LATIUM CLINICAL SEMINAR

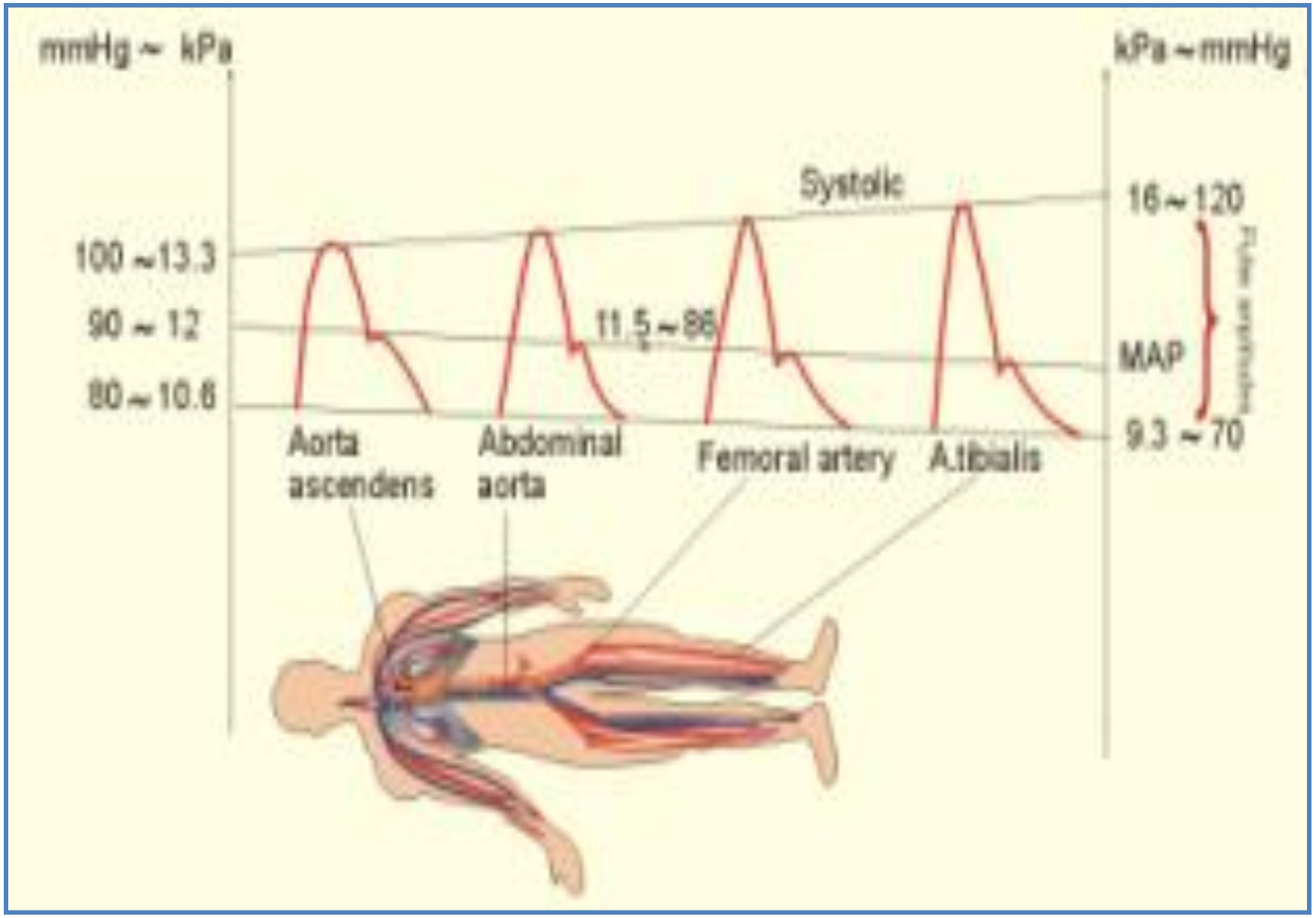
Roma Policlinico Umberto I

21 aprile 2012

Il danno vascolare: la rigidità arteriosa

Vascular damage: arterial stiffness

Giuseppe Germanò


mmHg ~ kPa
kPa ~ mmHg
Systolic
16 ~ 120
100 ~ 13.3
90 ~ 12
11.5 ~ 86
MAP
80 ~ 10.6
9.3 ~ 70
Aorta ascendens
Abdominal aorta
Femoral artery
A.tibialis

2007 ESH/ESC Hypertension Guidelines

Factors influencing prognosis: SUBCLINICAL ORGAN DAMAGE

- Electrocardiographic LVH (Sokolow-Lyon >38 mm; Cornell >2440 mm*ms).
- Echocardiographic LVH (LVMI M 125 g/m2, W 110 g/m2).
- Carotid wall thickening (IMT>0.9 mm) or plaque.
- Carotid-femoral pulse wave velocity >12 m/s.
- Ankle/brachial BP index <0.9.
- Slight increase in plasma creatinine: M: 115–133 mmol/l (1.3–1.5 mg/dl); W: 107–124 mmol/l (1.2–1.4 mg/dl).
- Low estimated glomerular filtration rate by MDRD formula (<60 ml/min/1.73m2) or creatinine clearance by Cockroft Gault formula (<60 ml/min).
- Microalbuminuria 30–300 mg/24 h or albumin-creatinine ratio: 22 (M); or 31(W) mg/g creatinine.

J Hypertens 2007;25:1105–1187

Arterial Stiffness

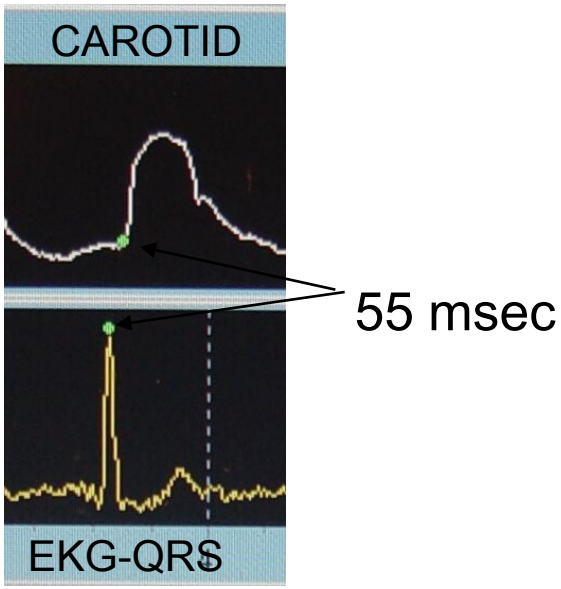
Esistono tre processi separati responsabili dell'aumento della rigidità arteriosa:

- Modificazione strutturale delle fibre di elastina
  - Si presenta soprattutto nell'aorta
  - Legata all'avanzamento dell'età (milioni di cicli cardiaci)
- Danno alla funzione endoteliale
  - Si presenta soprattutto nella muscolatura liscia delle arterie
  - Legata all'avanzamento delle patologie (es. Diabete di tipo 2, ipercolesterolemia, aterosclerosi)
- Aumento della pressione arteriosa media
  - Si presenta sistematicamente in tutto il sistema arterioso

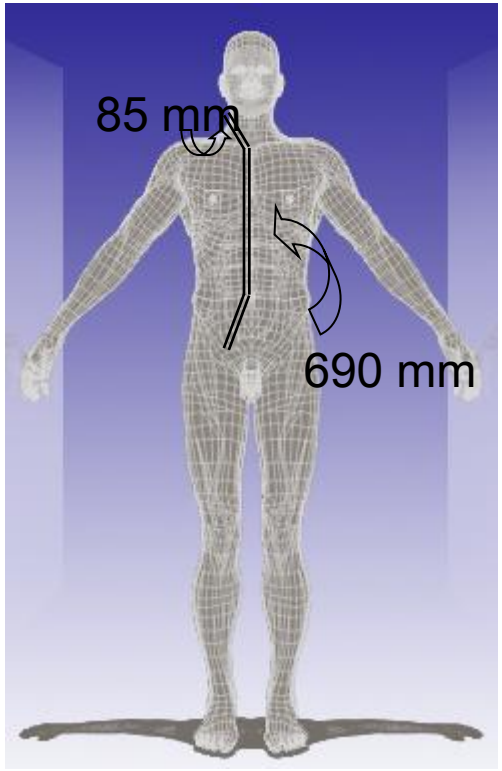
Measures of Arterial Stiffness

- Central Aortic Pressure
- Pulse Wave Velocity (PWV)
- Augmentation Index (AIx)

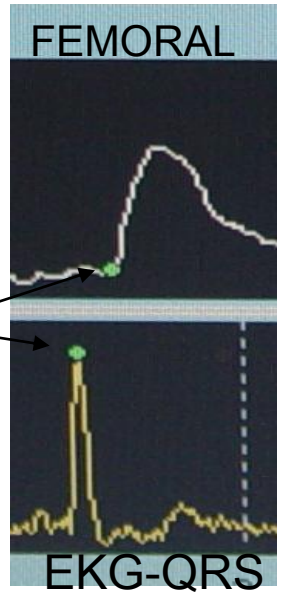
How PWV is measured...



55 msec



135 msec



Velocity = Distance/Time

QRS-carotid	QRS-femoral	△ time	Notch-carotid	Notch-femoral	△ distance	Aortic PWV (△distance/△tim
55 msec	135 msec	80 msec	85 mm	690 mm	605 mm	7.6 m/sec

e)

APWV measurement (cont.)

