Validity of Aortic Stiffness as Surrogate Marker of Cardiovascular Disease

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Surrogate Markers of Cardiovascular Disease

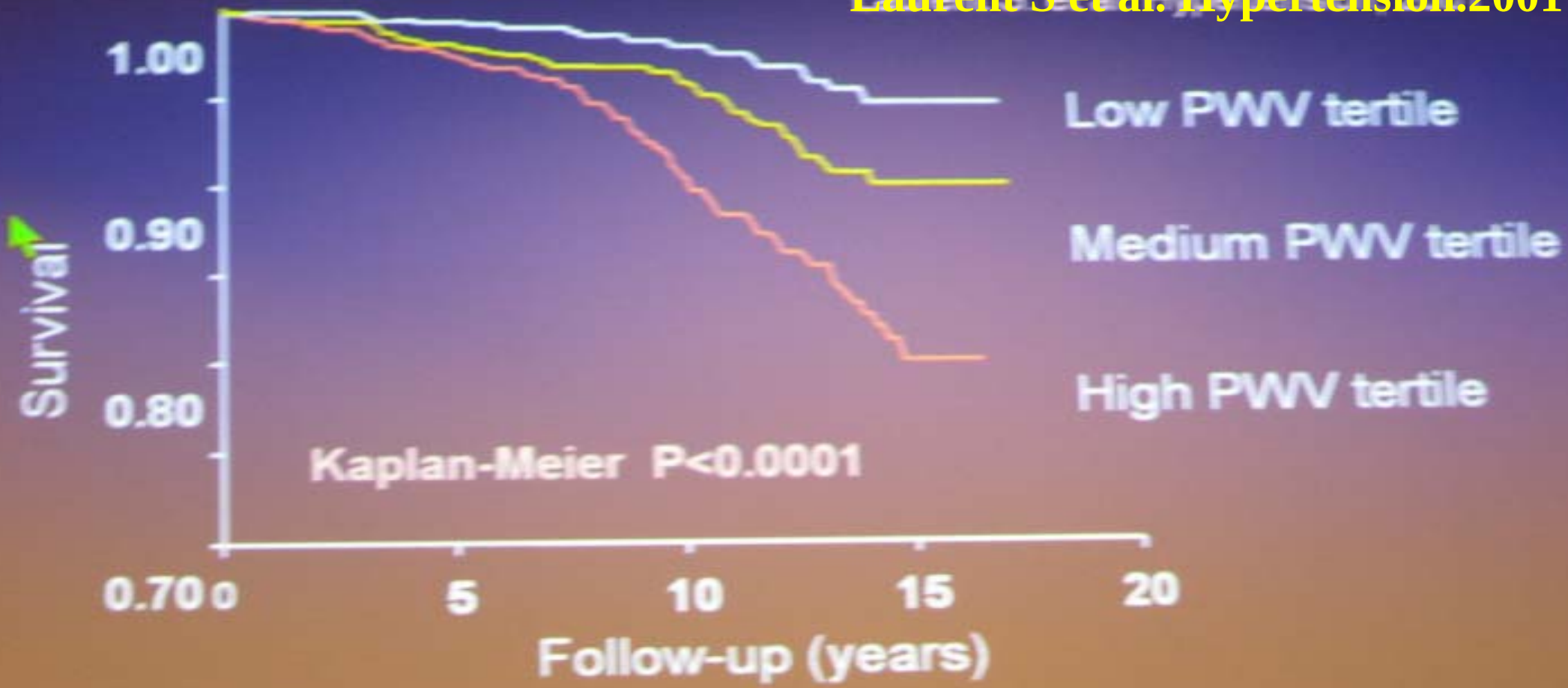
- Carotid IMT
- LVH
- Endothelial function(FMD)
- CRP
- Aortic stiffness

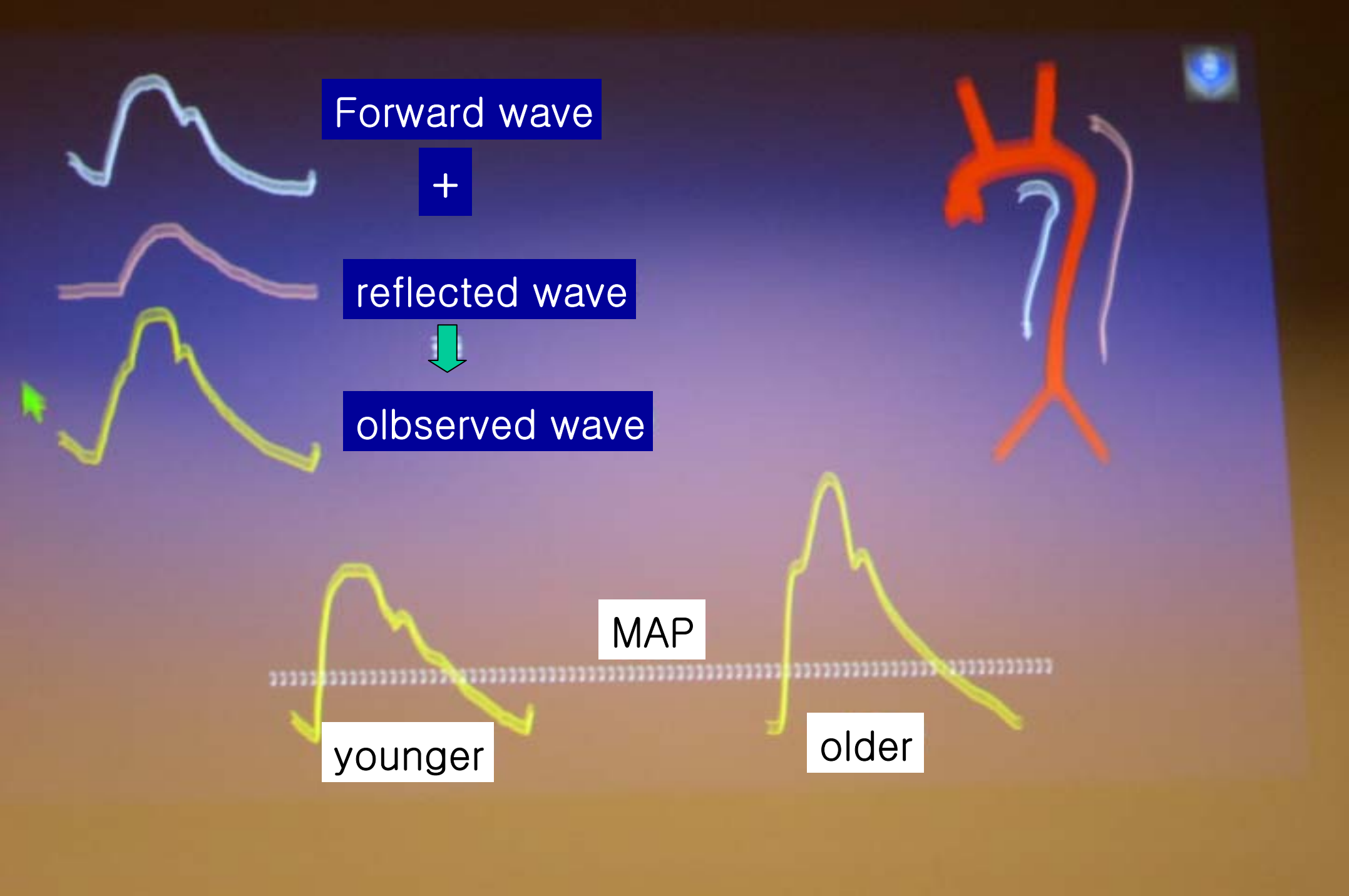
Parameters of Aortic Stiffness

- Aortic strain
- Aortic distensibility
- Aortic stiffness index
- Augmentation index
- Pulse wave velocity

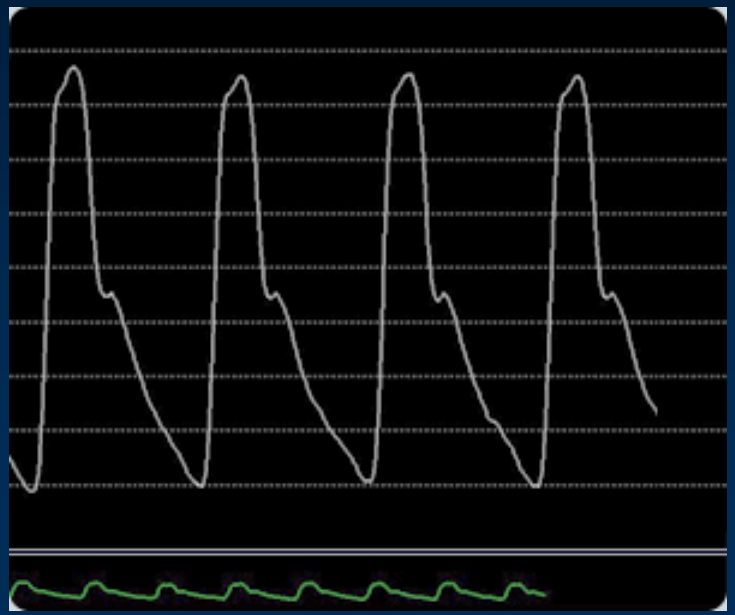
Aortic stiffness and all-cause mortality in 1980 hypertensives

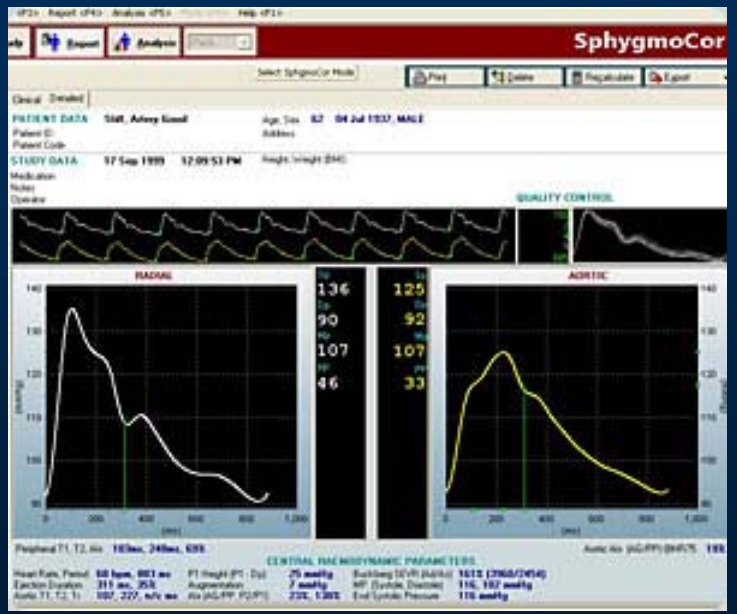
Laurent S et al. Hypertension.2001

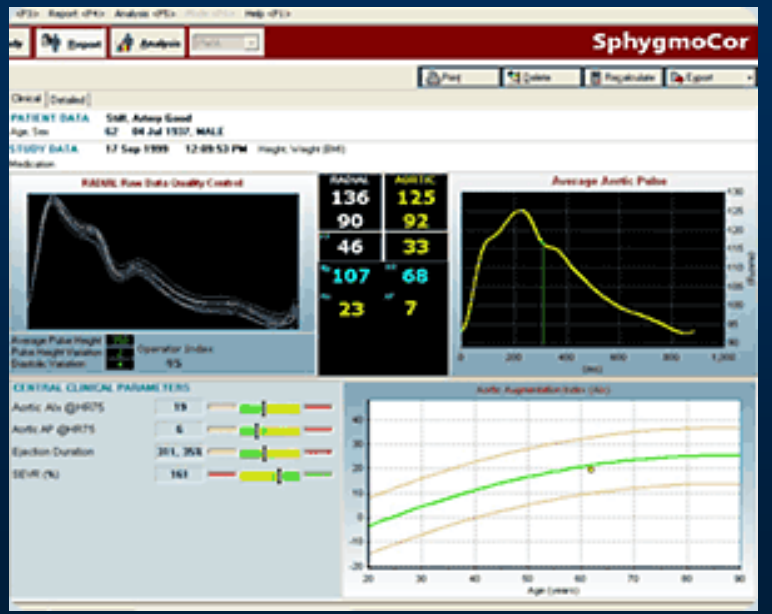



Forward wave
+
reflected wave
olbserved wave
MAP
younger
older

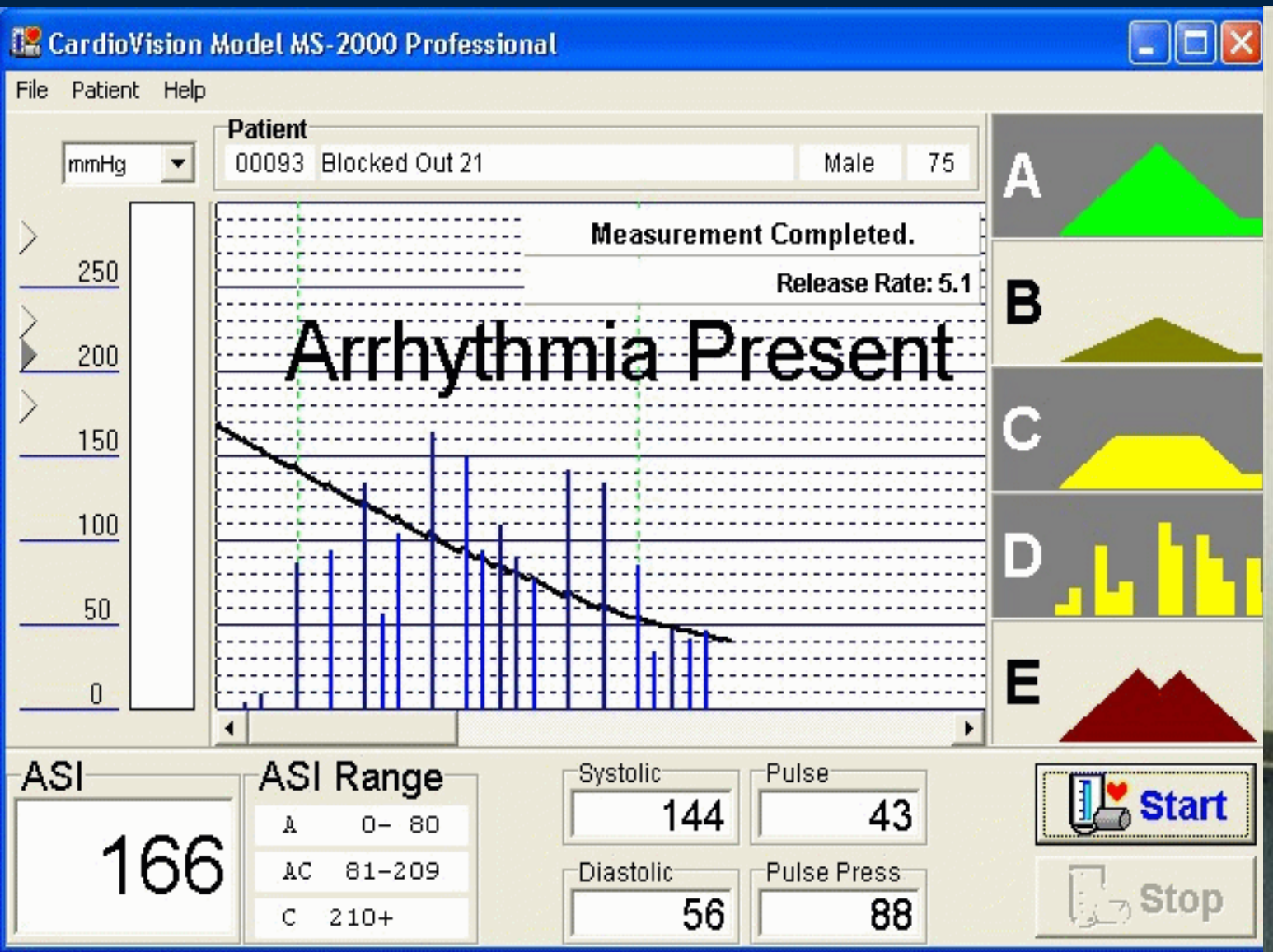
Applanation tonometry (SphygmoCor)



