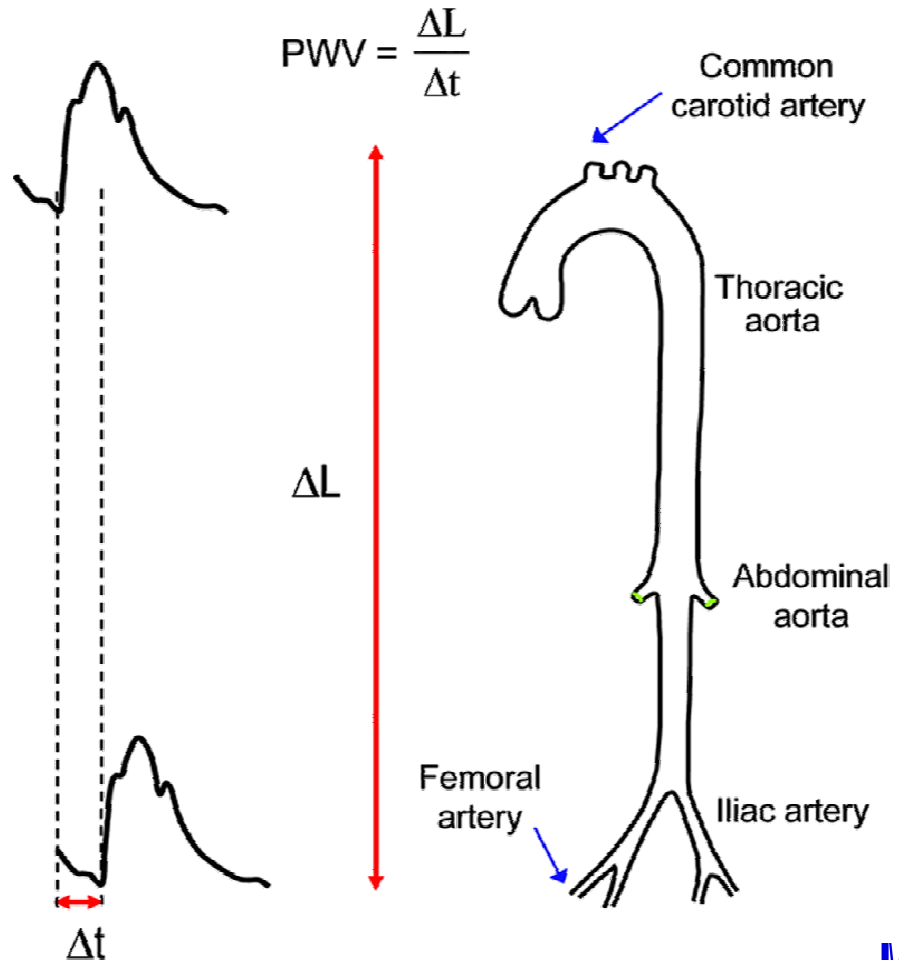
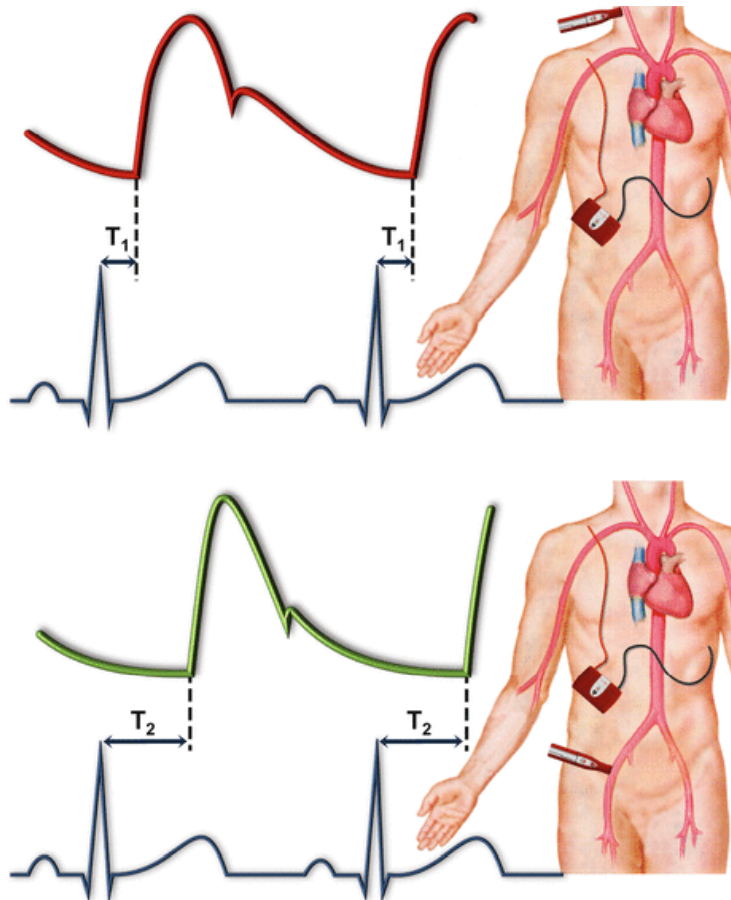