"…studies clearly demonstrate that PWV and the augmentation index are associated with the structural changes of atherosclerosis"

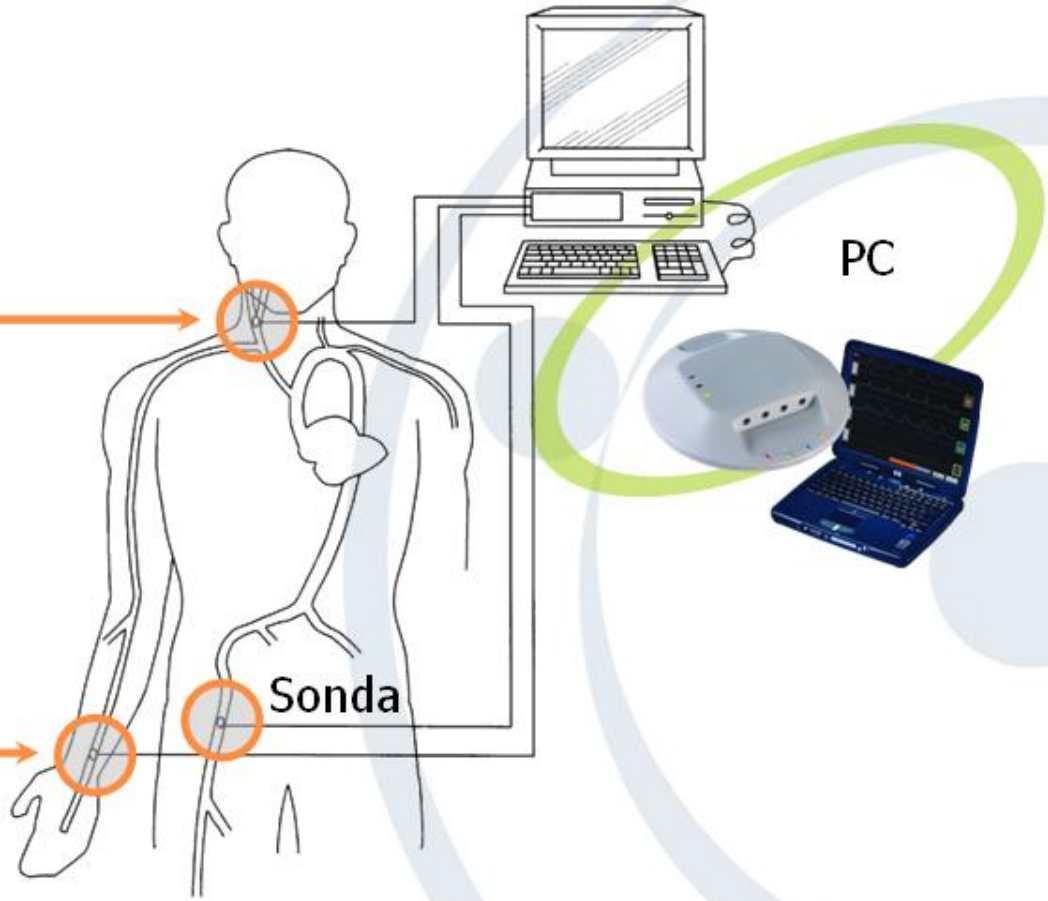
Davies, J.I., J Hypertens 21:463-472; 2003

- Pulse Wave Velocity (PWV)
  - Complior (Carotid-Femoral PWV)
  - SphygmoCor (Applanation Tonometry)
  - Tensiomed Arteriograph
- Augmentation Index (Aix)
  - SphygmoCor (Applanation Tonometry)
  - Tensiomed Arteriograph
- Central Blood pressure (SBP, PP)
  - SphygmoCor (Applanation Tonometry)
  - Tensiomed Arteriograph

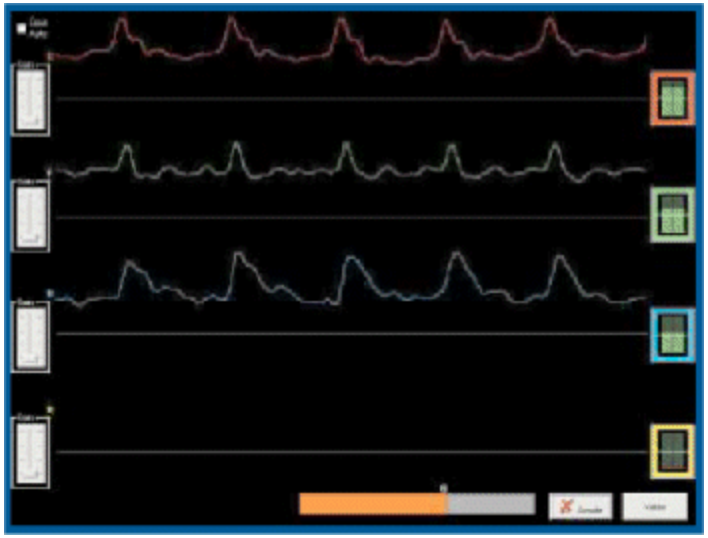
Velocità dell'onda pulsatoria

Sonda

Sonda



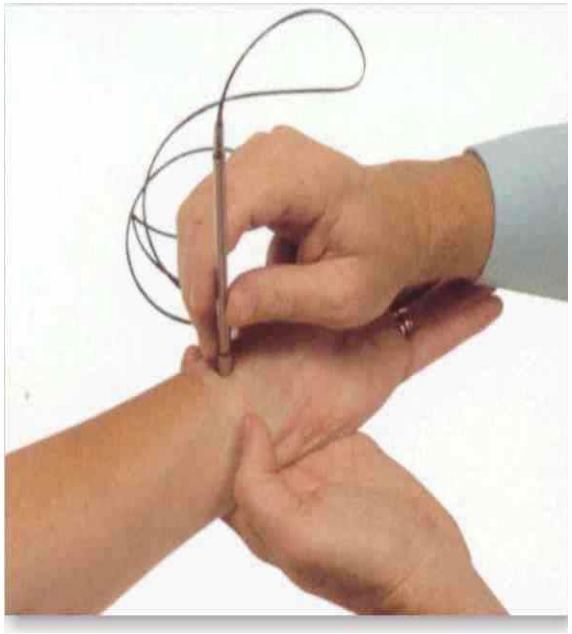
PULSE WAVE VELOCITY

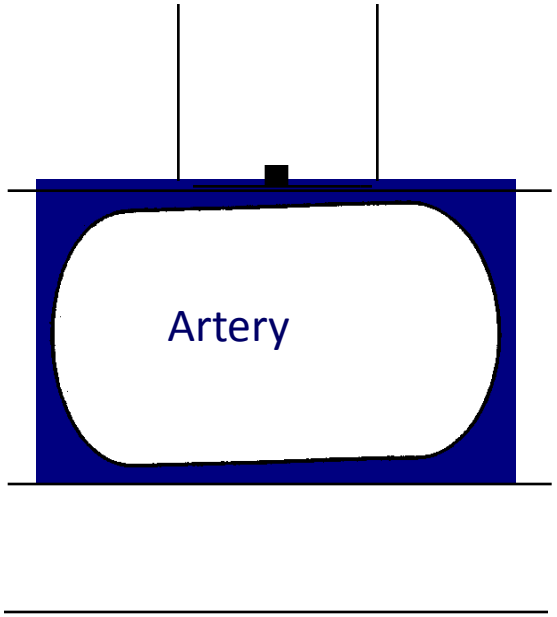


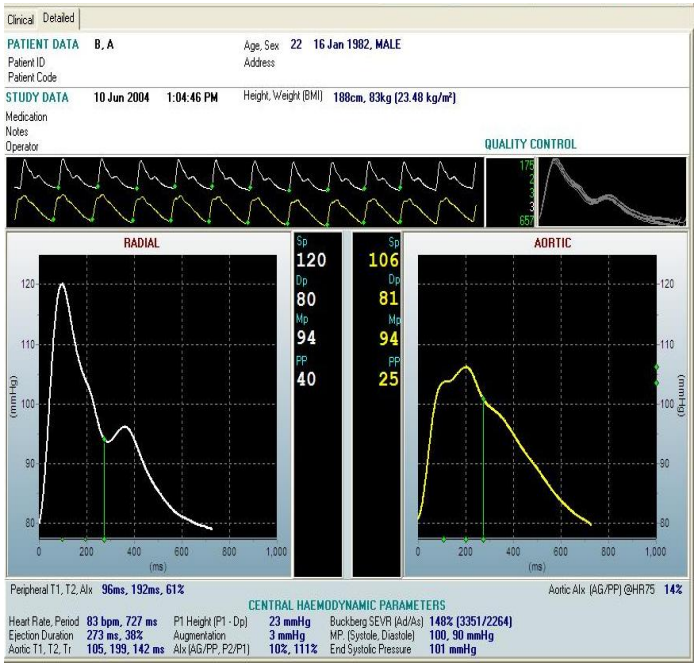
PULSE WAVE VELOCITY

Augmentation Index (Aix)