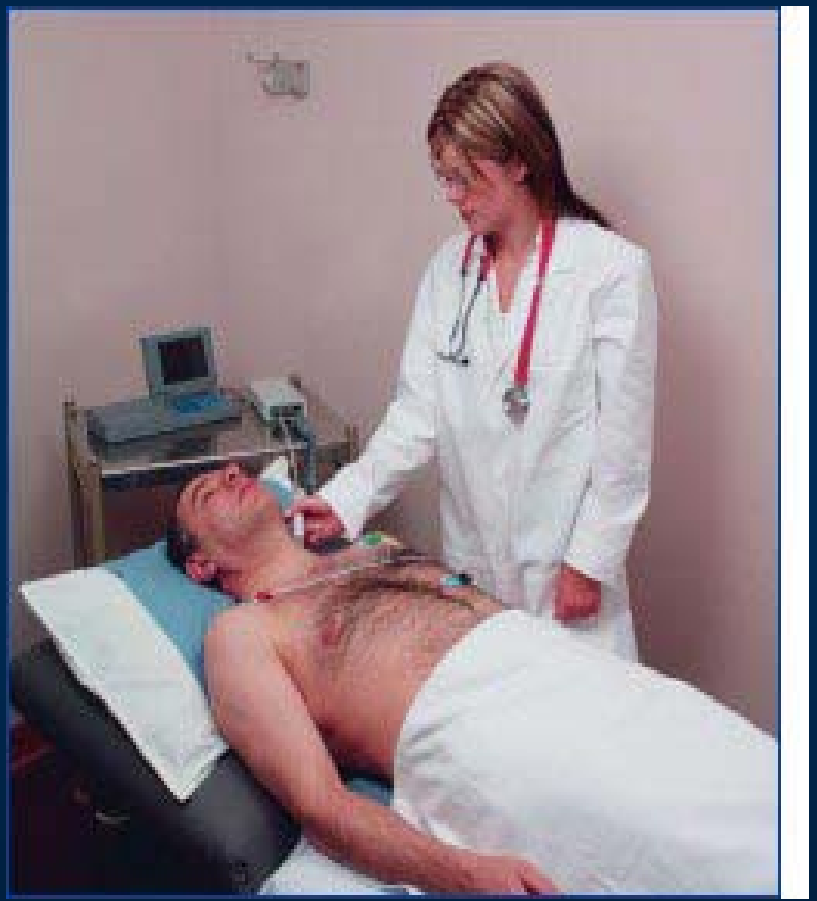




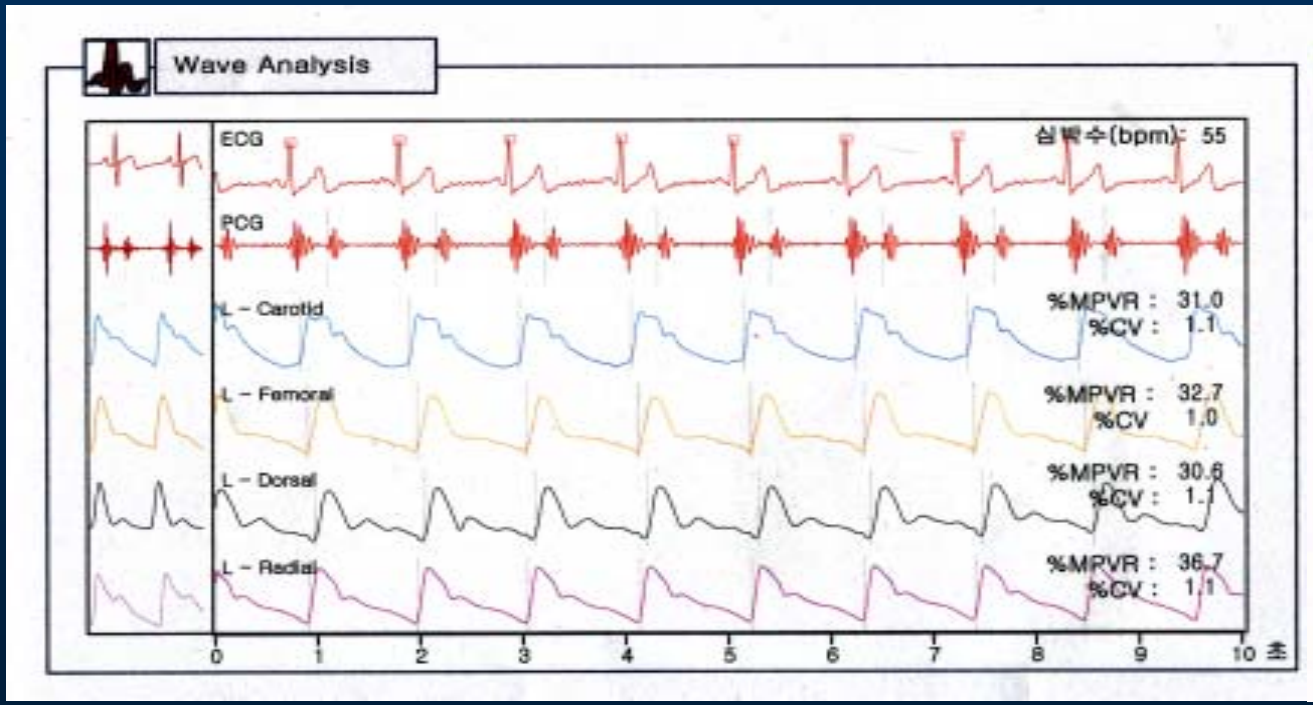
Arterial stiffness index (ASI)