Ultrasound measurement



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

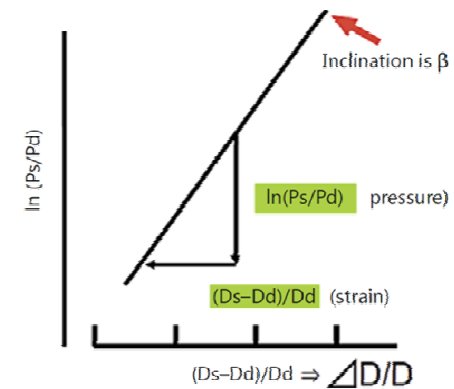
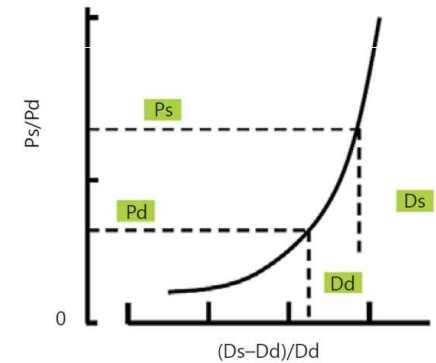
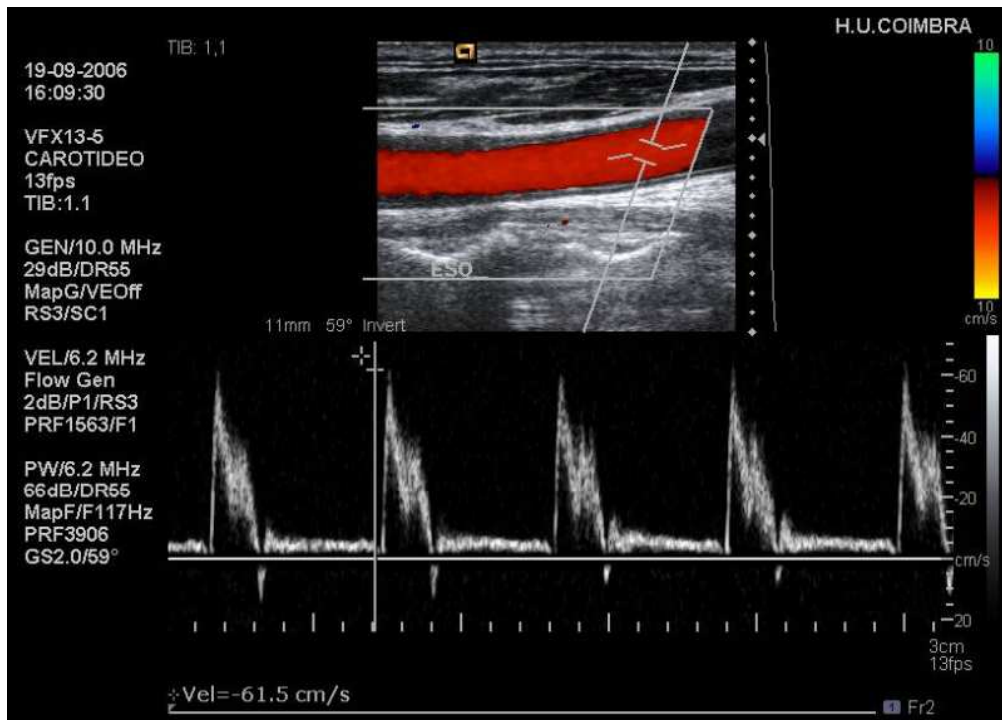
PWV measurement



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

Ultrasound measurement (β – index).