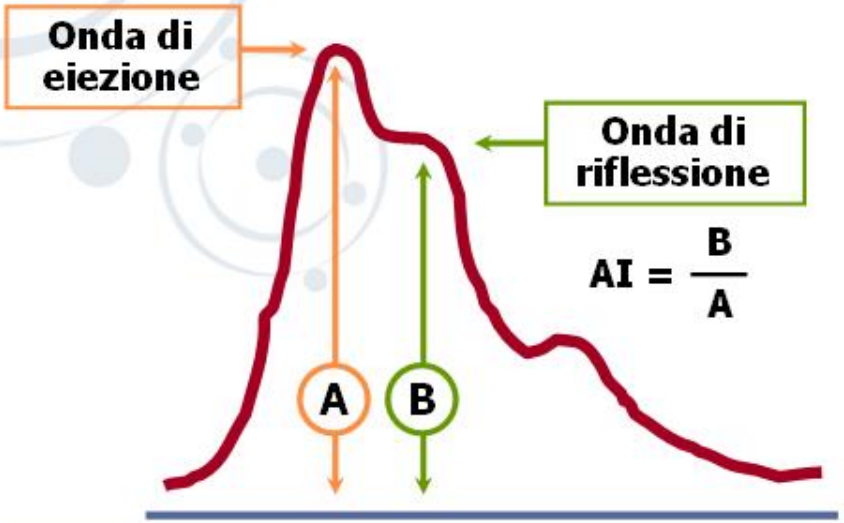
The SphygmoCor device





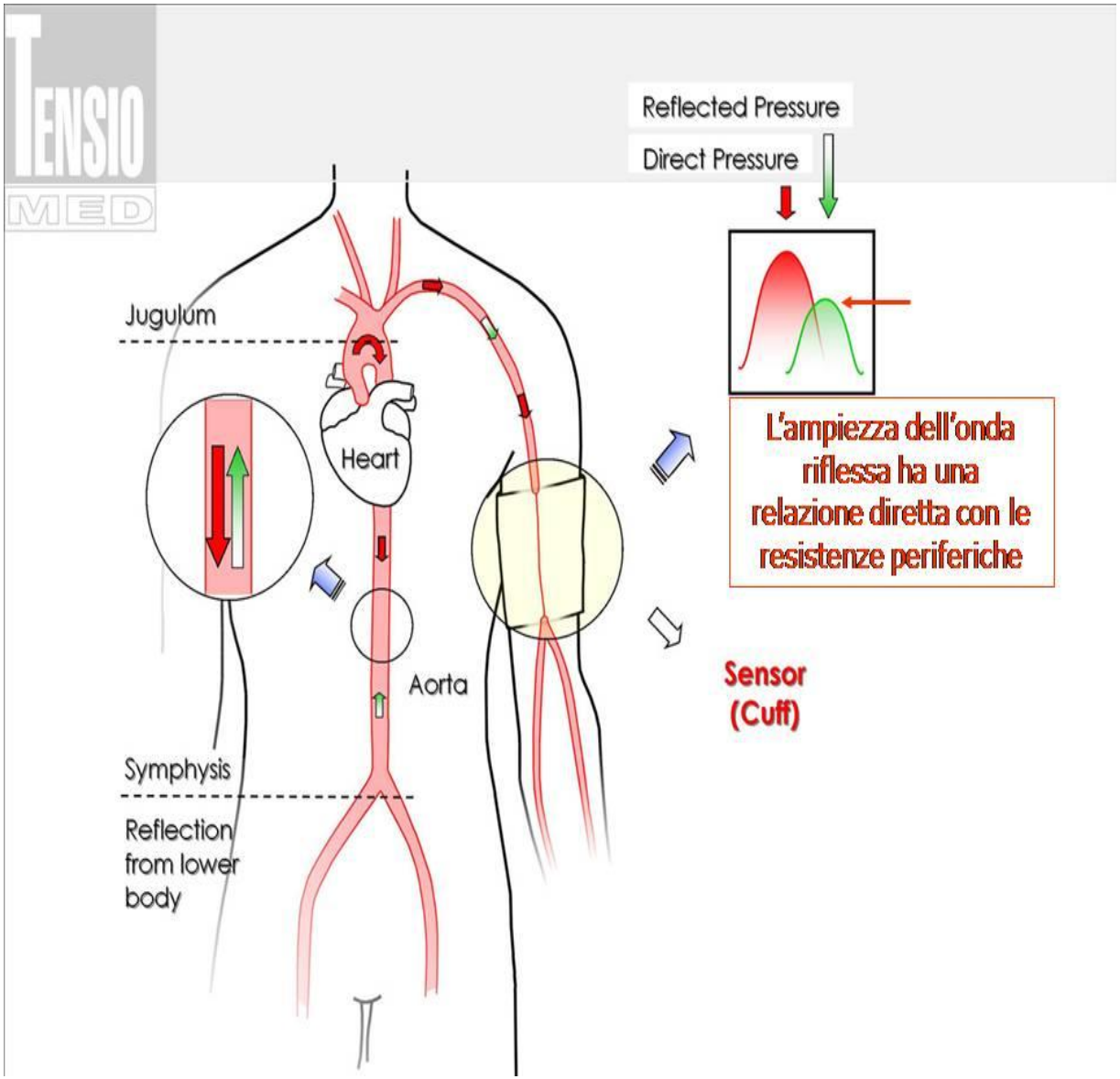


Augmentation Index (AI)

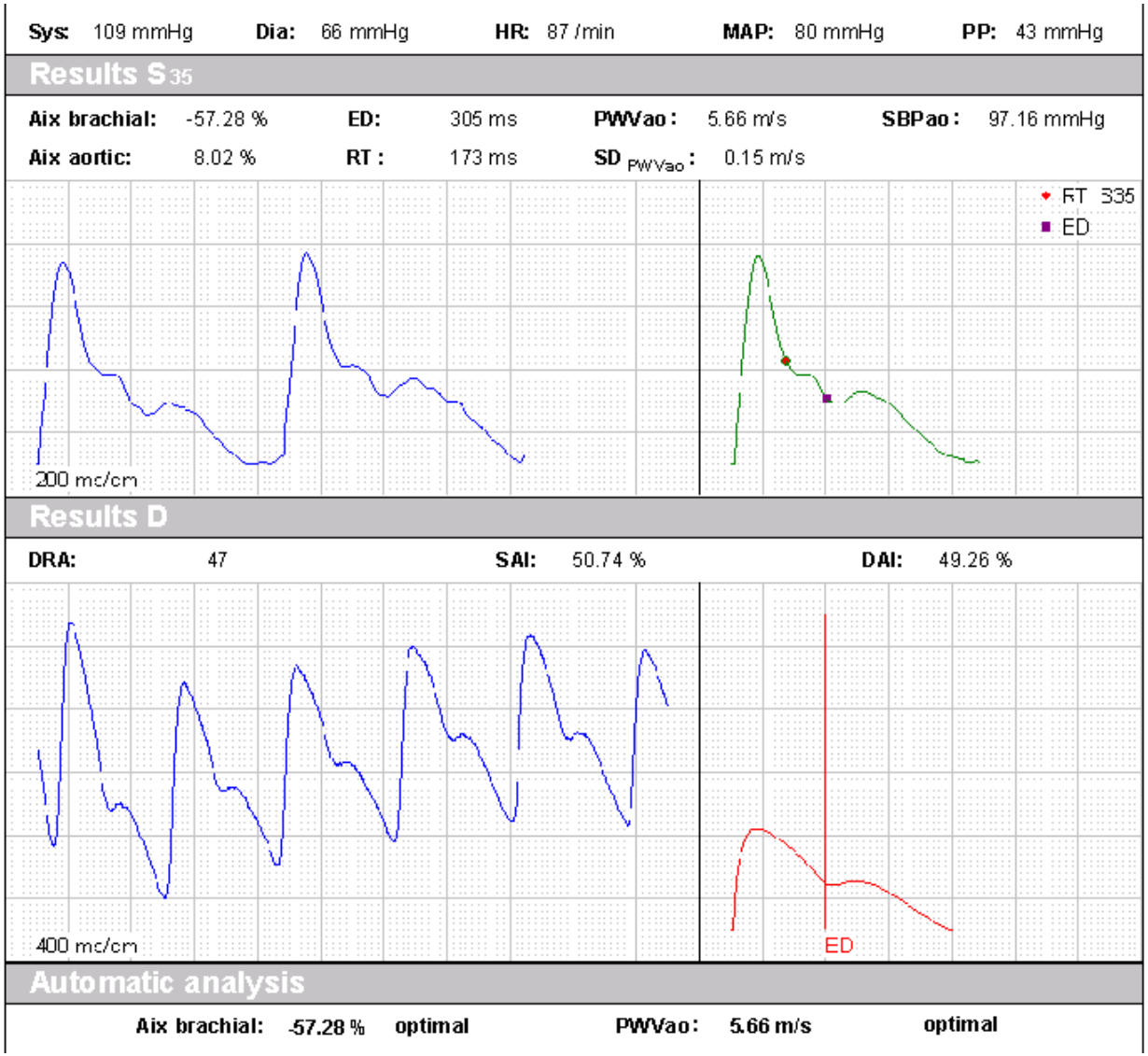


THE AUGMENTATION INDEX (Aix)

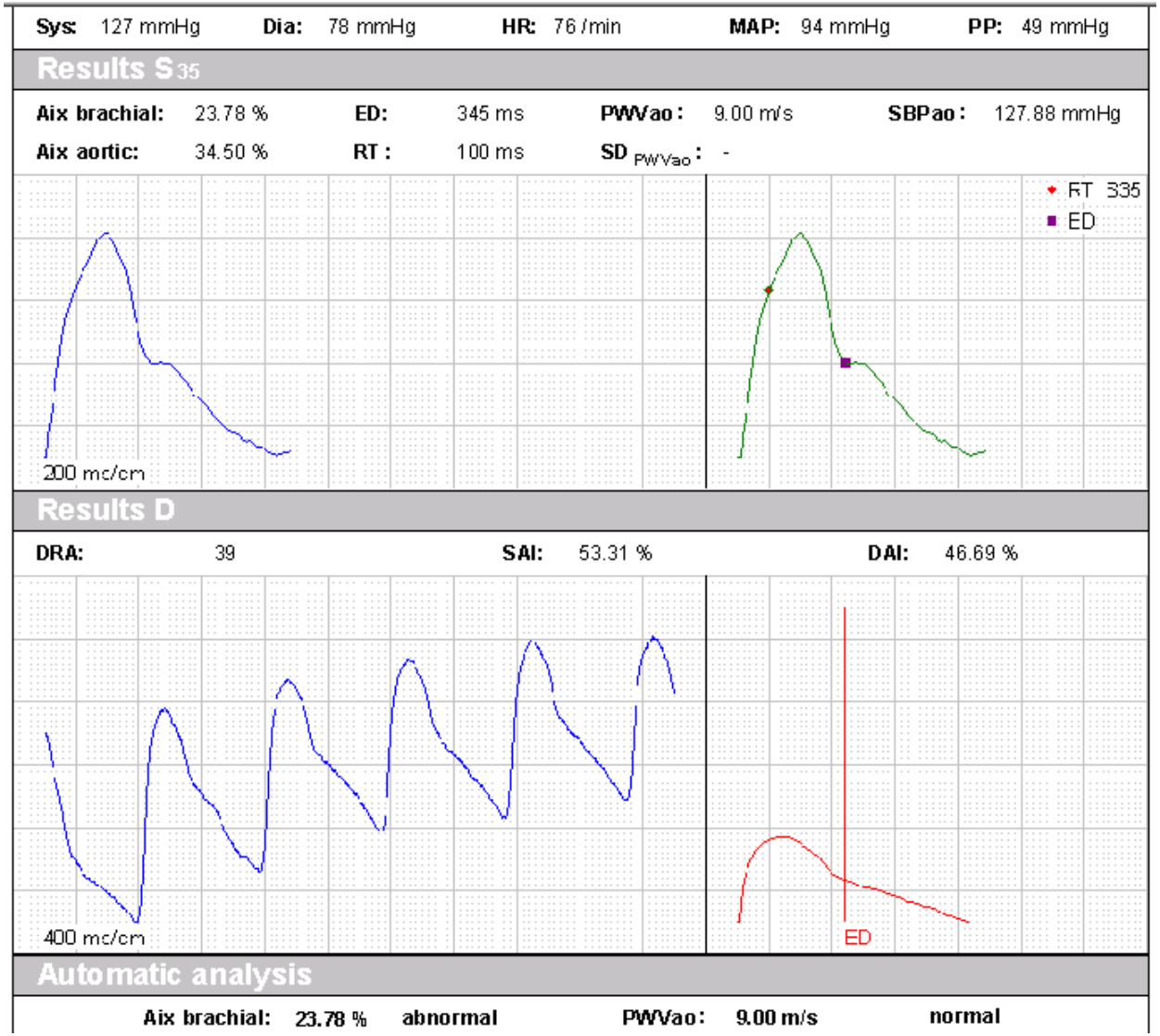
Augmentation index (Aix %) = (P2 – P1 / PP) x 100