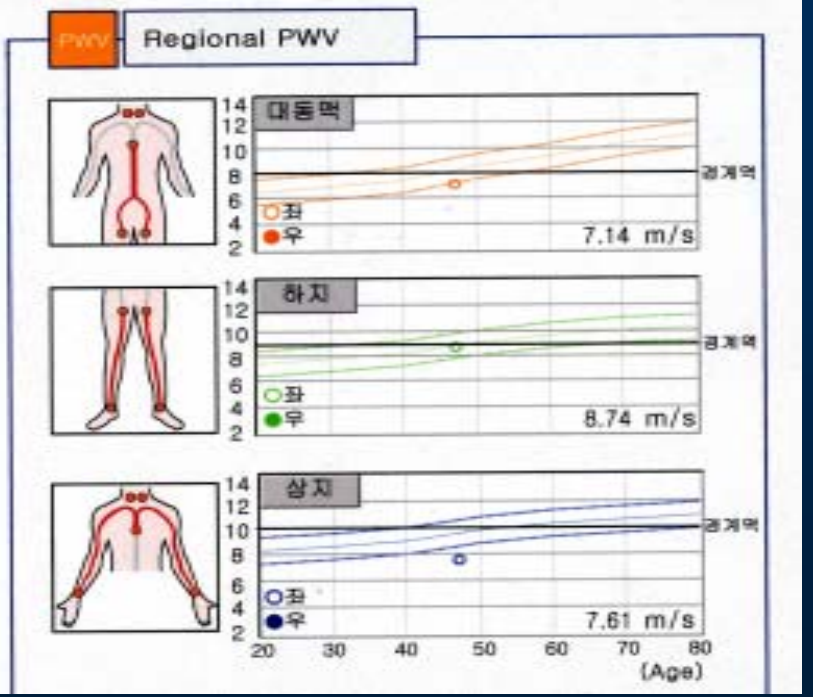


Complior, Micro-system, Omron

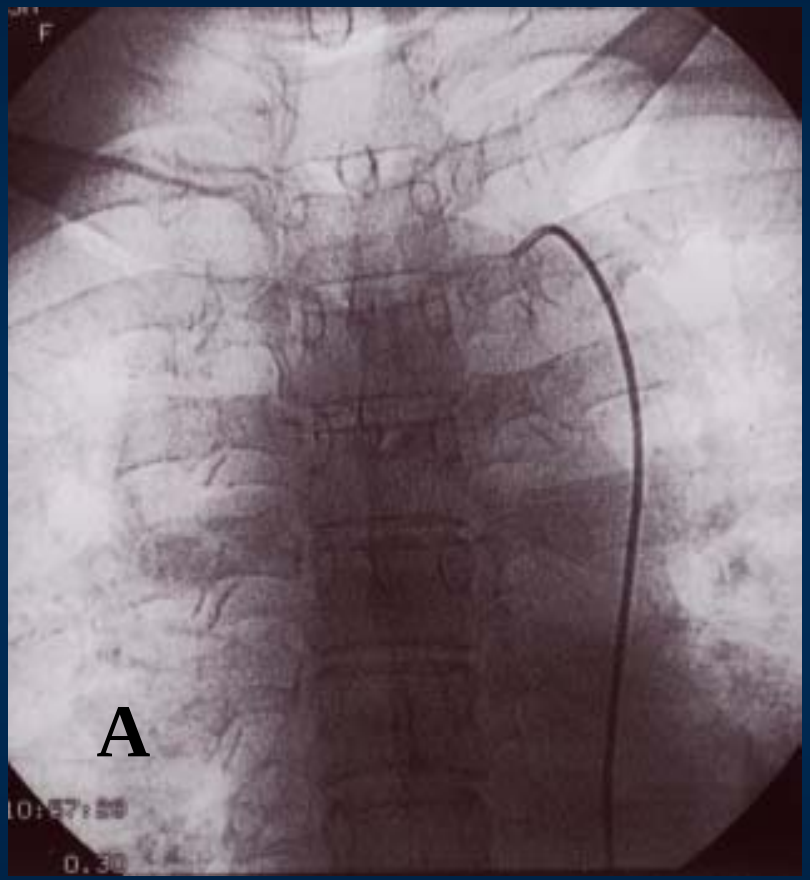


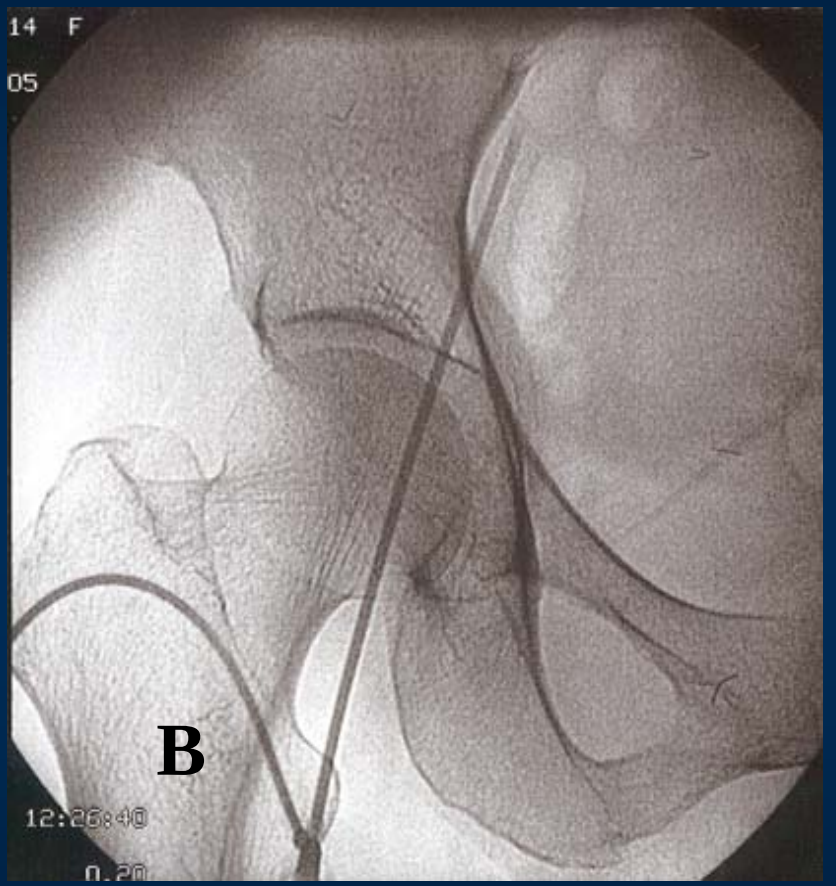
BaPWV and ABI by Colin



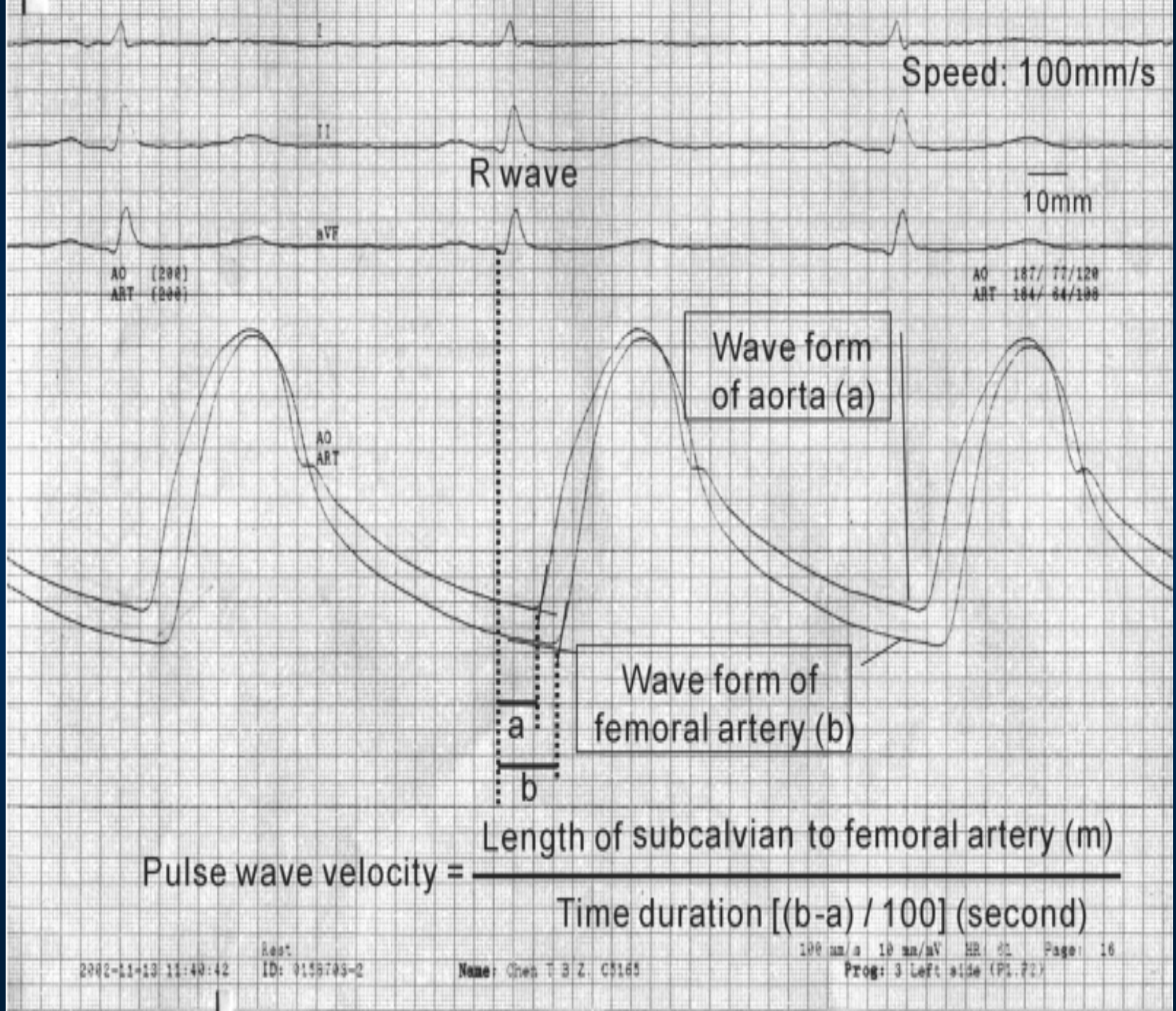


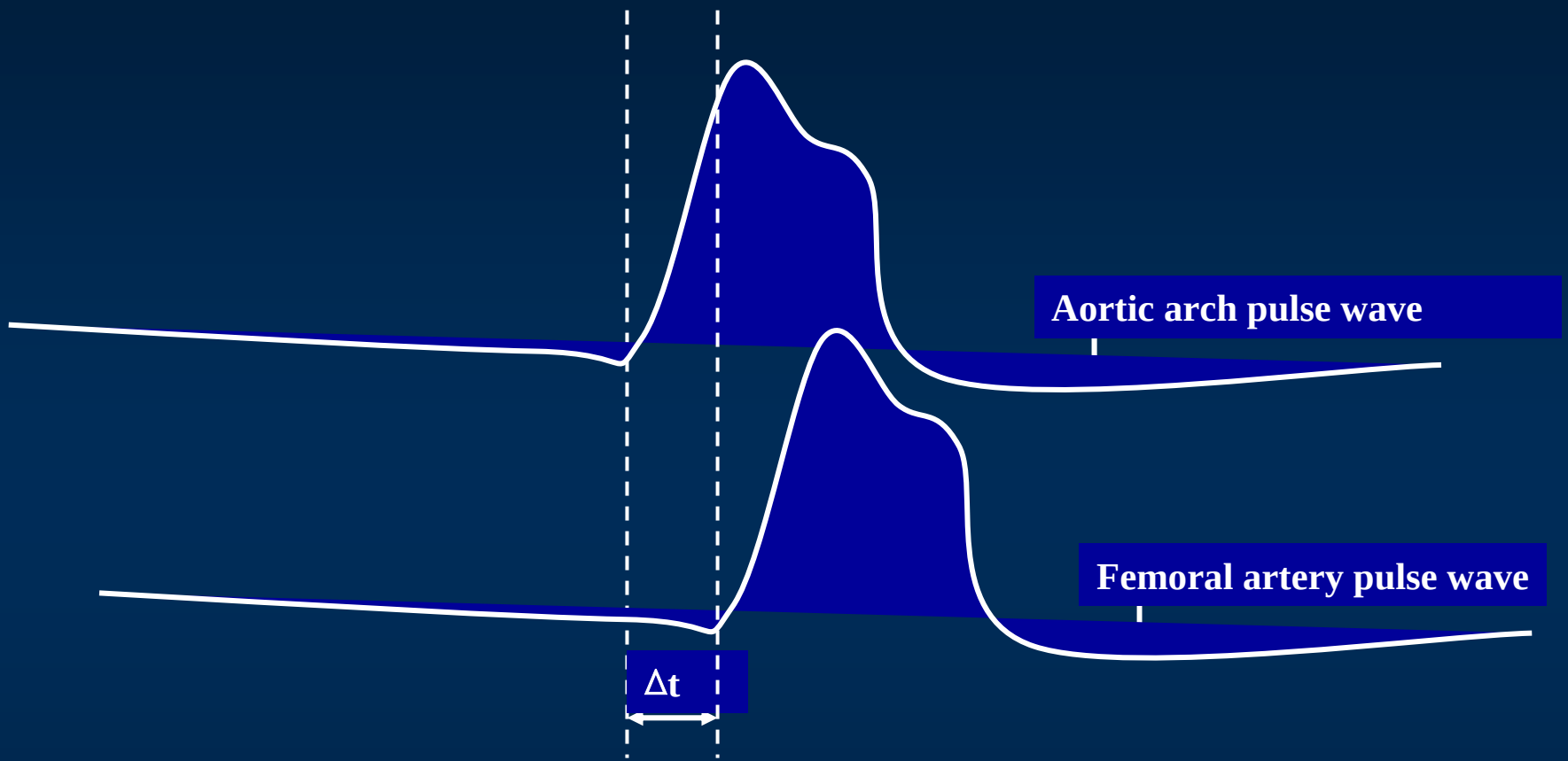
PWV by Cardiac Catherization





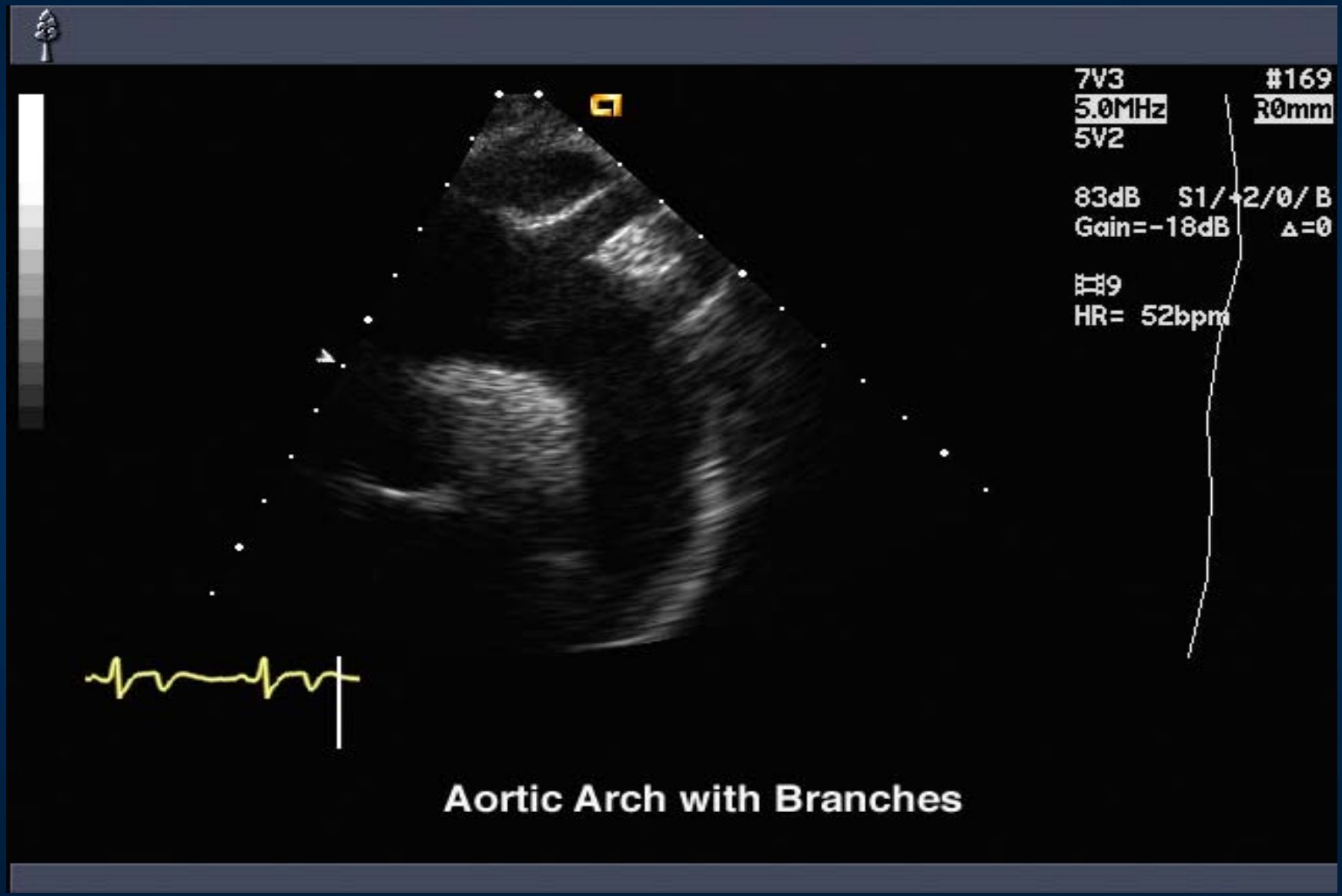
Aorto-iliac pulse wave velocity (PWV) was measured between aortic arch (A), just distal to the left subclavian artery ostium and right common iliac artery (B).


I
II
aVF
Speed: 100mm/s
R wave
10mm
AO [200]
ART [200]
AO 187/ 77/120
ART 184/ 84/100
Wave form of aorta (a)
AO
ART
Wave form of femoral artery (b)
a
b
Pulse wave velocity = Length of subcalvian to femoral artery (m) / Time duration [(b-a) / 100] (second)
2002-11-13 11:40:42
ID: 0158703-2
Name: Chen T B Z C5165
100 mm/s 10 mm/mV HR 61 Page: 16
Prog: 3 Left side (P1.72)



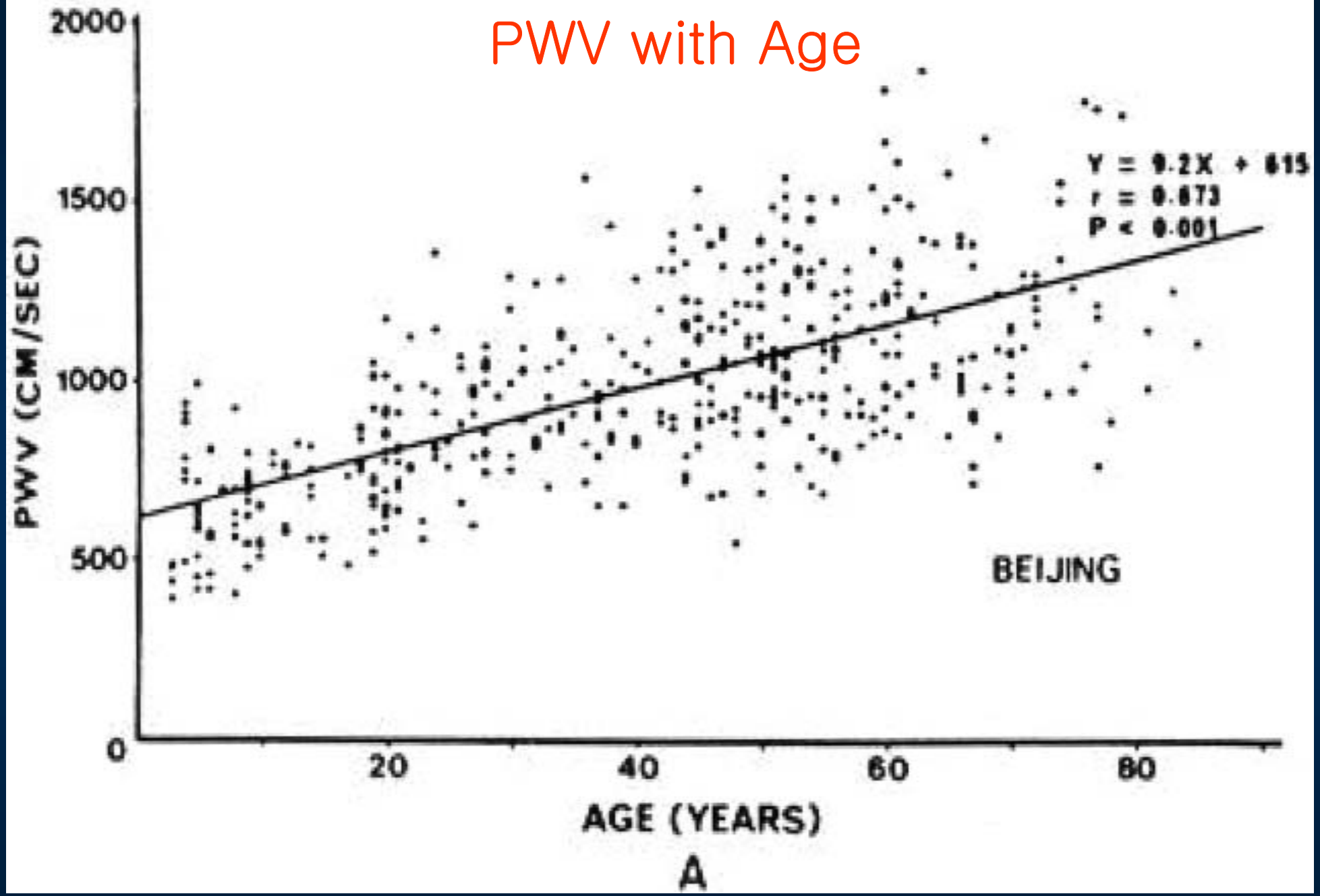
Δt is the time interval between two pulse waves.

PWV by Echocardiography



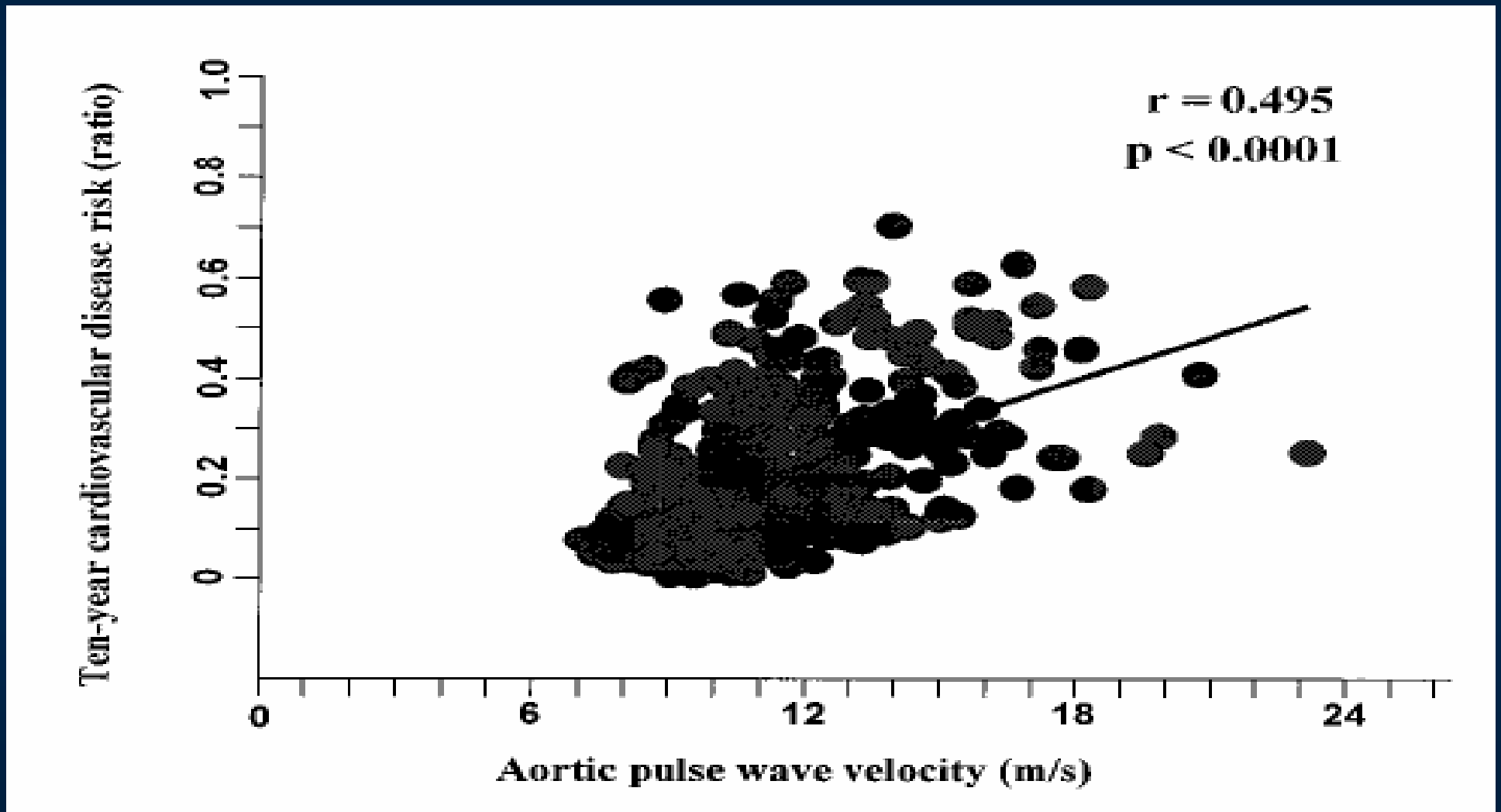
PWV = length (Aortic arch-femoral a) / (T2 – T1)
meter/ sec

PWV with Age



Circulation. 1983; 68: 50–58

Relation between 10-year CVD risk and Aortic PWV



Hypertension. 1999;33:1111-1117

Odds Ratio of Being in High-Risk Group

Parameter	Odds Ratio of Being in High-Risk Group (95% CI)					
	MI	CHD	CHD Mortality	Stroke	CVD	Cardiovascular Mortality
Pulse wave velocity, >13.5 m/s	3.5	4.6	4.9	6.1	5.3	7.1
	(2.3–5.5)	(2.9–7.2)	(3.1–7.8)	(3.8–9.6)	(3.4–8.4)	(4.5–11.3)
Gender, male	6.6	7.1	7.3	2.0	3.8	2.9
	(4.4–9.9)	(4.5–11.2)	(4.3–12.7)	(1.3–3.1)	(2.6–5.7)	(1.9–4.3)
Age, >60 y	3.0	3.9	7.3	11.1	6.1	12.9
	(2.0–4.4)	(2.6–5.9)	(4.5–11.9)	(6.7–18.2)	(4.0–9.2)	(8.1–20.5)
Plasma glucose, >7.0 mmol/L	8.1	5.9	5.5	7.1	8.4	4.7
	(4.8–16.8)	(2.3–6.0)	(1.6–4.3)	(1.2–3.2)	(2.3–6.3)	(1.4–3.6)
Tobacco life-long dose, >20 pack-years	4.4	2.0	1.9	1.7	2.6	1.7
	(2.6–7.2)	(1.3–3.2)	(1.2–3.2)	(1.1–2.8)	(1.6–4.1)	(1.1–2.8)
Total/HDL cholesterol, ratio >5	3.7	3.9	3.6	1.5	3.6	2.8
	(2.5–5.5)	(2.6–5.9)	(2.3–5.7)	(1.0–2.3)	(2.3–5.4)	(1.9–4.3)
Left ventricular hypertrophy, yes-no	2.2	11.2	3.0	2.2	4.9	4.5
	(1.2–4.1)	(5.3–23.8)	(1.6–5.6)	(1.2–4.0)	(2.5–9.5)	(2.4–8.4)
Plasma creatinine, >100 μmol/L	1.8	2.5	2.7	1.7	1.8	1.8
	(1.1–2.7)	(1.6–3.9)	(1.7–4.3)	(1.1–2.8)	(1.2–2.8)	(1.2–2.8)

Ten-year absolute MI risk >5%, 10-year absolute CHD risk >15%, 10-year absolute CHD mortality risk >5%, 10-year absolute stroke risk >5%, 10-year absolute CVD risk >20%, and 10-year cardiovascular mortality risk >5% were considered high.

	MI	CHD	CHD mortality	Stroke	CVD	CV mortality
PWV>13.5m/s	3.5	4.6	4.9	6.1	5.3	7.1

Odds Ratios of Developing Hypertension during 4 yrs F/U in Relation to Aortic Stiffness (Multivariate Logistic regression models)

Variable	Men		Women	
	Odds Ratio	P value	Odds Ratio	P value
Systolic BP	8.7619	< 0.001	8.6920	< 0.001
Diastolic BP	6.6947	< 0.001	6.7582	< 0.001
Age	8.8211	< 0.001	9.0145	< 0.001
Aortic stiffness index	1.2165	< 0.05	1.1981	< 0.05

2005-06-21

Hypertension 1999;33:1447-1452

BLOOD PRESSURE 2004; 13: 1–7

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Aortic Pulse Wave Velocity as an Independent Marker of Coronary Artery Disease

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Euy Lim H, Gyu Park C, Hee Shin S, Cheon Ahn J, Seog Seo H, Joo Oh D. *Aortic pulse wave velocity as an independent marker of coronary artery disease.* Blood Pressure 2004; 13: 000–000.

Background: Arterial stiffness has been known as a major contributory factor to cardiovascular (CV) morbidity and mortality in patients with hypertension. Pulse wave velocity (PWV), a surrogate measurement of large artery damage, has not been ascertained as an independent risk factor of coronary artery disease (CAD). The aim of this study was to assess whether PWV is associated with CV risk. **Methods and results:** We prospectively enrolled 326 consecutive patients undergoing coronary angiography for the assessment of suspected CAD. Arterial stiffness was assessed through aorto-femoral PWV using fluid-filled system. PWV was higher in patients with CAD than those without CAD (12.5 ± 5.1 vs 10.2 ± 3.1 m/s, $p < 0.001$). In multivariate logistic regression analysis, after entering for age, diabetes and other CV risk factors, PWV remained the significant independent variable for CAD ($p = 0.050$). When the severity of CAD was expressed as one-, two- or three-vessel disease, PWV was a significantly associated with the severity of CAD ($p < 0.001$). **Conclusions:** Our findings suggest that PWV is an independent risk marker for CAD, as well as strongly associated with the severity of CAD.
Key words: arterial stiffness, cardiovascular risk factor, coronary artery disease, pulse wave velocity.