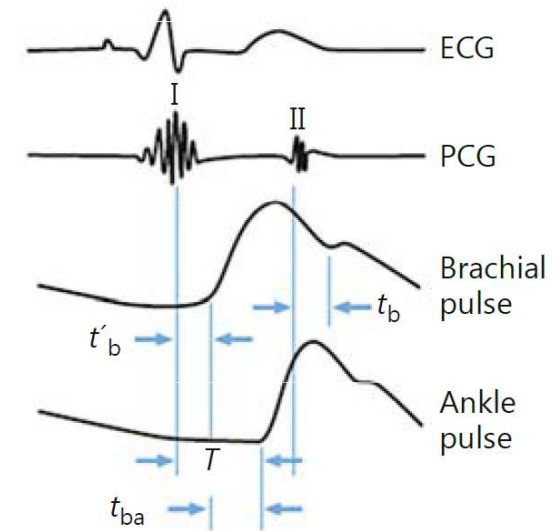
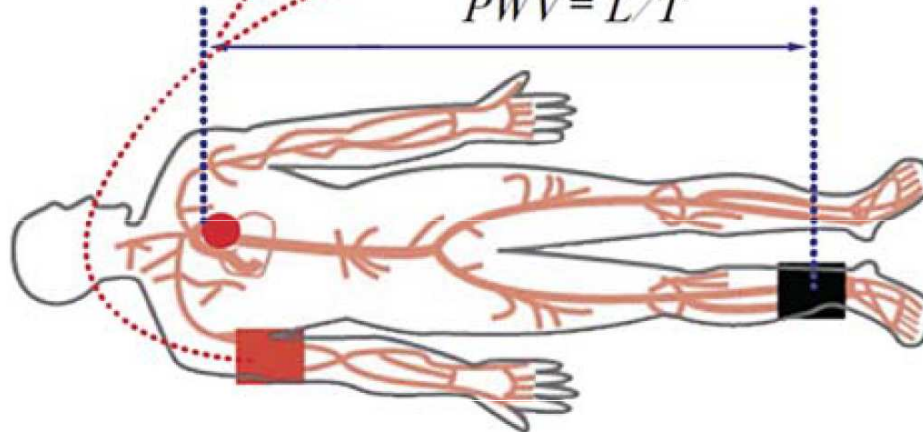
$$\beta = \left(\ln \frac{P_s}{P_d} \right) \left(\frac{D}{\Delta D} \right)$$