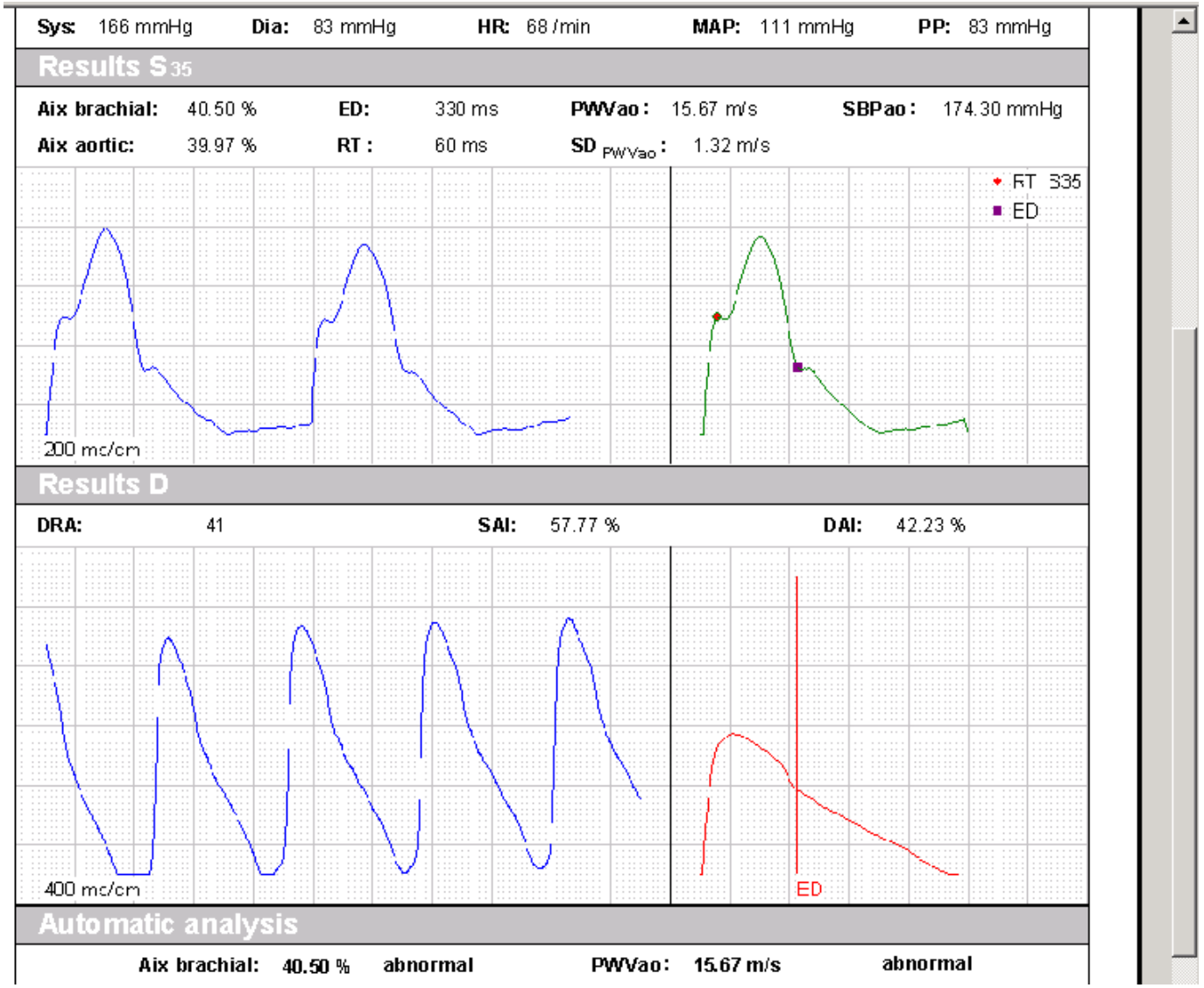
Subject 30 y old



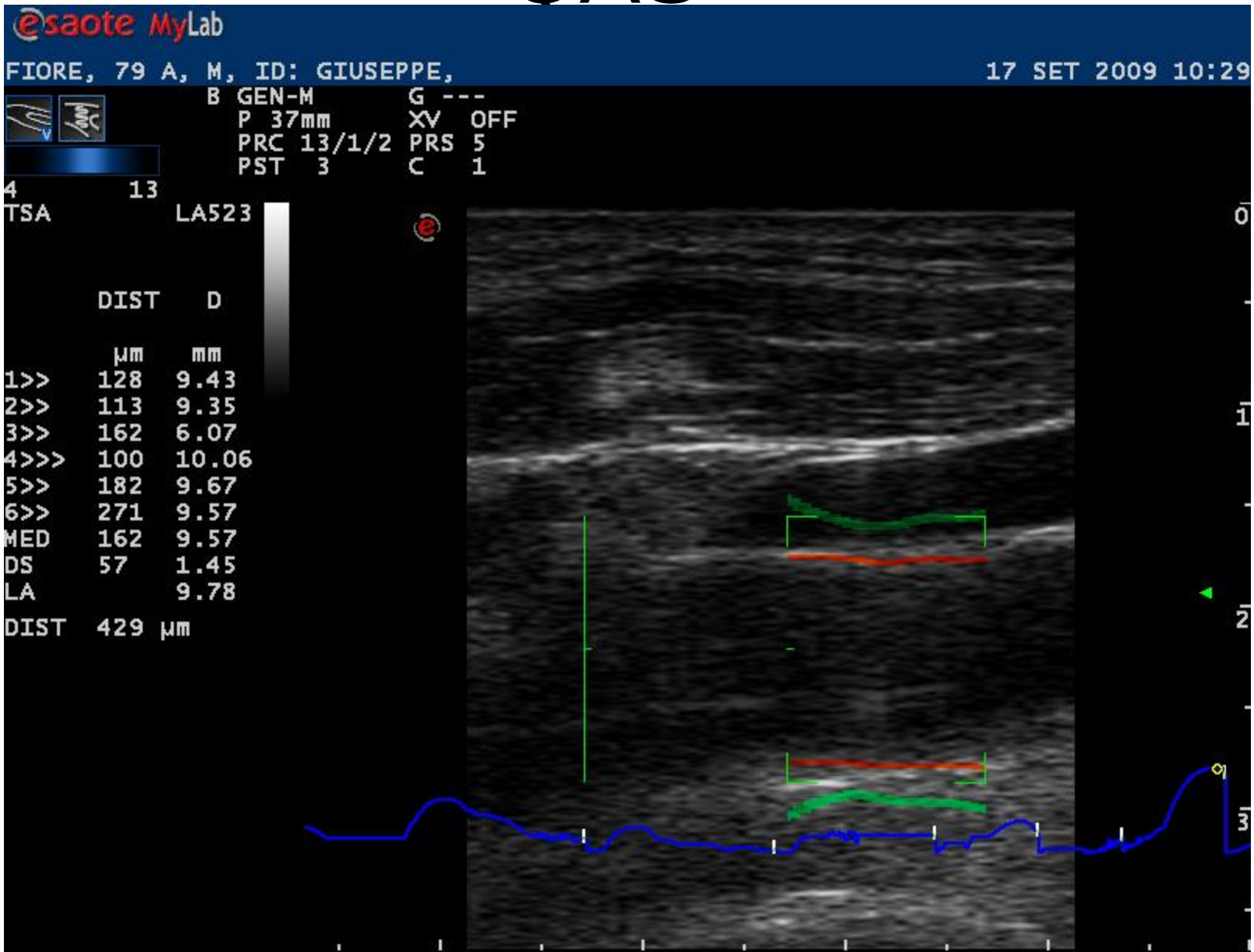
Subject 60 year old

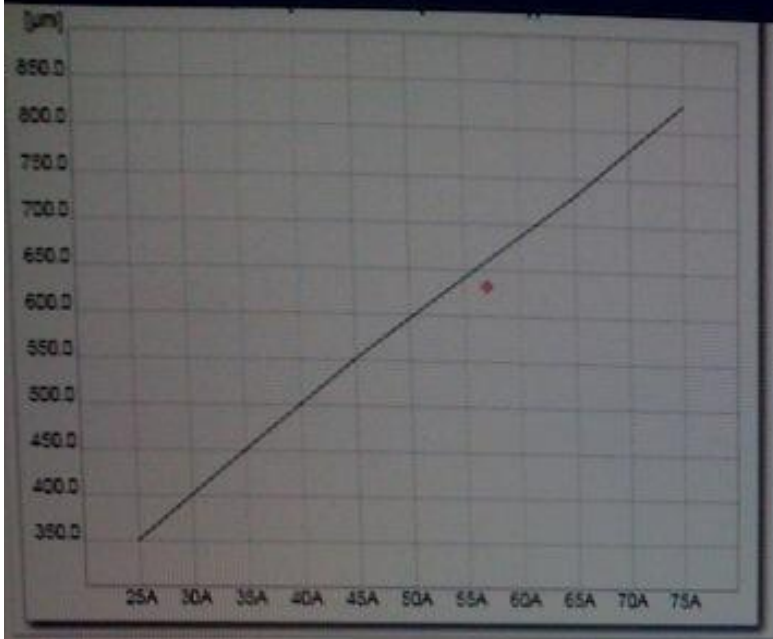


Subject 90 y old



OAS


esaote MyLab
FIORE, 79 A, M, ID: GIUSEPPE,
17 SET 2009 10:29
B GEN-M
G ---
P 37mm
XV OFF
PRC 13/1/2
PRS 5
PST 3
C 1
4
13
TSA
LA523
DIST
D
µm
mm
1>> 128 9.43
2>> 113 9.35
3>> 162 6.07
4>>> 100 10.06
5>> 182 9.67
6>> 271 9.57
MED 162 9.57
DS 57 1.45
LA 9.78
DIST 429 µm
0
1
2
3