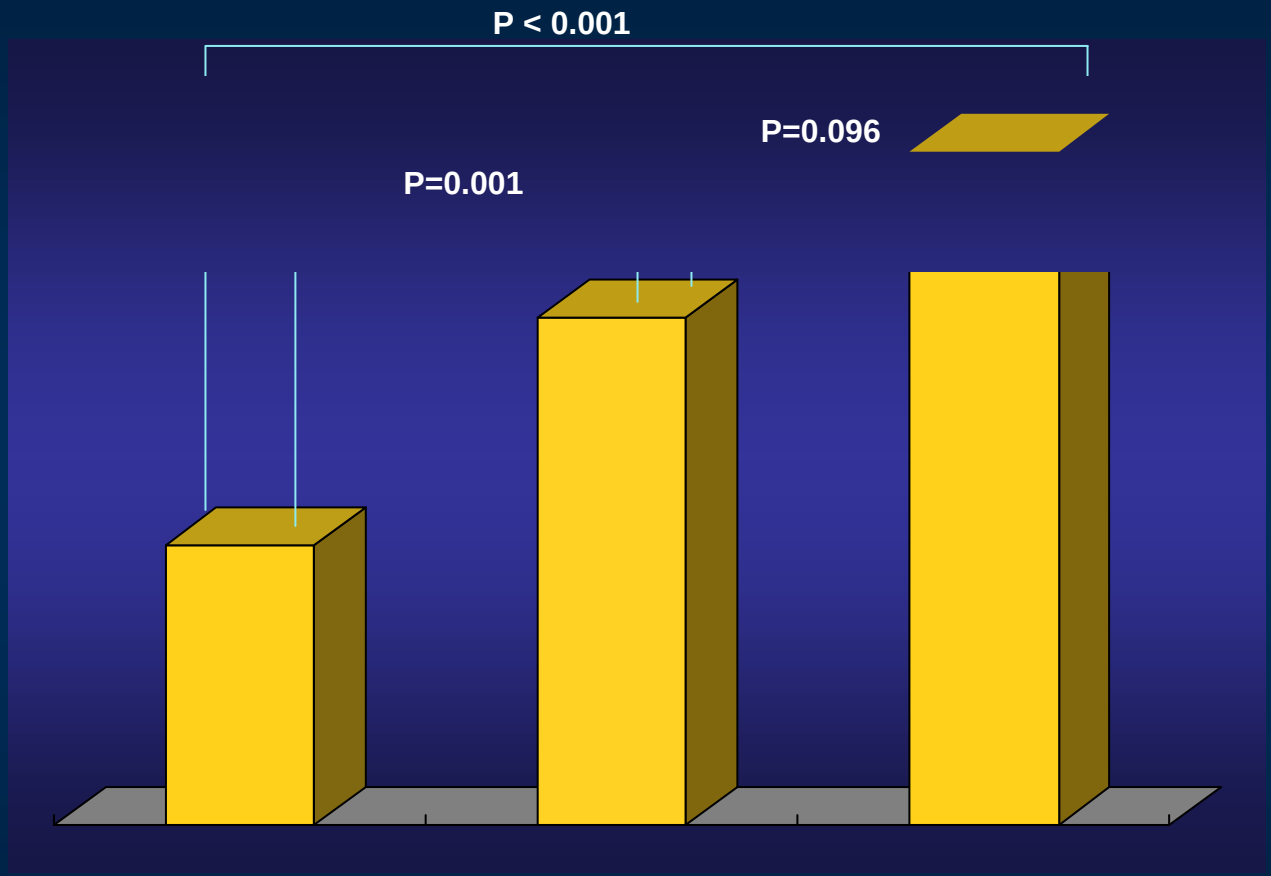
Table I. *Clinical characteristics of subjects with and without coronary artery disease*

Parameters	CAD ($n = 146$)	No CAD ($n = 180$)	p-value
Age, years	61.9 ± 10.7	55.8 ± 10.3	<0.001
Gender, men/women	71/75	72/108	0.118
Diabetes, %	27.4% (40)	12.2% (22)	0.001
Cigarette smoking, %	41.1% (60)	28.3% (51)	0.016
Previous antihypertensive treatment, %	67.8% (99)	50.0% (90)	0.001
Body mass index, kg/m^2	24.5 ± 3.3	24.7 ± 4.5	0.607
PWV, m/s	12.5	10.2	<0.001
TG	144.0 ± 69.3	129.0 ± 73.3	0.061
LDL-C	115.4 ± 36.9	105.9 ± 32.5	0.013
Office blood pressure, mmHg			
Systolic	145.2 ± 24.2	140.9 ± 25.4	0.114
Diastolic	87.1 ± 12.9	87.0 ± 13.5	0.984
Pulse	58.2 ± 18.7	53.8 ± 16.5	0.026
Pulse wave velocity, m/s	12.5 ± 5.1	10.2 ± 3.1	<0.001

CAD, coronary artery disease; HDL-C, high-density lipoprotein cholesterol; TG, Triglyceride; LDL-C, low-density lipoprotein cholesterol. Continuous variables are expressed as mean ± SD.

Park CG et al. BLOOD PRESSURE 2004;13:1-7

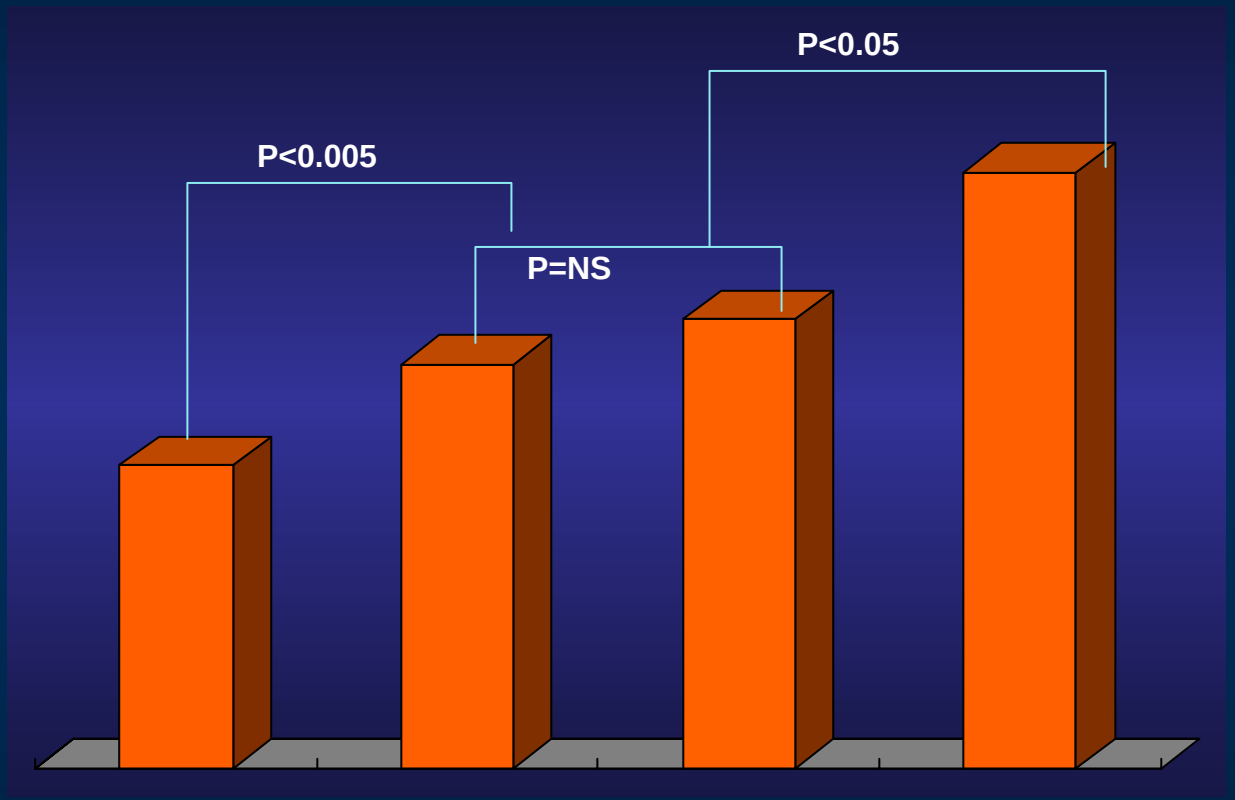
Correlation between PWV and coronary artery calcification



	No calcification	ca: 1,2 segment	ca: above 3 segment
	n=141	n=27	n=18
PWV	10.15+/- 0.37	13.14+/- 0.84	16.62+/-1.05