CAVI measurement

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

$PWV = L/T$



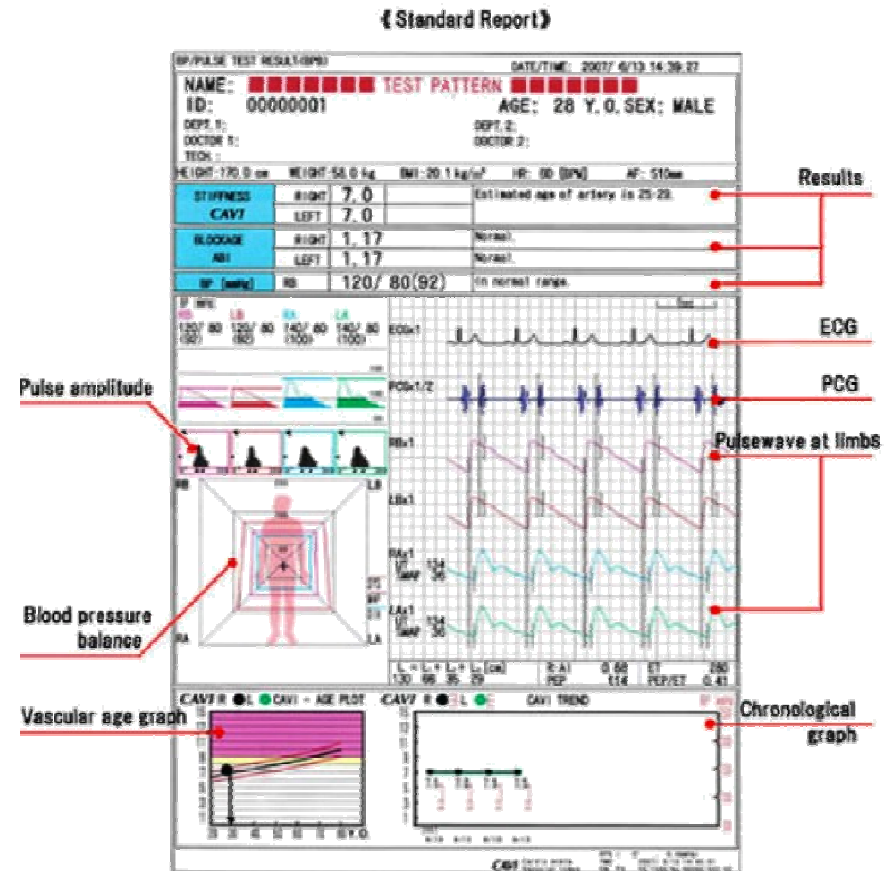
Reference value of CAVI

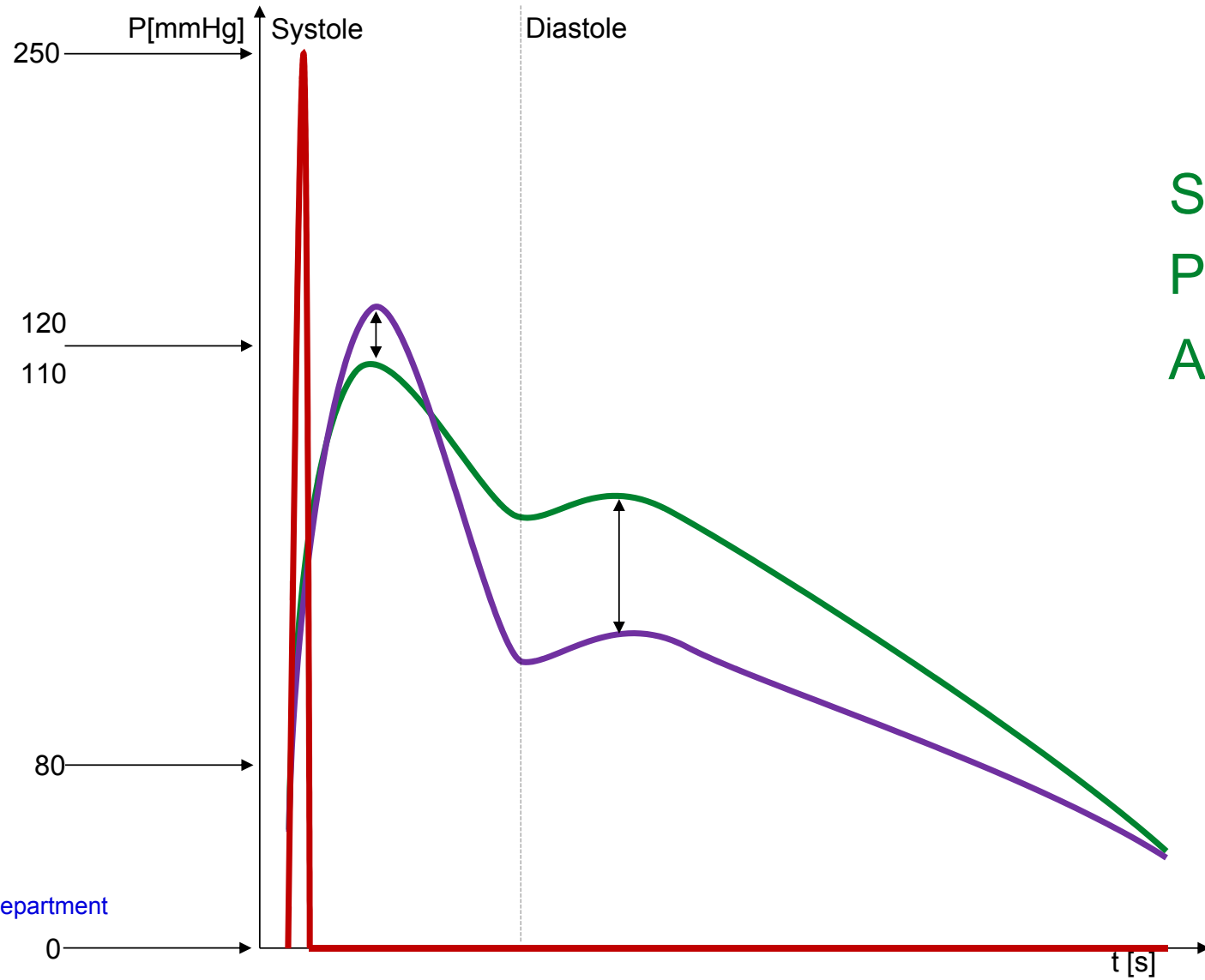
CAVI < 8.0	Normal range
$8.0 \leq CAVI < 9.0$	Borderline
$9.0 \leq CAVI$	Arteriosclerosis suspected

CAVI measurement



15 Physiology department





SBP < SBP

$P_2 > P_2$

AP < AP

Thank you for your attention