QIMT S

QIMT S :	607	µm

QIMT D

QIMT D :	631	µm

QIMT (RF)

QIMT (RF) :	631	µm
DS :	4	µm
DIAMETRO :	6.7	mm
DS :	0.03	mm
LARGHEZZA :	10.1	mm
TABELLA QIMT:	HOWARD (BIANCA)	
QIMT PRESUNTO:	658	µm

QAS ACC SIN

DISTENSIONE :	515	µm
DS :	55	µm
DIAMETRO :	6.60	mm
DS :	0.07	mm
PR BR sis :	145.0	mmHg
PR BR dia :	95.0	mmHg

CALCOLI

V PW:	5.68	m/s

QAS ACC DES

DISTENSIONE :	325	µm
DS :	69	µm
DIAMETRO :	6.88	mm
DS :	0.10	mm

CALCOLI

V PW:	7.81	m/s

Aortic Stiffening and Early Wave Reflection

Young compliant arteries : Normal PW velocity (8 m/sec)

Diastole

(1) Ventricular-Vascular coupling

(2) ↑ coronary blood flow

Elderly stiff arteries with ISH : Increased PW velocity (12 m/sec)

Systole

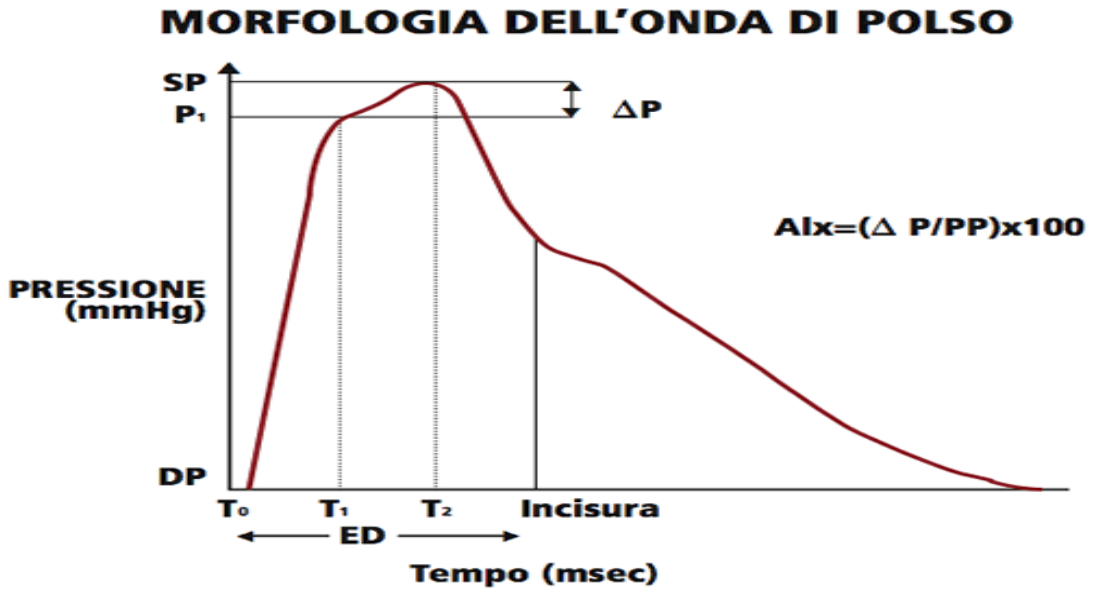
(1) Ventricular-vascular mismatch

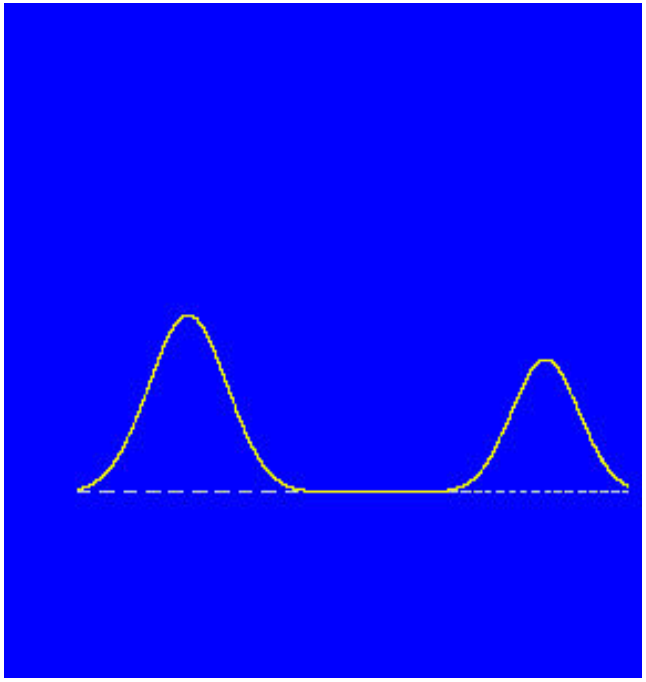
(2) The reflected wave increases or “augments” central SBP during late systole:

THE AUGMENTATION INDEX (Aix)

E' DEFINITO COME LA DIFFERENZA TRA IL SECONDO (ONDA RIFLESSA) ED IL PRIMO PICCO (ONDA INCIDENTE) ED ESPRESSO COME PERCENTUALE DELLA PRESSIONE DIFFERENZIALE.

Augmentation index (Aix %) = (P2 – P1 / PP) x 100





ONDA DI POLSO: ONDA INCIDENTE + ONDA RIFLESSA

AIX È UN INDICE INDIRETTO DELLA RIGIDITA AORTICA, RAPPRESENTA L'EFFETTO DELL'ONDA RIFLESSA SULL'ONDA INCIDENTE A LIVELLO DELL'AORTA ASCENDENTE.

È UNA MISURA DEL CARICO ADDIZIONALE A CUI IL Vsx È SOTTOPOSTO A CAUSA DELL'ONDA DI RIFLESSIONE.

SphygmoCor

- **Arterial stiffness measures**
  - **CBP (central BP)**
  - **AIX (Augmentation Index)**
  - **PVW(Pulse wave velocity)**

- ? Evidence to change management?
- Does depend on accurate peripheral blood pressure measurement eg: BPtru / manual BP
- How to incorporate it with out interfering with the work flow?

Vantaggi dell'Augmentation Index

- L'AI aumenta in tutte quelle condizioni in cui vi è un'alterazione strutturale e funzionale dell'arteria: diabetici, dislipidemici, coronaropatici, pazienti con ipertrofia ventricolare sinistra ed ipertesi
- L'AI aumenta con l'età, nei pazienti fumatori e con fattori di rischio CV
- Un aumento dell'AI si associa ad una maggiore mortalità
- È facile da misurare con apparecchi adatti
- L'AI, a differenza della PWV, non dipende dalla sede della misurazione (che può essere anche periferica)

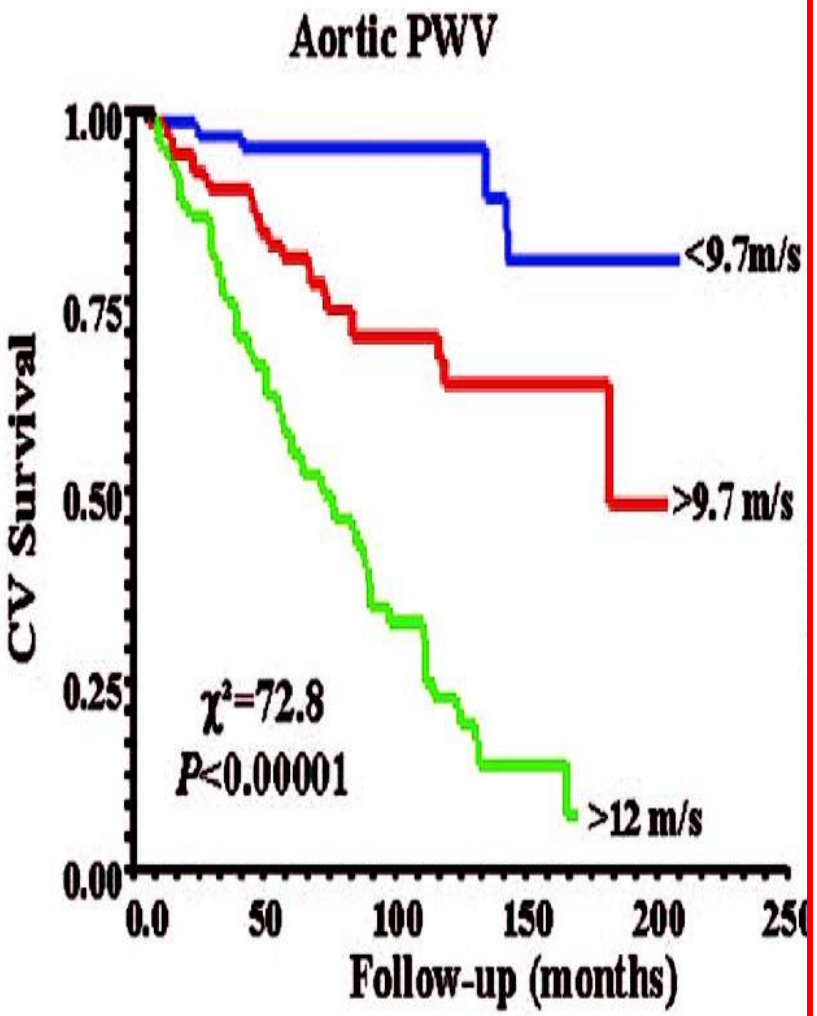
First author (year; country)	Events	Follow-up (years)	Type of patient (number)	Mean age at entry (years)
Aortic PWV – YES				
Blacher (1999;Fr)	CV mortality	6,0	ESRD (241)	51
Laurent (2001;Fr)	CV mortality	9,3	Hypertension (1980)	50
Meaume (2001;Fr)	CV mortality	2,5	Elderly (>70) (141)	87
Shoji (2001;Jp)	CV mortality	5,2	ESRD (265)	55
Boutouyrie (2002;Fr)	CHD events	5,7	Hypertension (1045)	51
Cruickshank (2002;GB)	All cause M.	10,7	Diabetes and MS (571)	51
Laurent (2003;Fr)	Fatal strokes	7,9	Hypertension (1715)	51
Sutton-Tyrrell (2005;USA)	CV events	4,6	Elderly (2488)	74