Park CG et al. J Hypertens. 2002;20:S157

Correlation between PWV and coronary artery stenosis

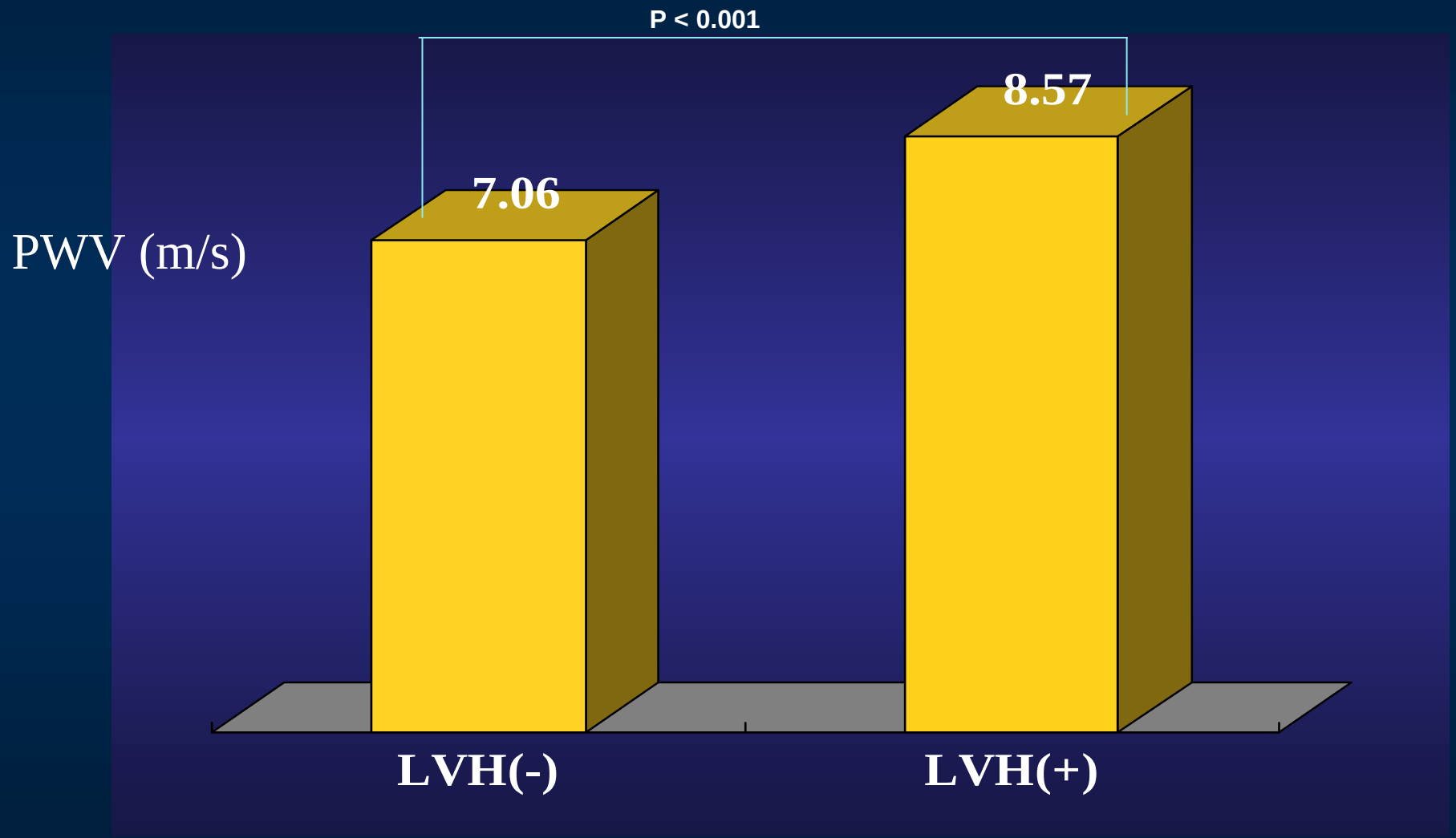


PWV	9.82+/- 0.43	12.56+/-0.62	12.89+/-0.98	17.22+/-1.57

Park CG et al. J Hypertens. 2002;20:S157

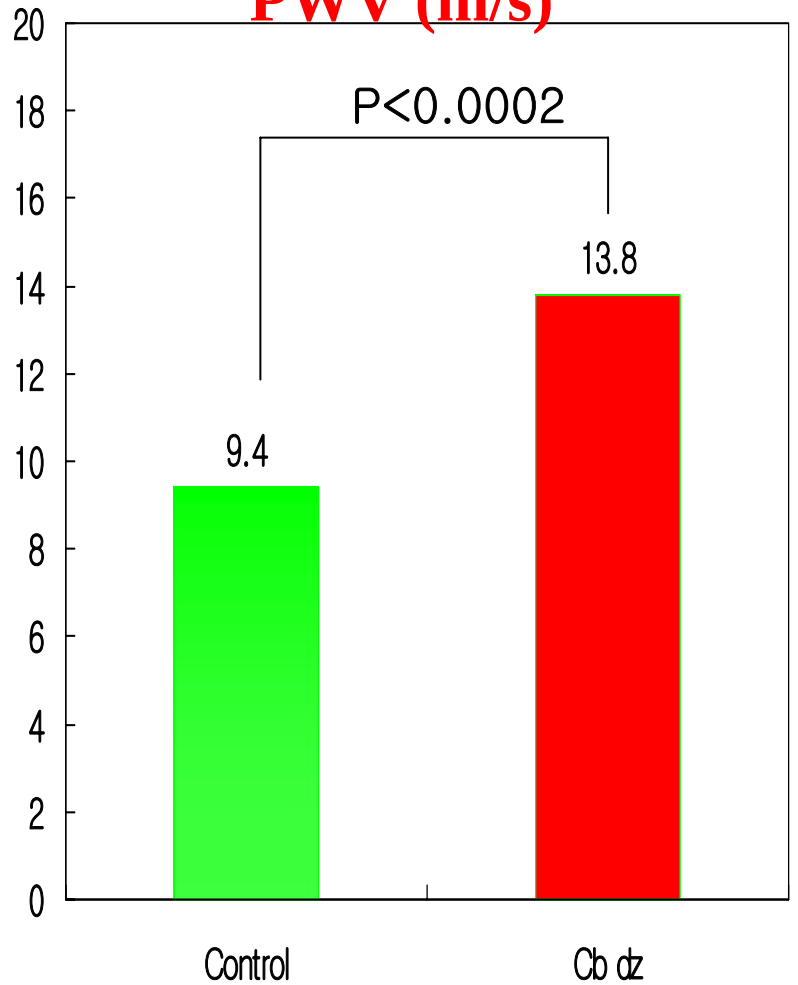
Aortic Stiffness and LVH

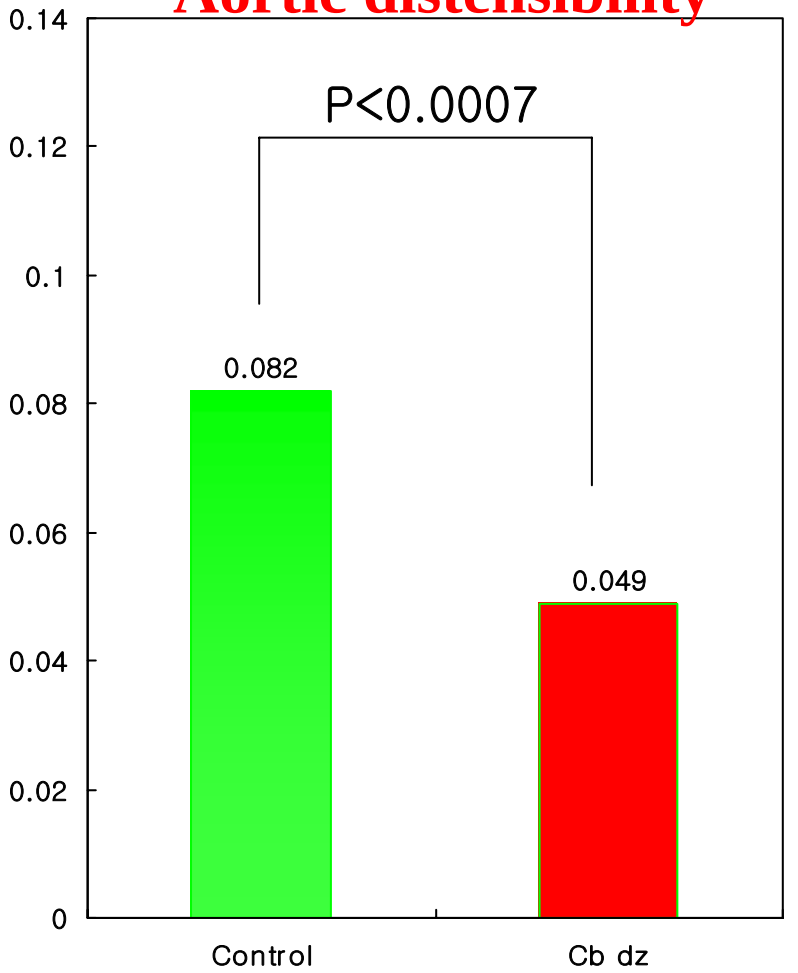
Correlation between PWV and LVMI



Park CG et al. J Hypertens. 2002;20:S384

Aortic Distensibility and Cerebrovascular Disease

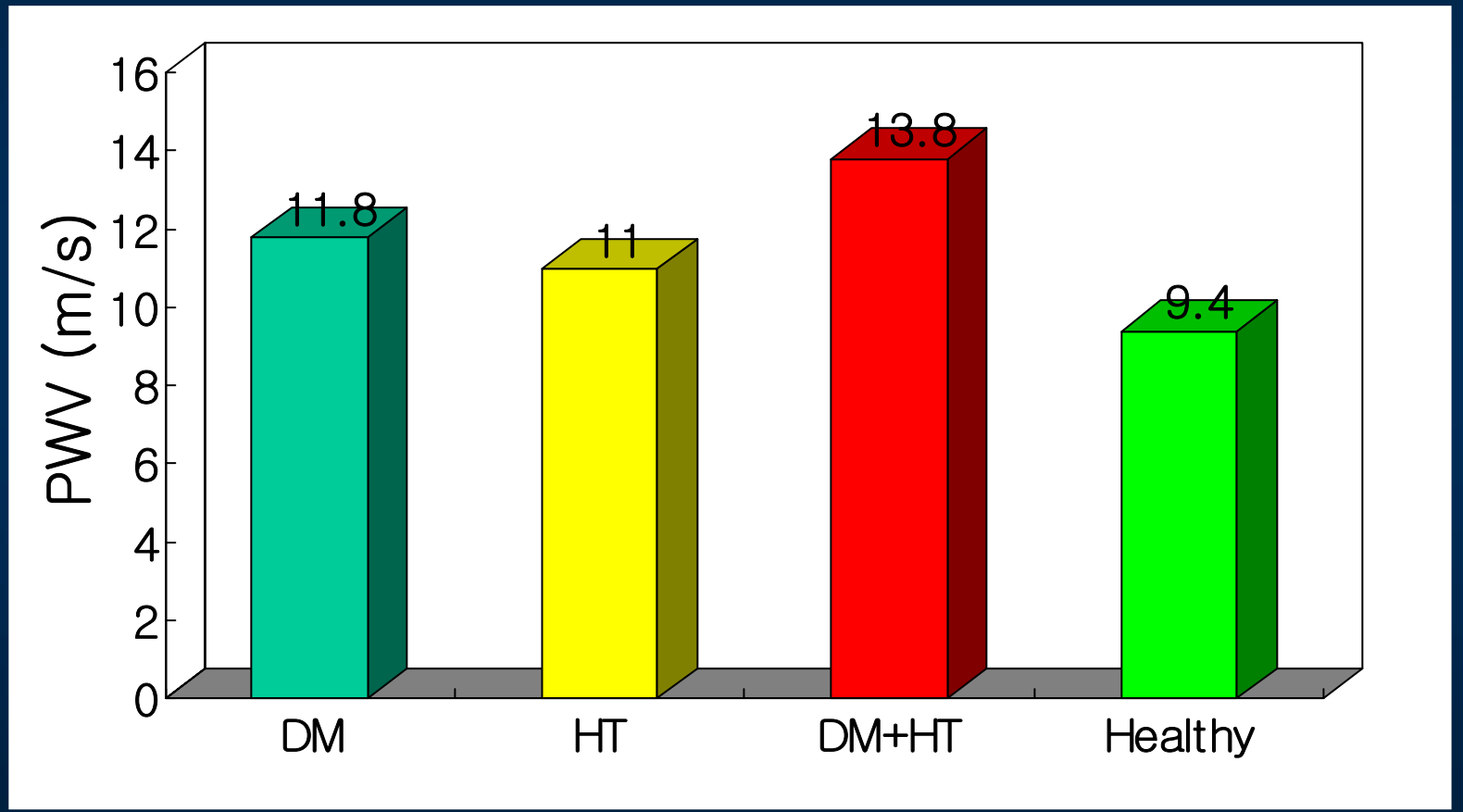




Clin Sci 1995;89:247-253

Aortic Stiffness and Diabetes

Hypertension and type II DM on Aortic Stiffness



Journal of Human Hypertension 2004;18:469-73

BLOOD PRESSURE 2004; 13: 236–242

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healthsciences

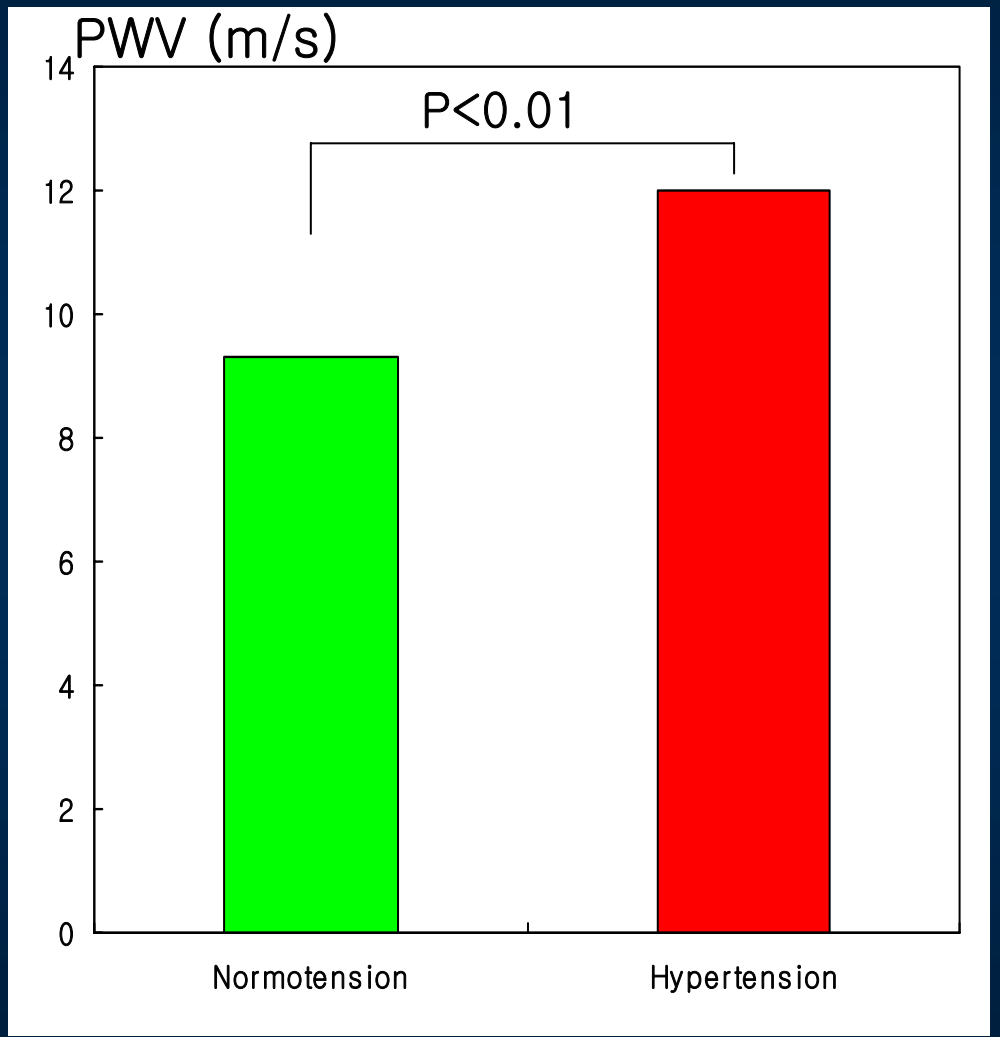
Associations among Plasma Adiponectin, Hypertension, Left Ventricular Diastolic Function and Left Ventricular Mass Index

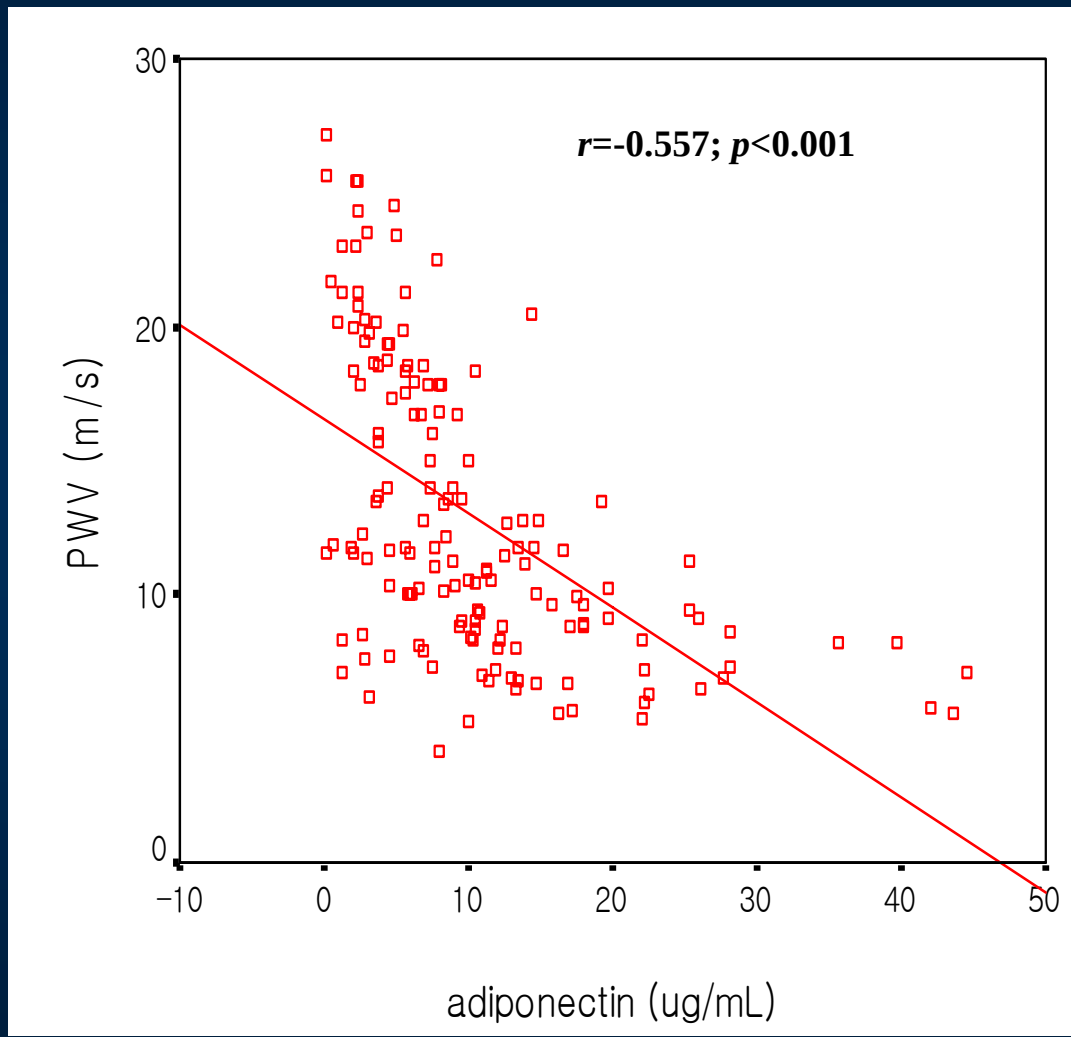
SOON JUN HONG, CHANG GYU PARK, HONG SEOG SEO, DONG JOO OH AND YOUNG MOO RO

From the Division of Cardiology, Cardiovascular Center, Korea University Hospital, Seoul, Korea

Hong SJ, Park CG, Seo HS, Oh DJ, Ro YM. *Associations among plasma adiponectin, hypertension, left ventricular diastolic function and left ventricular mass index.* Blood Pressure 2004; 13: 236–242

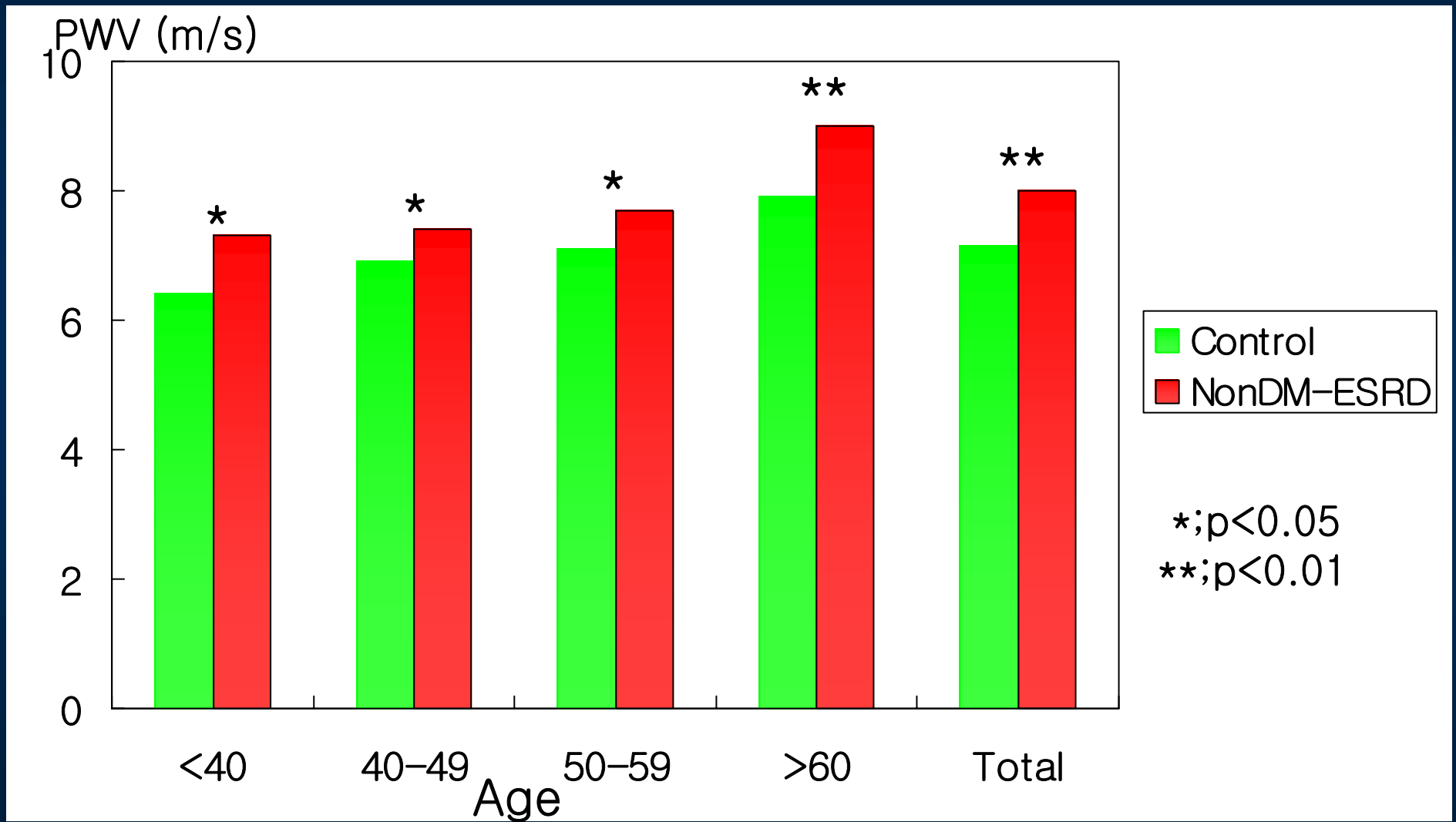
Correlation between plasma adiponectin and PWV