By Laurent S

First author (year; country)	Events	Follow-up (years)	Type of patient (number)	Mean age at entry (years)
Central pulse pressure				
Safar (2002;Fr)	All cause mortality	4,3	ESRD (180)	54
Williams (2006;UK)	CV events	3,4	HT, ASCOT study (2073)	63
Carotid augmentation index				
London (2001;Fr)	All cause and CV mortal	4,3	ESRD (180)	54
Weber (2005;Austria)	Severe CV events	2	Undergoing PCI (262)	66
Chirinos (2005;USA)	CV events	3,2	Undergoing PCI (297)	64
Williams (2005;UK)	CV events	3,4	HT, ASCOT study (2073)	63

PCI: percutaneous coronary intervention

By Laurent S



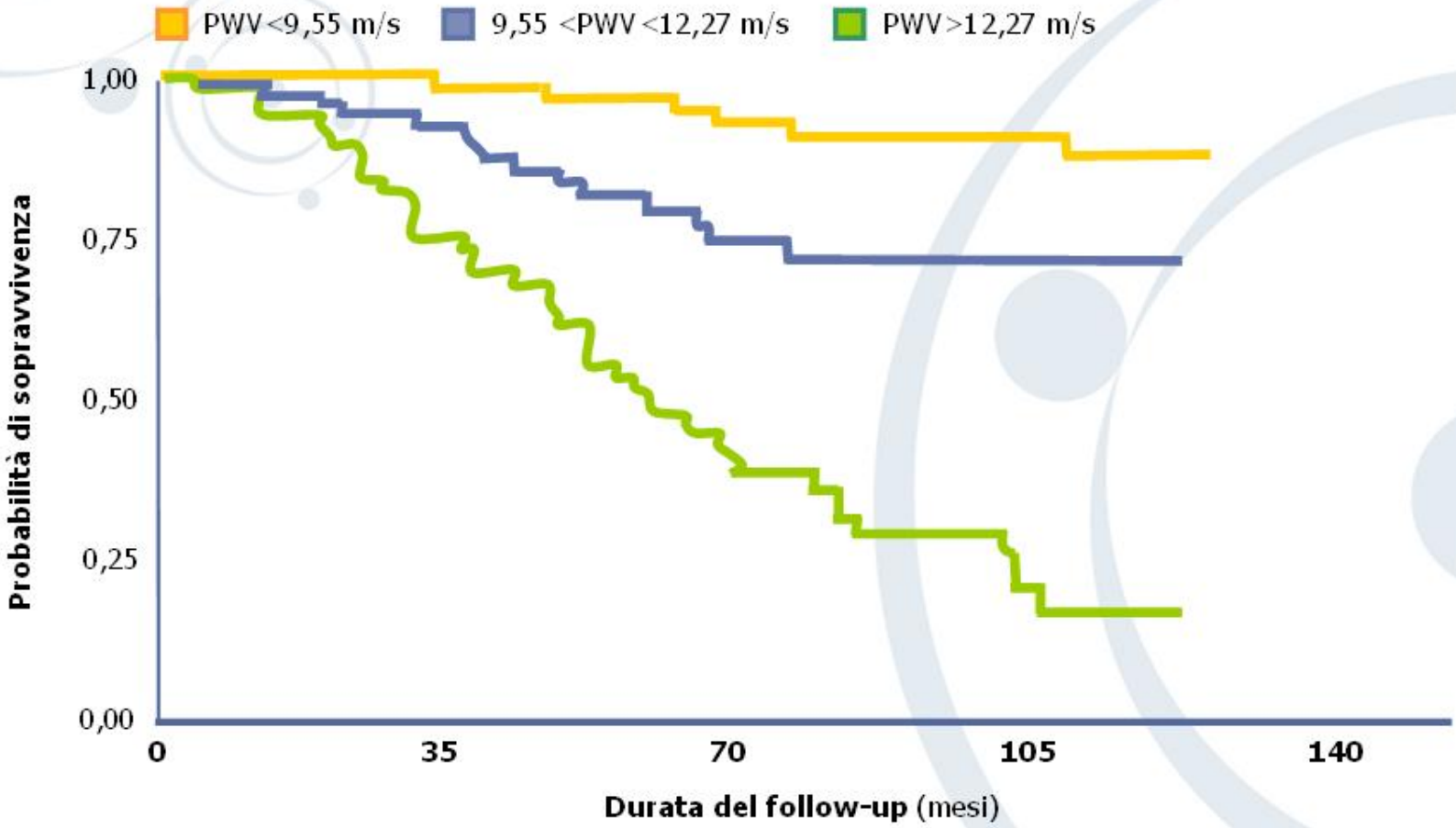
-Arterial wave reflections and survival in end stage renal failure.
London GM et al Hypertension 2001;38:434-438.

- Central pulse pressure and mortality in end stage renal failure.
Safar ME et al Hypertension 2002;39:735-738.

- Increased arterial wave reflections predict severe cardiovascular events in patient undergoing percutanous coronary interventations
Eur Heart J 2005;26:2657-2663

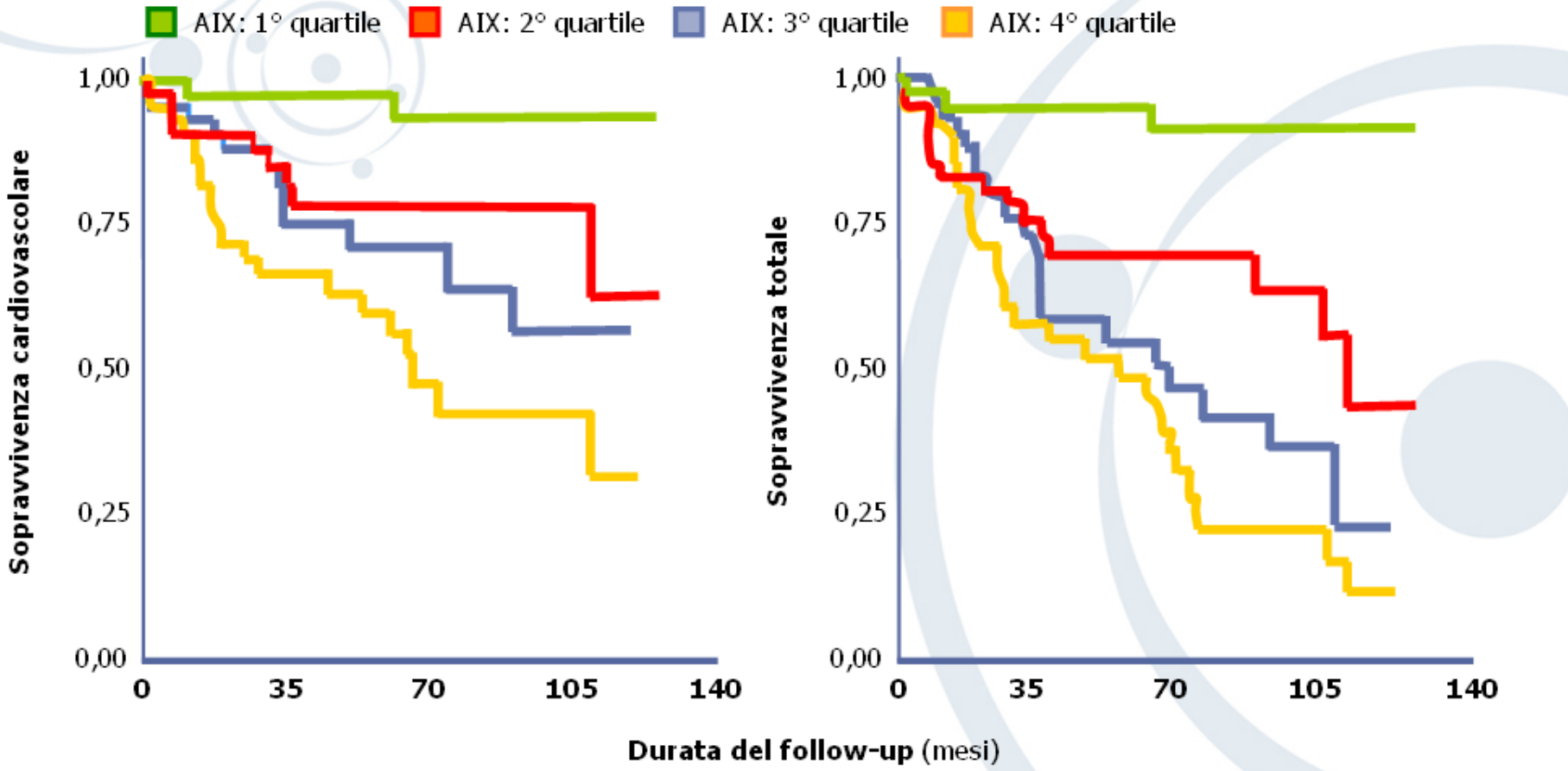
- Central pressure more strongly relates to vascular disease and outcome than does brachial pressure: the Strong Heart Study.
Roman MJ et al Hypertension 2007;50:197-203.

PWV ed eventi



Pannier B et al. Hypertension 2005; 45:592-596

AI ed eventi



London GM et al. Hypertension 2001; 38:434-438

Arterial Stiffness

PULSE WAVE VELOCITY (PWV)
AUGMENTATION INDEX (Aix)

	Aix	PWV
Ottimale	**<- 30%**	**<7m/s**
Normale	**da -30% a < -10%**	**da 7m/s a < 9.7m/s**
Aumentato	**da -10% a <10%**	**da 9.7m/s a <12m/s**
Anormale	**> 10%**	**>12m/s**

Carotid to femoral pulse wave velocity (PWV) has emerged as the gold standard method of arterial stiffness for:

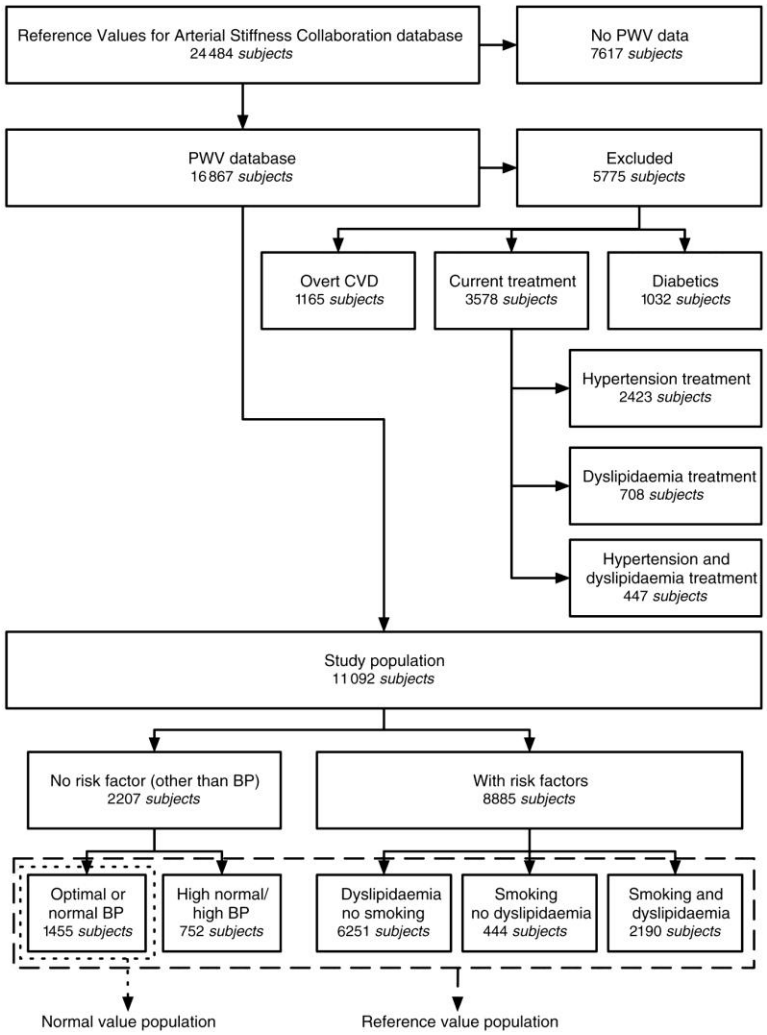
- its relative ease in determination,
- its perceived reliability

and because of :

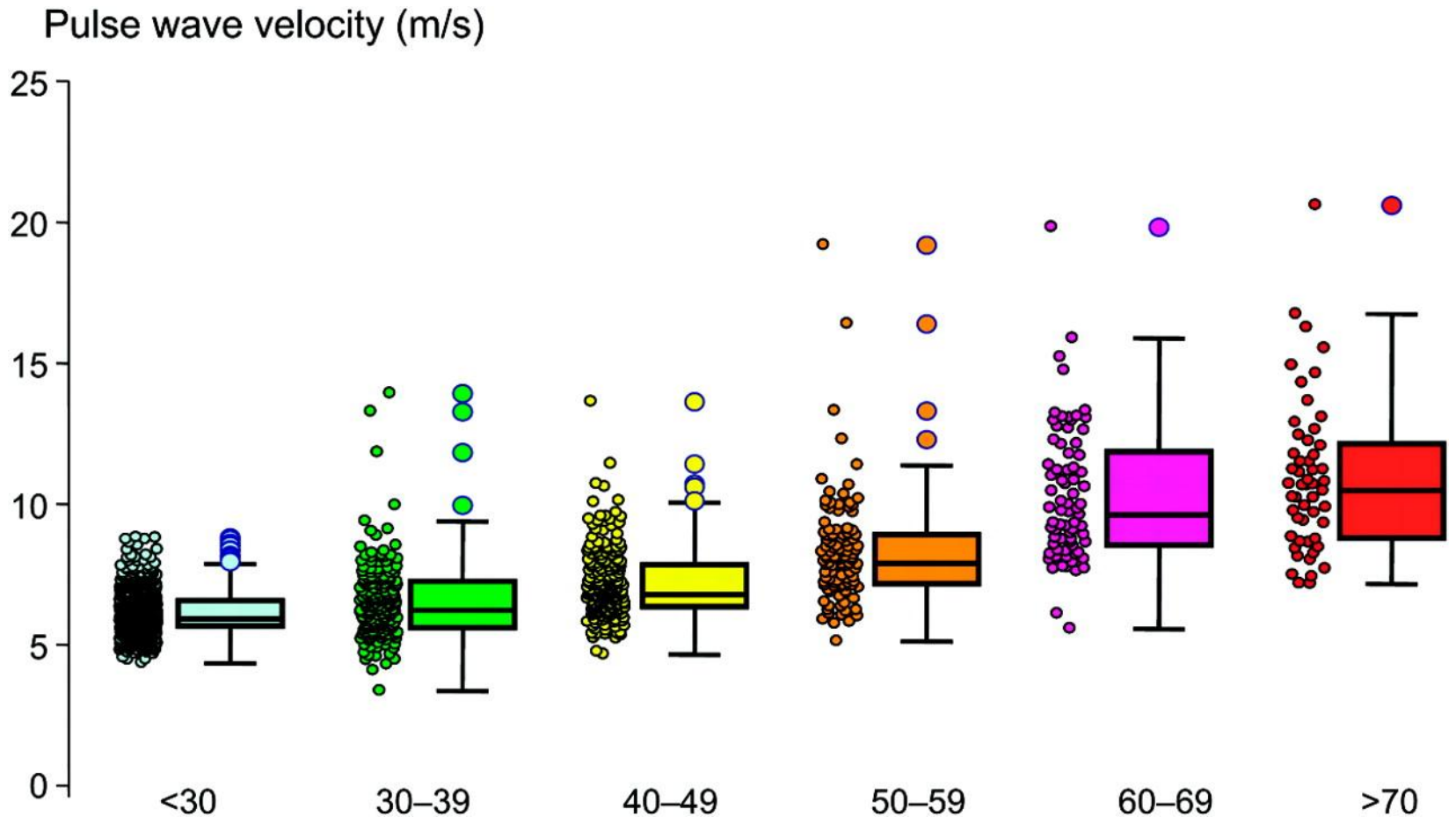
- its association with incident CV disease

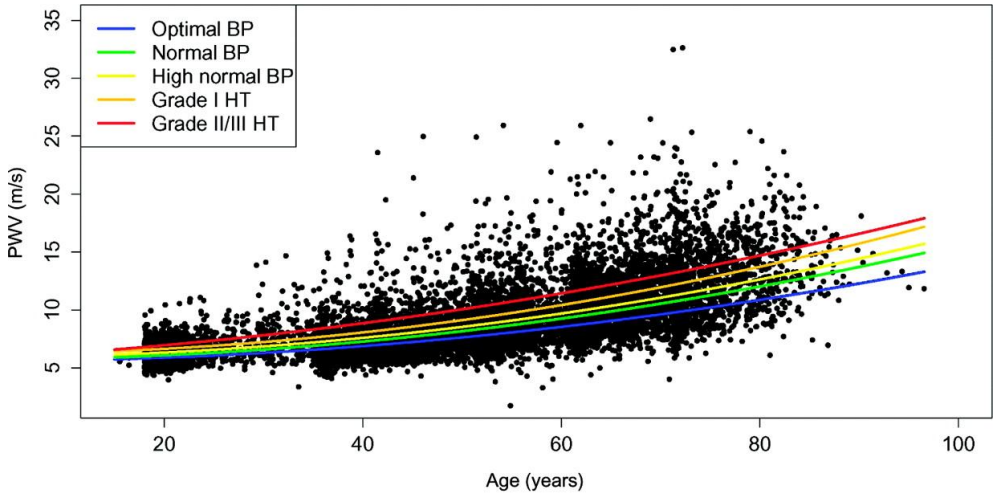
independently of traditional risk factors