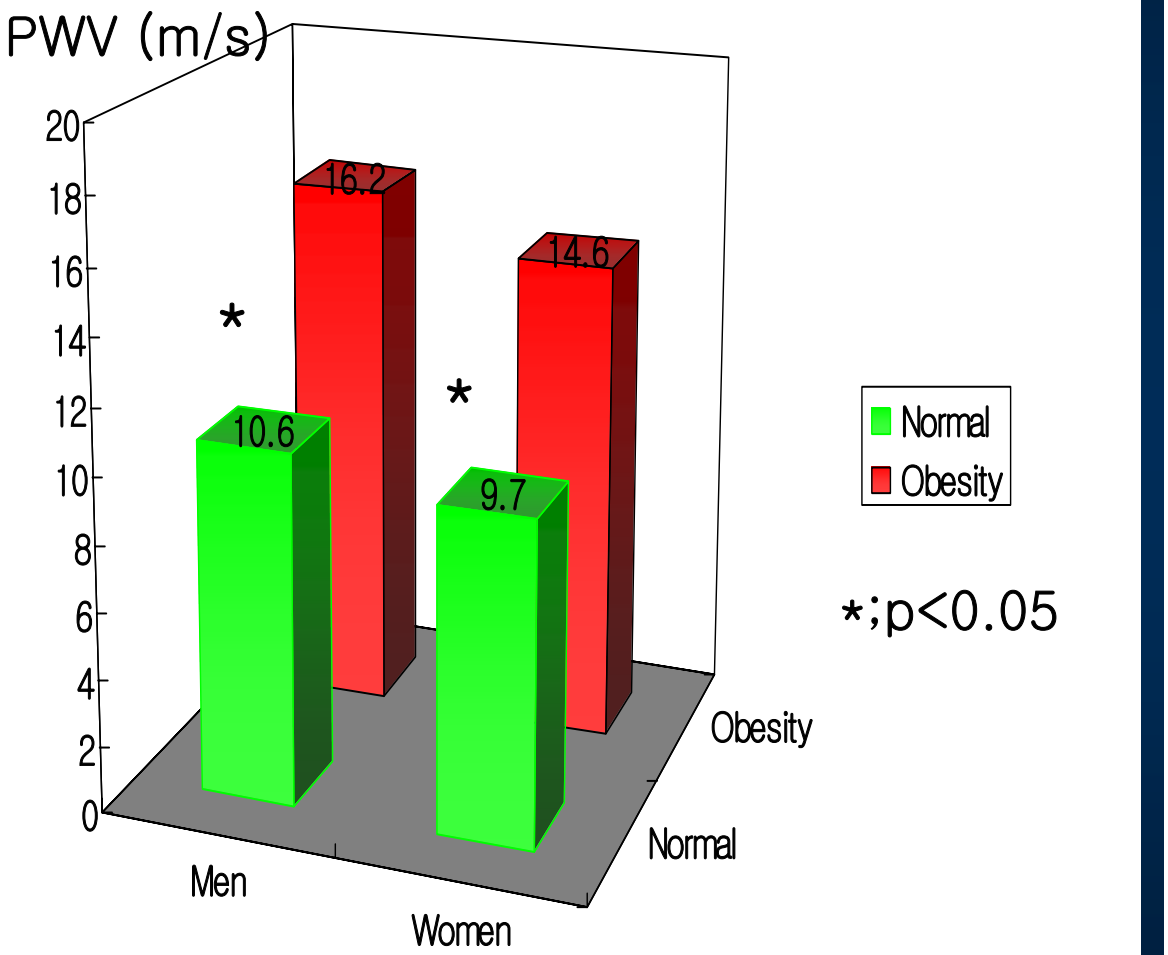
Park CG et al. BLOOD PRESSURE 2004;13:236-242

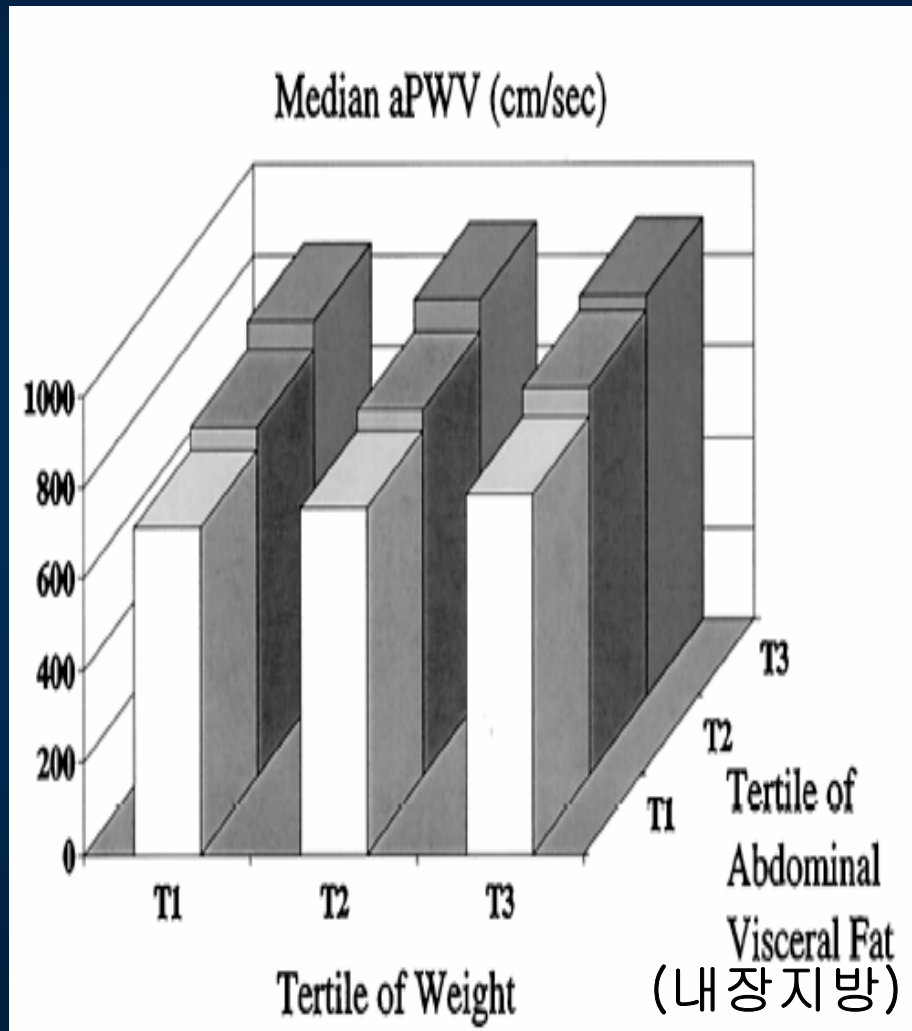
PWV in Non-Diabetic Hemodialysis Patients



J Am Soc Nephrol 1998;9:1277-84

PWV and Obesity





Am Heart J 1986;112:136-140

Blood Pressure. 2005; 000: 1–6

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Acute and chronic effects of cigarette smoking on arterial stiffness

JIN WON KIM[1], CHANG GYU PARK[1], SEUNG JOON HONG[1], SEONG MI PARK[3], SEUNG WOON RHA[1], HONG SEOG SEO[1], DONG JOO OH[1] & YOUNG MOO RHO[2]

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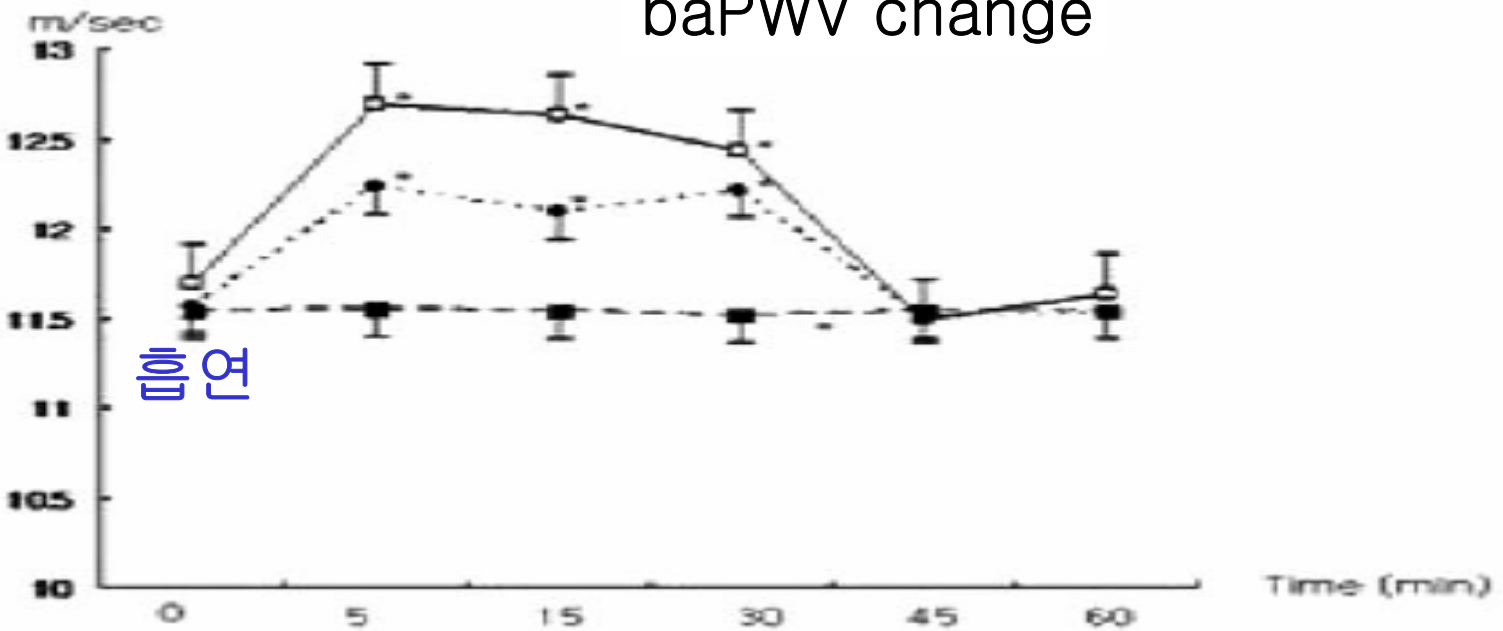
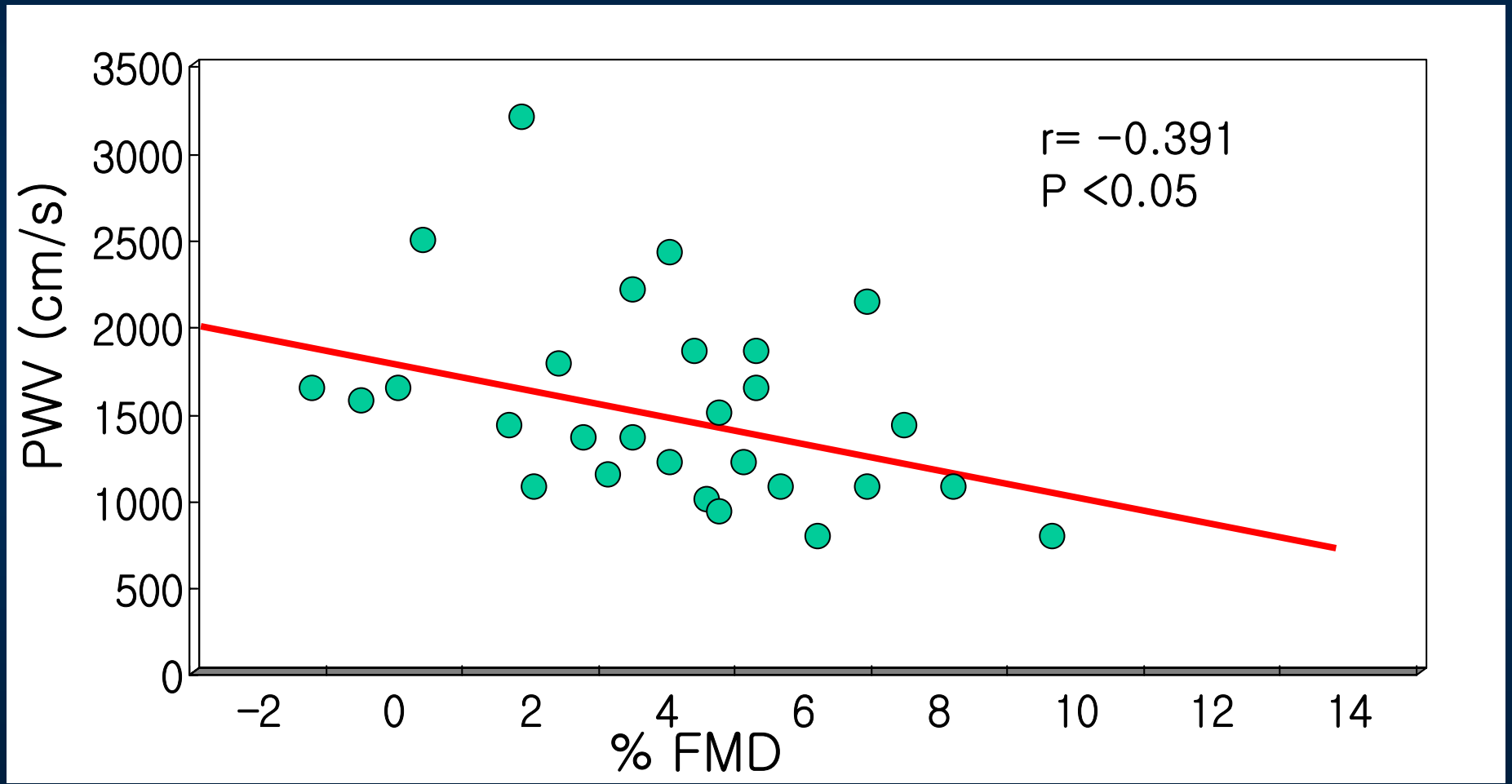
baPWV change



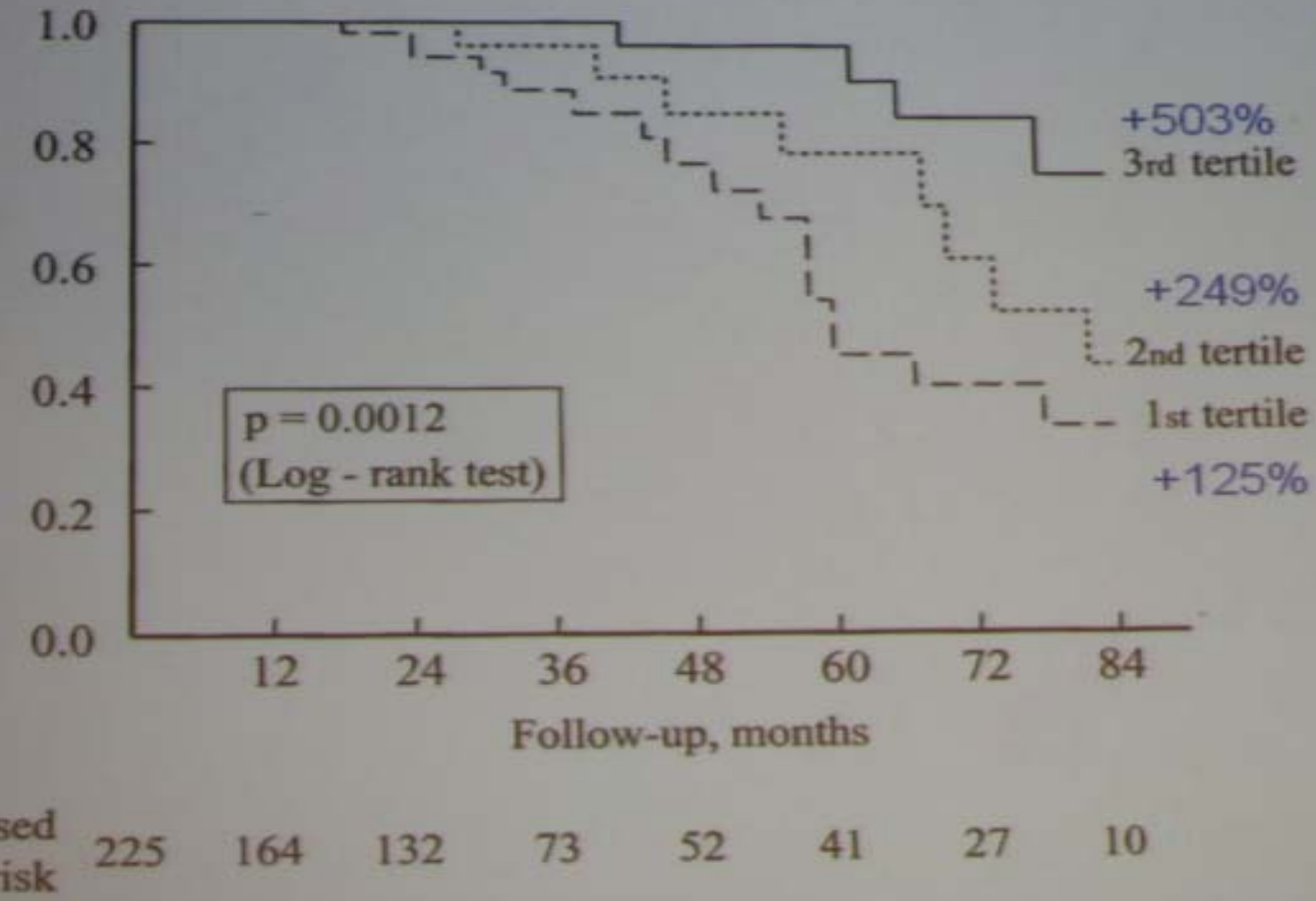
PWV and Endothelial Function



Hypertens Res 2000;23:233-8

Prognostic Value of Forearm Vascular Endothelial Dysfunction (FMD) In hypertensive patients