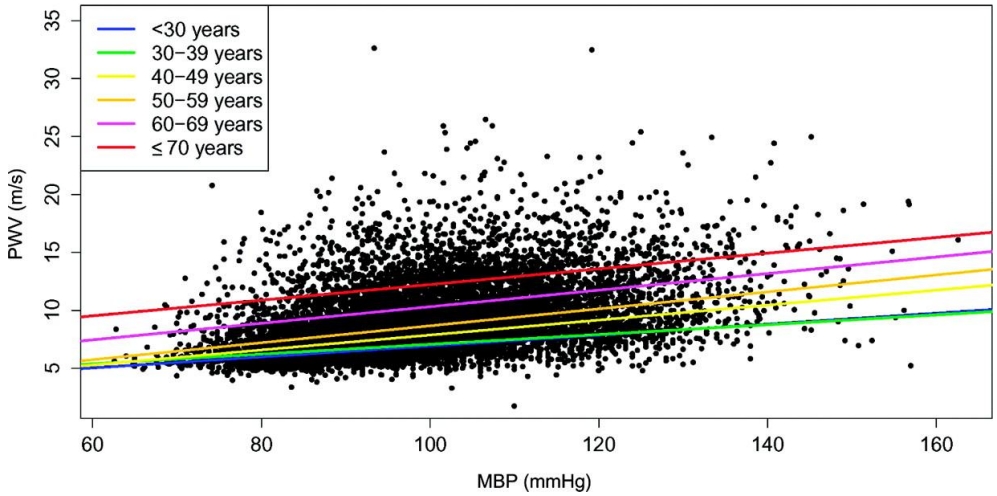
- The fixed threshold value (12 m/s) proposed in the 2007 ESH/ESC hypertension guidelines was based on published epidemiological studies but could not take into account the multiple factors influencing PWV
- it has been proven that important differences in absolute PWV values exist between methodologies and/or between populations.
- its strong dependence on age and BP
-



European Heart Journal

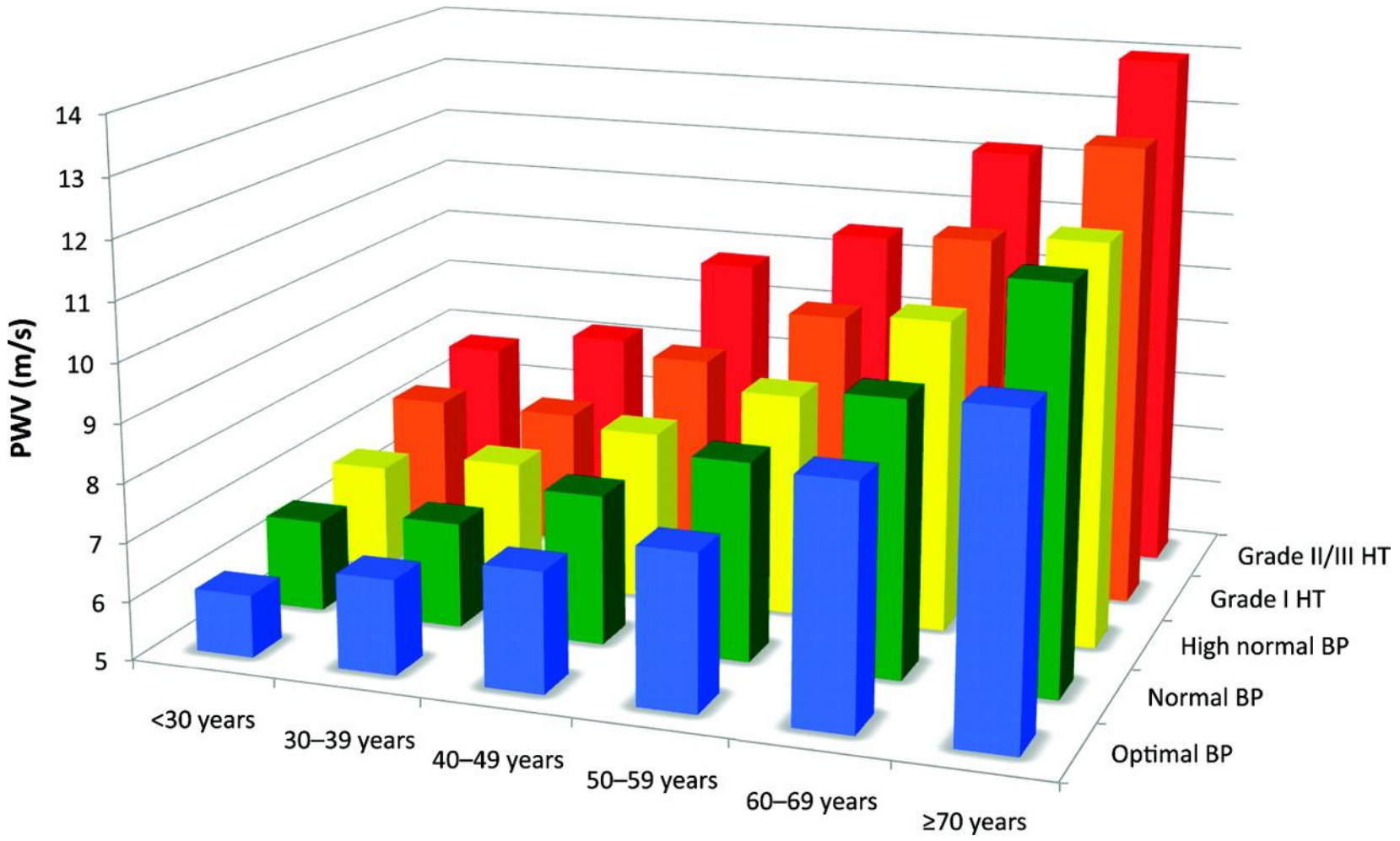






European Heart Journal

Reference values for pulse wave velocity (PWV): mean values according to age and blood pressure (BP) categories (11 092 subjects).

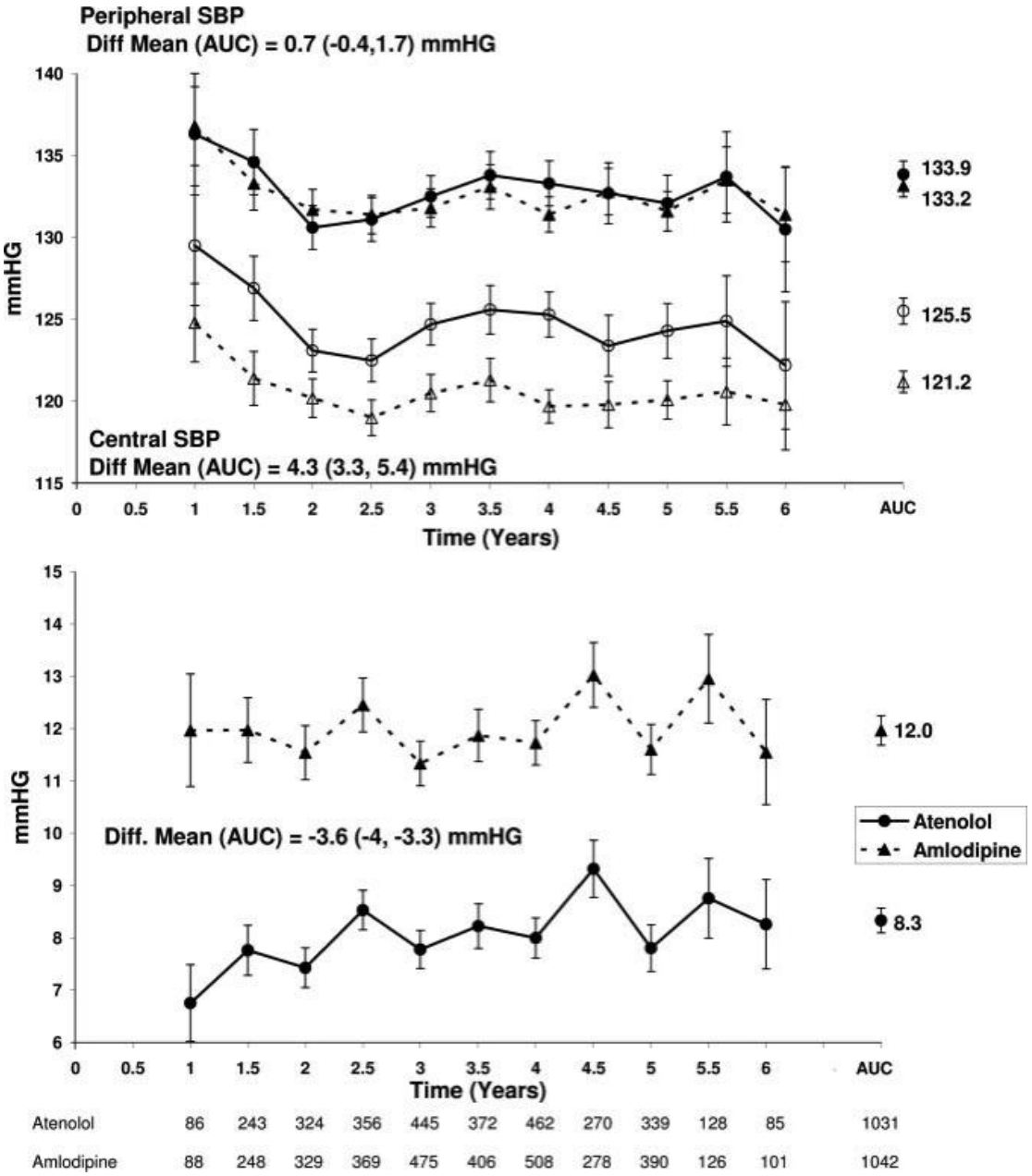


European Heart Journal

RESULTS

- The establishment of normal and reference values for PWV based on an extensive data set obtained from 13 centres distributed across Europe
- to take into account different methodological approaches for the determination of PWV
- to apply previously established conversion equations for path lengths and transit times.
- to present reference values per age decade and BP category.

TOP: Brachial (solid symbols) and derived central aortic (open symbols) systolic blood pressure with time (mean, 95% CI) for patients randomized to receive atenolol ± thiazide- or amlodipine ± perindopril-based therapy.
BOTTOM: Systolic blood pressure difference (brachial minus central aortic; mean, 95% CI) with time. For calculation of AUC, see the Data Supplement. Numbers below abscissa represent the number of patients seen at each time point. Time represents the duration from randomization into ASCOT to patient follow-up visit at which tonometry measurement was made in the CAFE study.
PP indicates pulse pressure.



CAFE Investigators, for ASCOT Investigators. Circulation 2006;113:1213.

CAFÉ Study Results