Perticone F et al., Circulation 2001



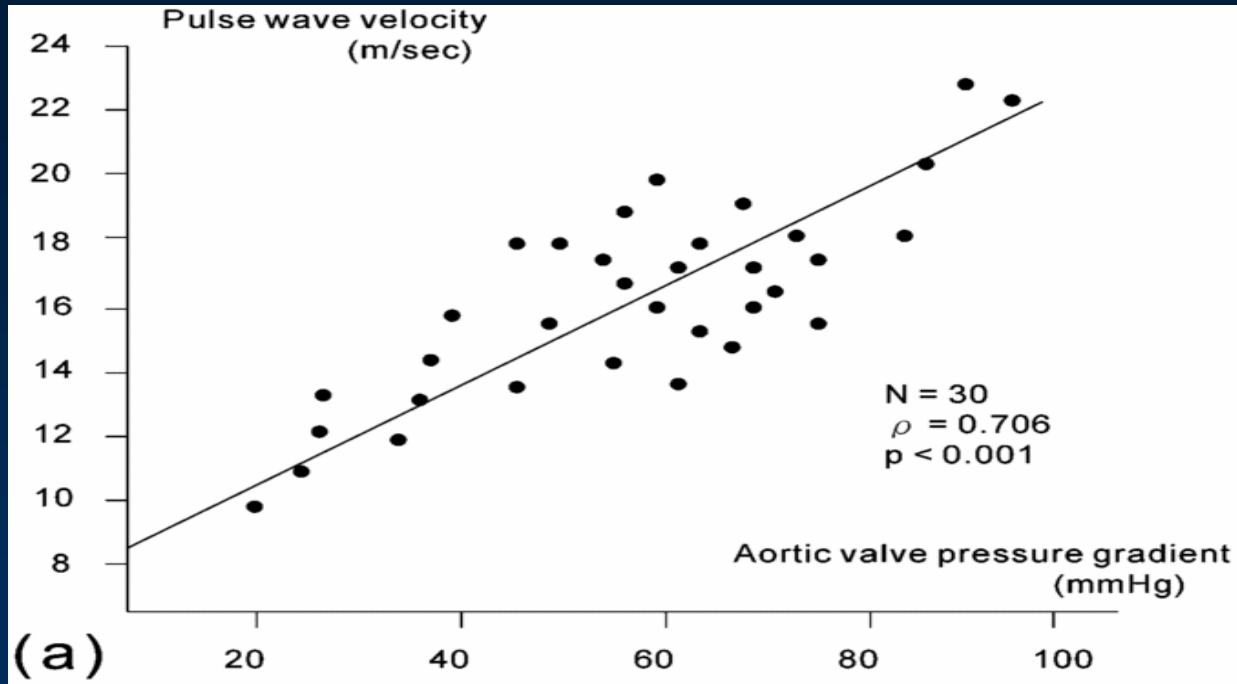
N= 225
never-treated HT

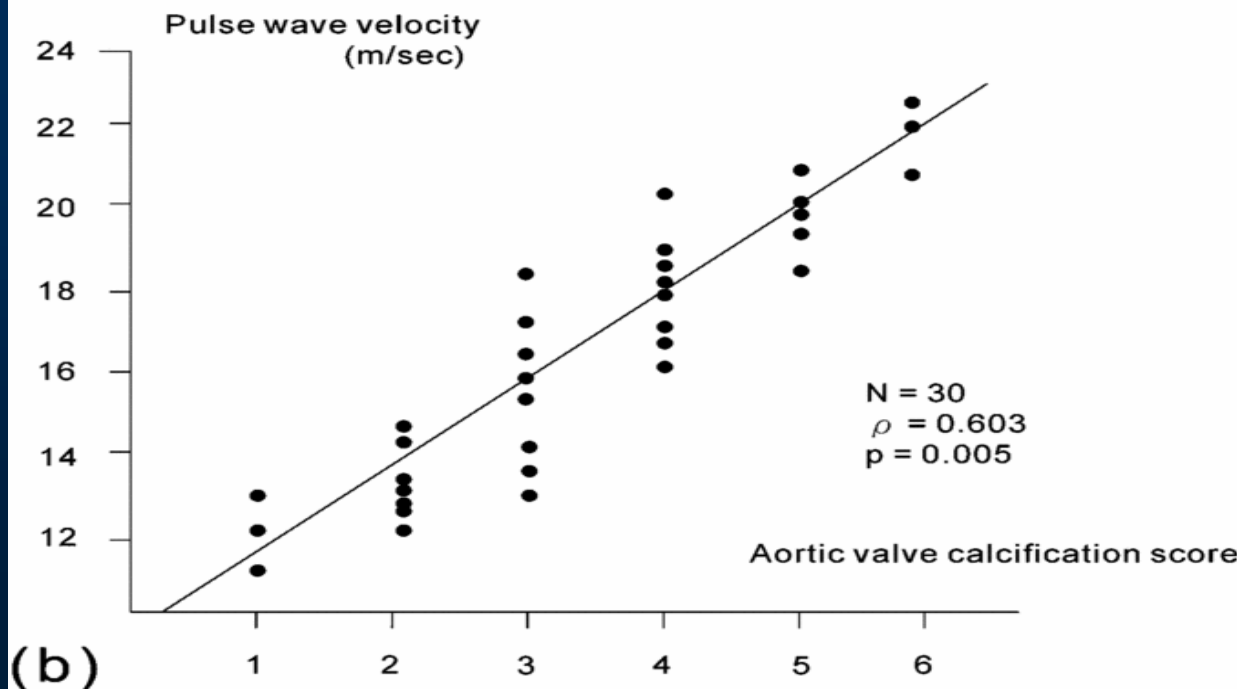
Mean follow-up : 31.5 months

Ach infusion
Forearm blood flow

Cox model :
3rd vs 1st tertile
RR = 2.08 (1.2-3.5)
P<0.01

Correlation between PWV and Aortic Valve Calcification, and Aortic Valve Stenosis





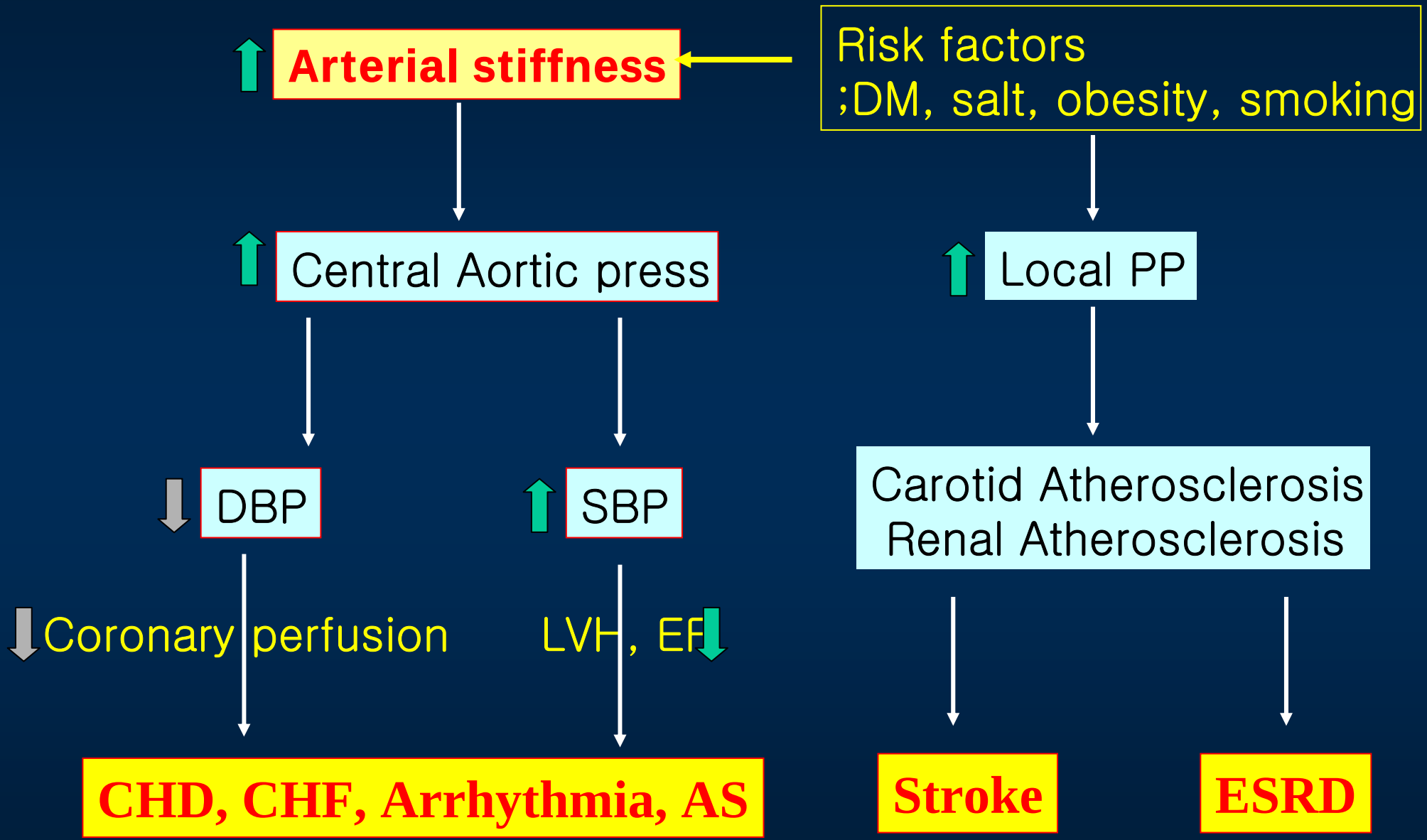
Clinical Science 2004; 107:415–422

Cox proportional analysis for significant AS

	Odds ratio	95% CI	*P* value
Univariate analysis			
Diabetes mellitus	3.4	1.5–6.1	0.01
Increased PWV	3.1	1.4–9.0	0.01
Systemic hypertension	2.6	1.3–6.6	0.01
Severe CAD (two-vessel disease)	2.2	1.5–4.7	0.03
Increased AV calcification	2.2	1.3–2.9	0.01
Lower LV ejection fraction	2.0	0.8–3.8	0.1
Increased age	1.7	0.8–3.8	0.2
Multivariate analysis			
Increased PWV	3.0	1.3–9.9	0.01
Diabetes mellitus	2.3	1.6–10.5	0.01
Systemic hypertension	2.2	1.1–5.2	0.03

CI, confidence interval.

Clinical Science 2004; 107:415–422

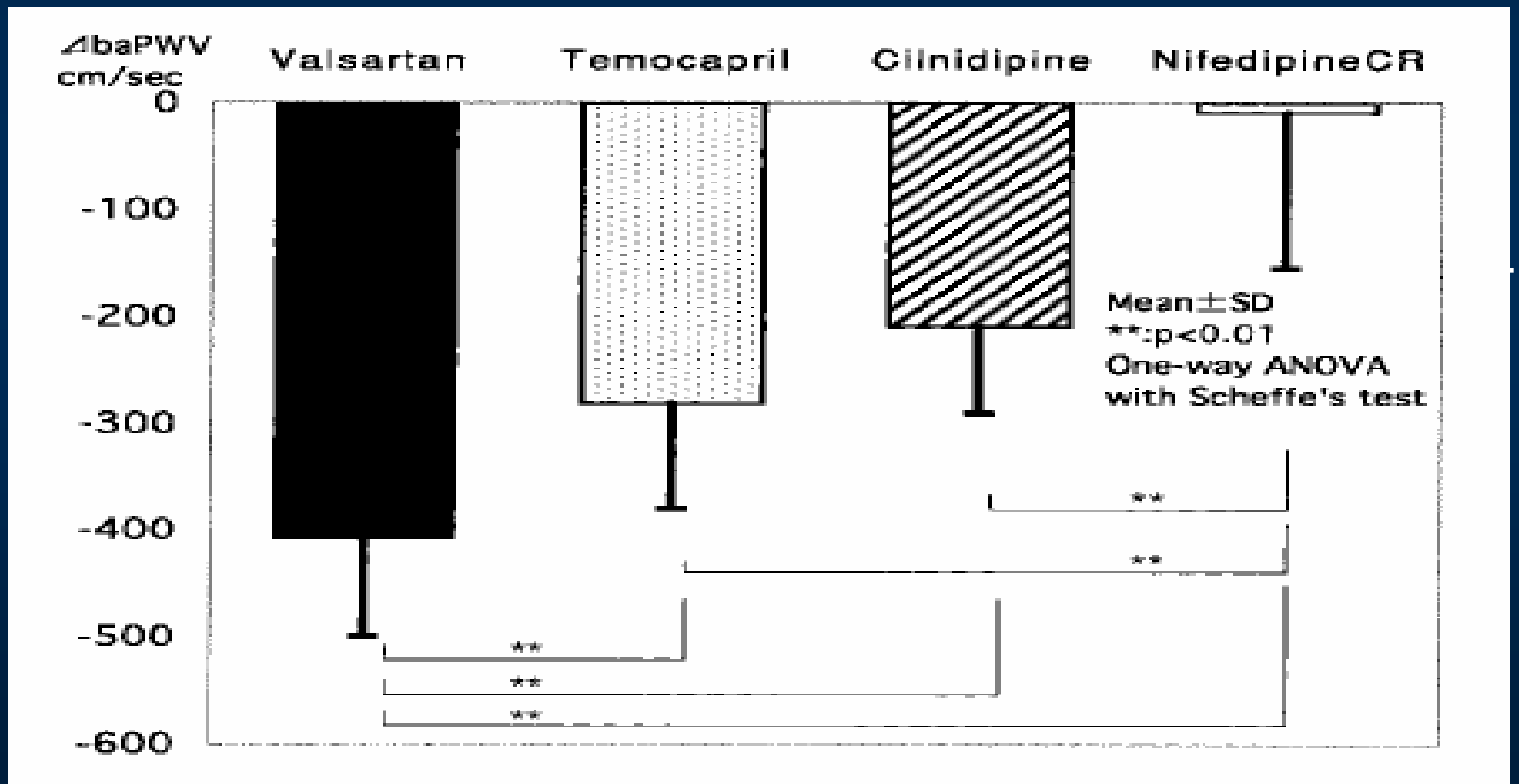

Arterial stiffness
Risk factors
;DM, salt, obesity, smoking
Central Aortic press
Local PP
DBP
SBP
Carotid Atherosclerosis
Renal Atherosclerosis
Coronary perfusion
LVH, EF
CHD, CHF, Arrhythmia, AS
Stroke
ESRD

Optimal treatment of Aortic Stiffness

Various Antihypertensives ; Changes in Vascular Stiffness

ARB	ACEI	Cilnidipine	L형 CCB
409 ± 90cm/s	281 ± 99cm/s	209 ± 82cm/s	9 ± 146cm/s

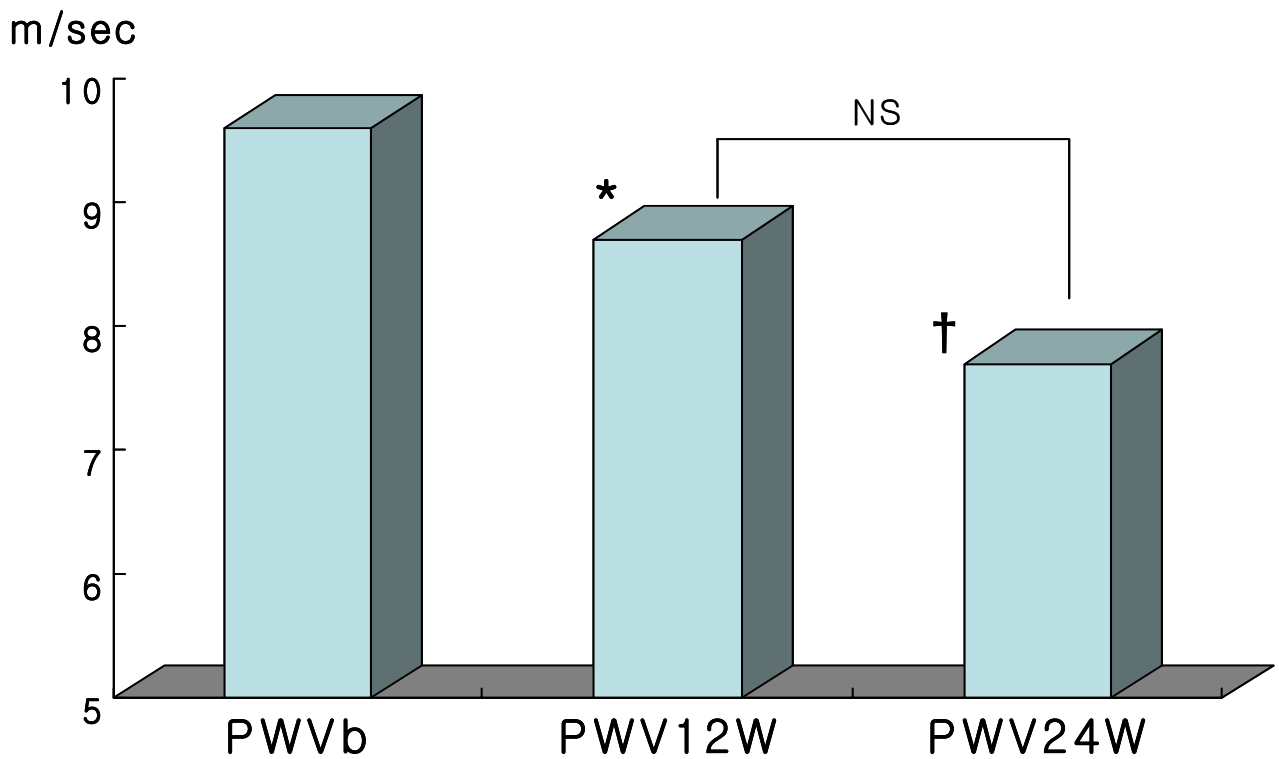
ΔbaPWV (cm/sec)



Hypertension research. 2003;26:609-614

ARB on PWV

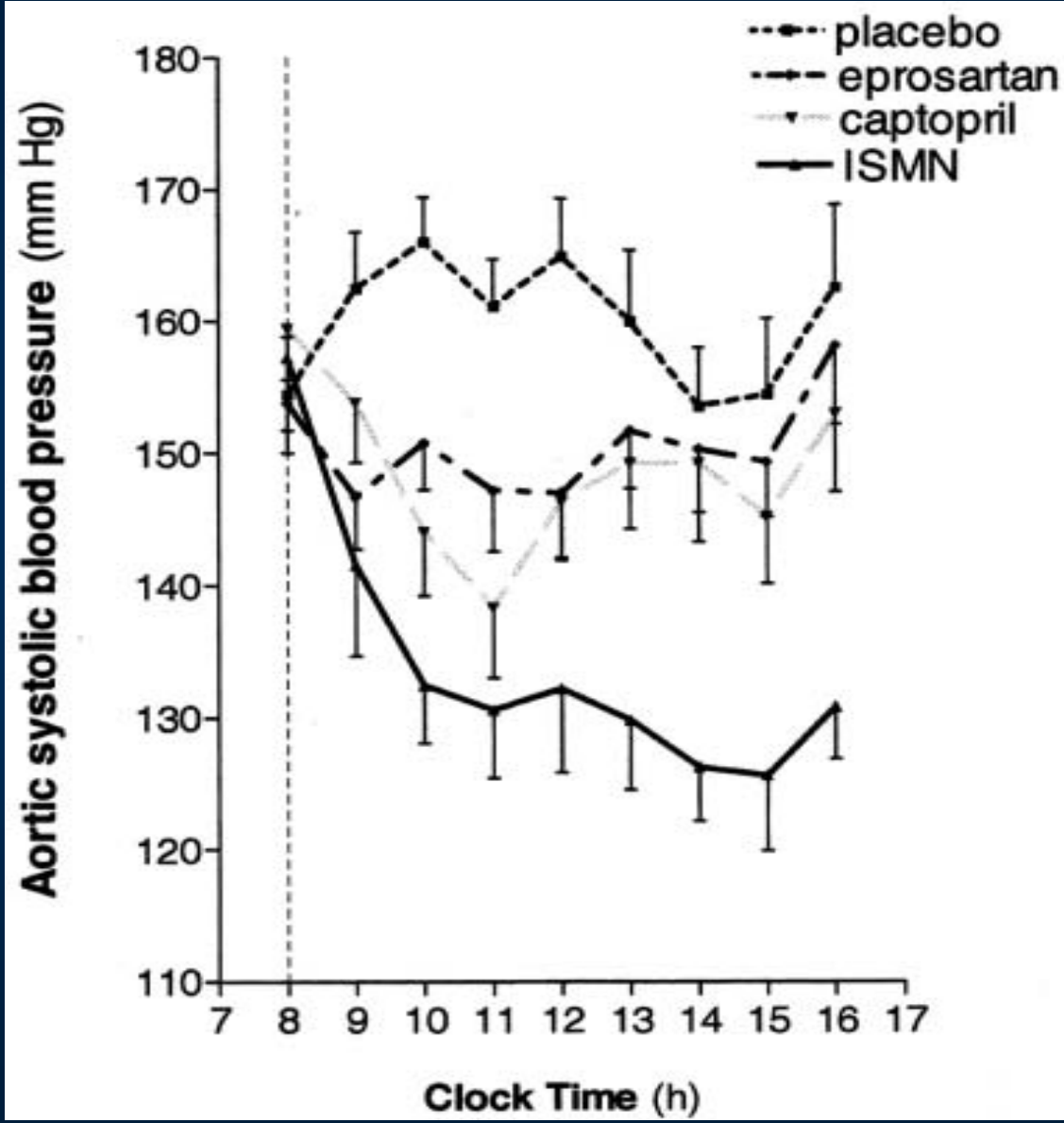
Figure 2. Change of PWV after Irbesartan treatment

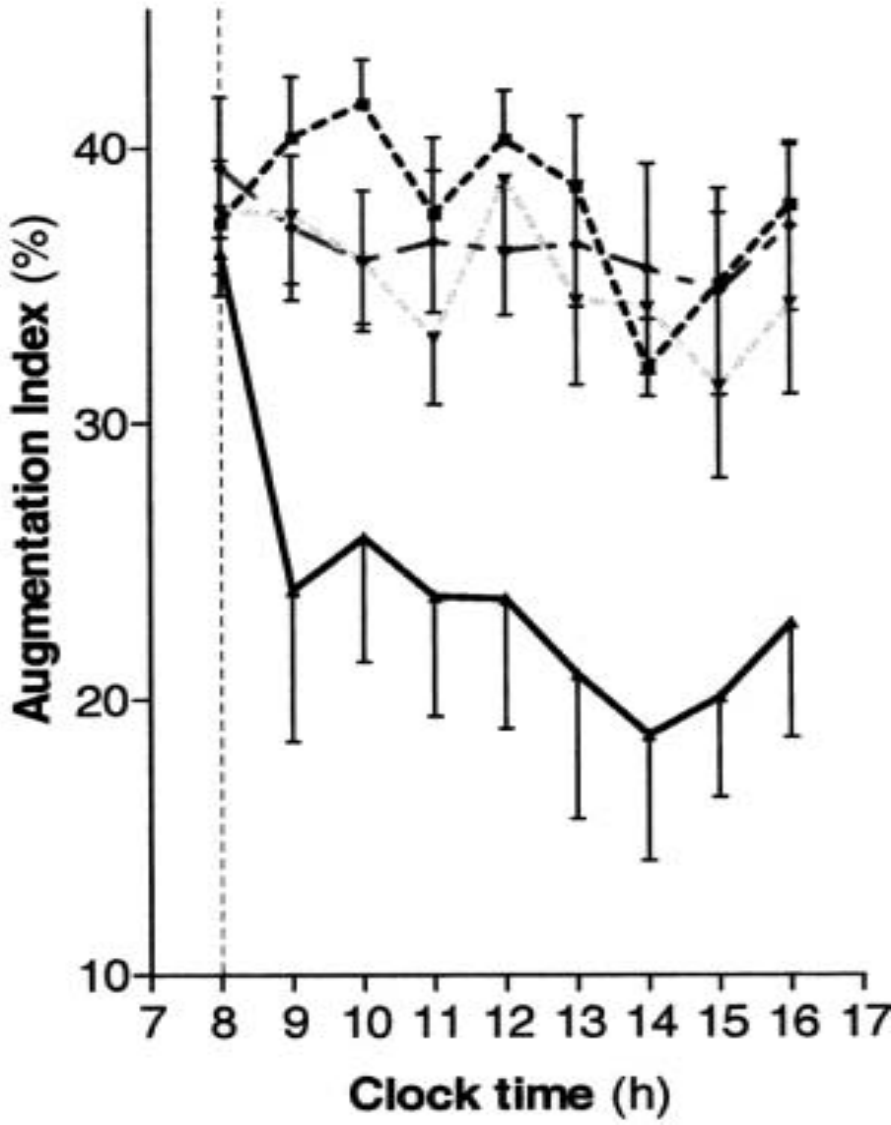


PWVb:before Irbesartan treatment, PWV12W:after 12 weeks of Irbesartan treatment, PWV12W:after 12 weeks of Irbesartan reatment
* : p=0.06 compared to PWVb, † : p=0.007 compared to PWVb, NS:p>0.05

Park CG et al. J Hypertension 2003

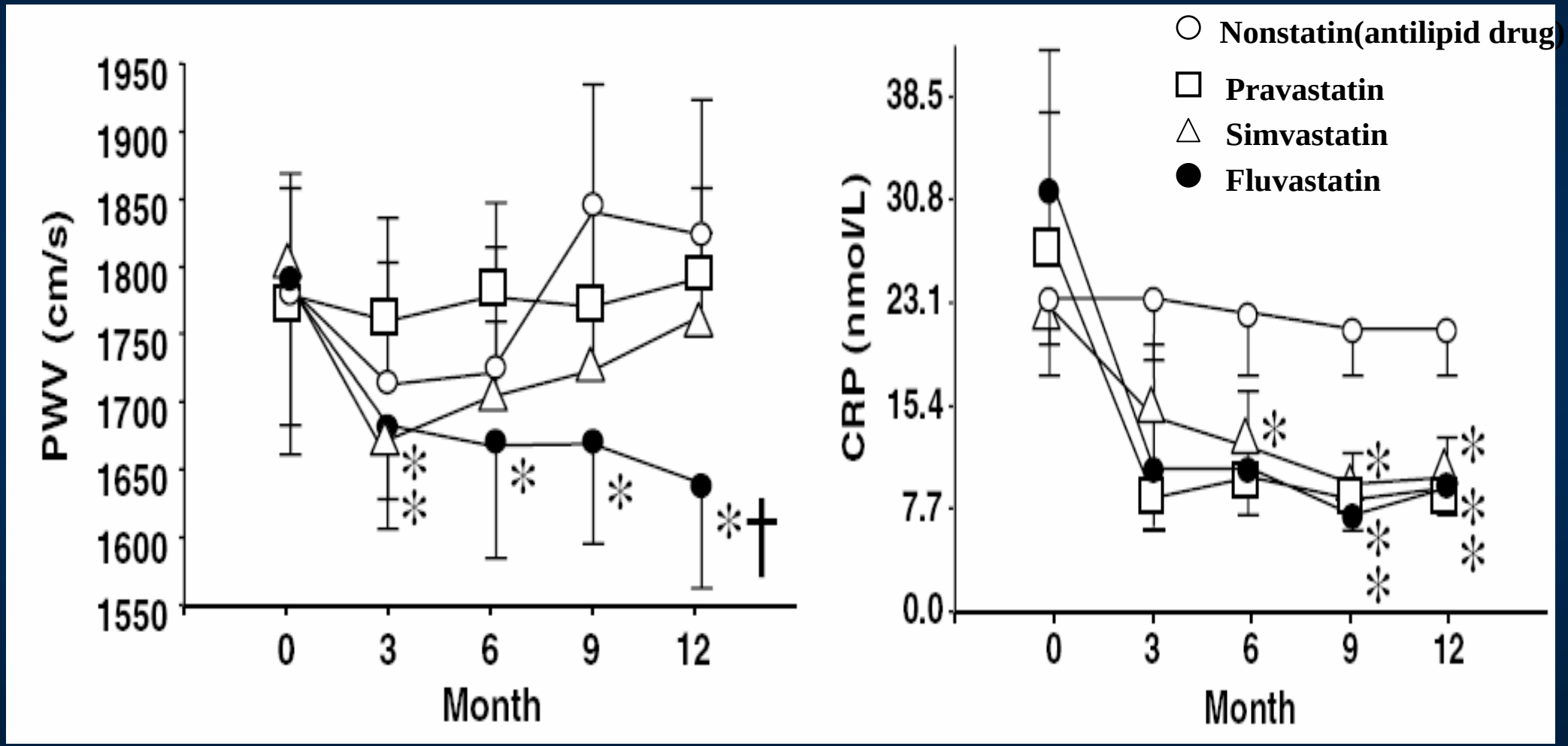
Effects of Isosorbide Mononitrate and AII Inhibition on Pulse Wave Reflection in Hypertension(SBP>150, DBP<100)





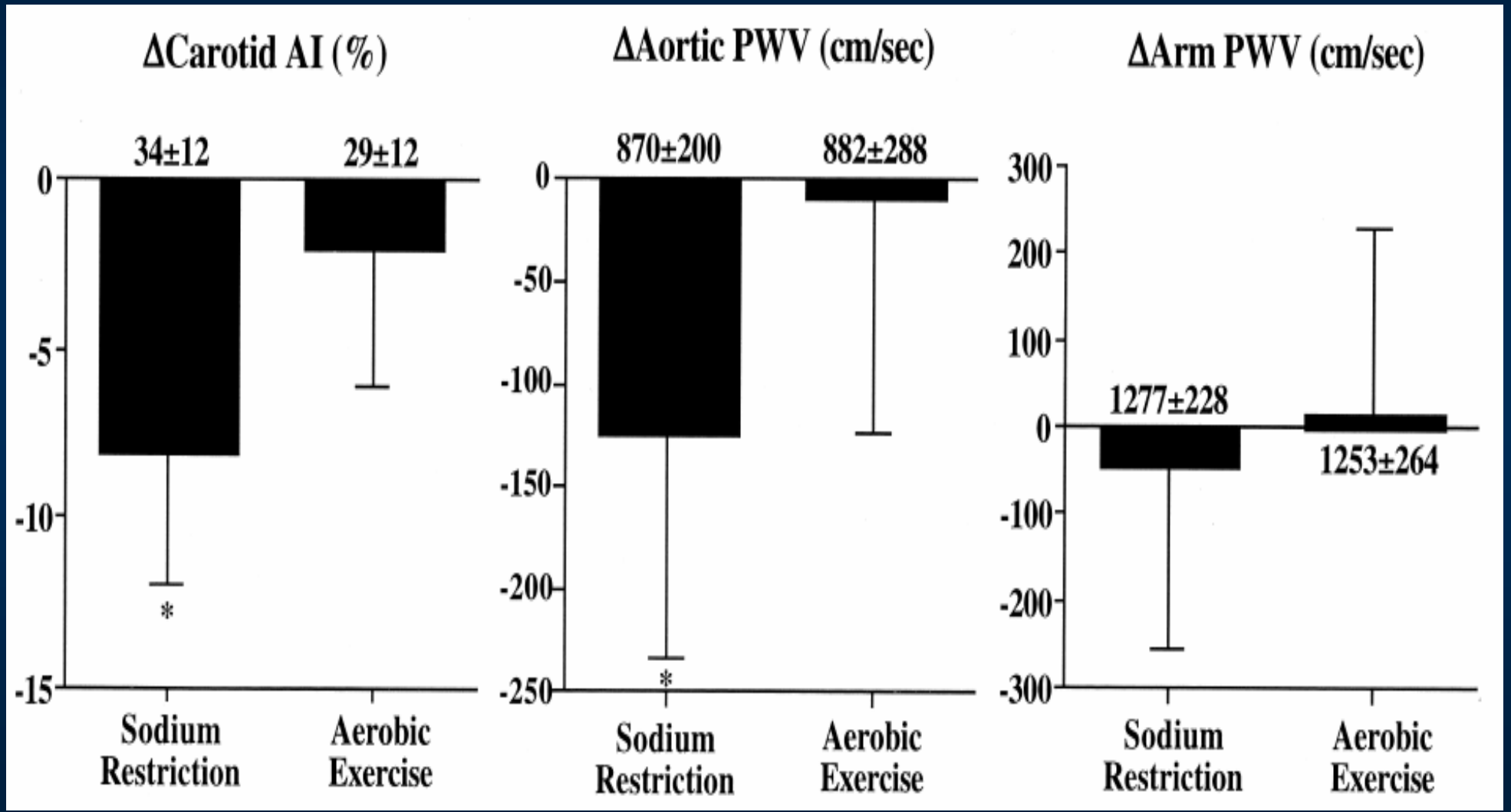
Hypertension. 2003;41:297

Statin and PWV



Journal of Human Hypertension (2005) 19, 103–109

Aortic Stiffness: Na Reduction and Exercise



JACC 2001;38: 506-13

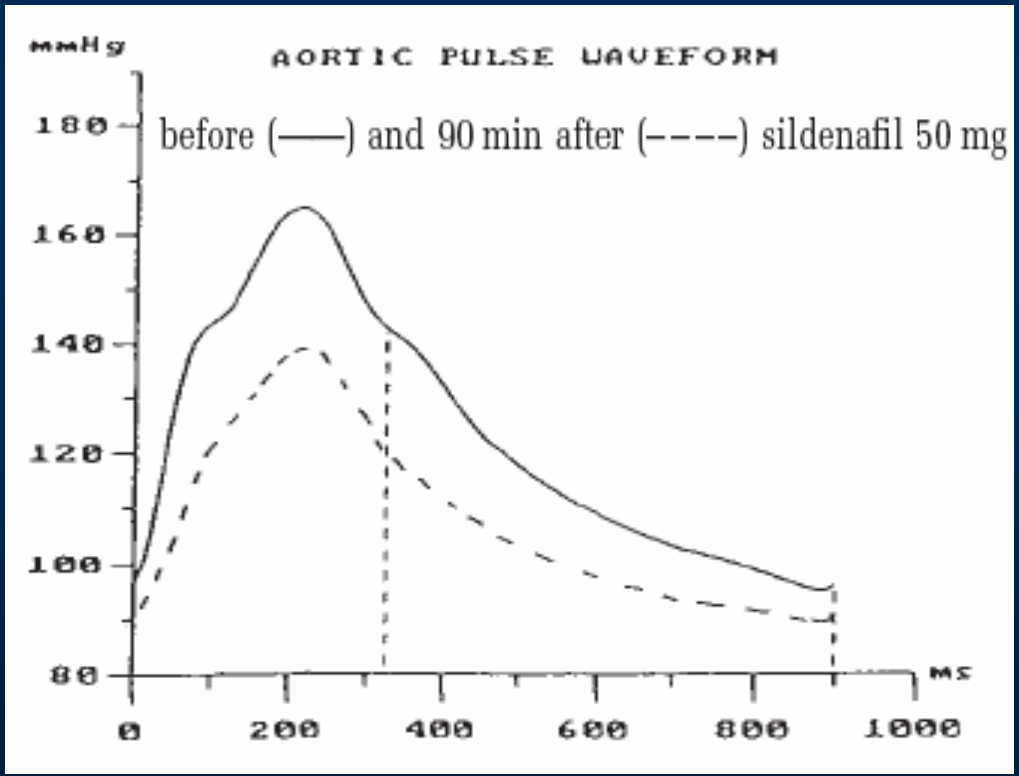
Journal of Human Hypertension (2001) 15, 707–713

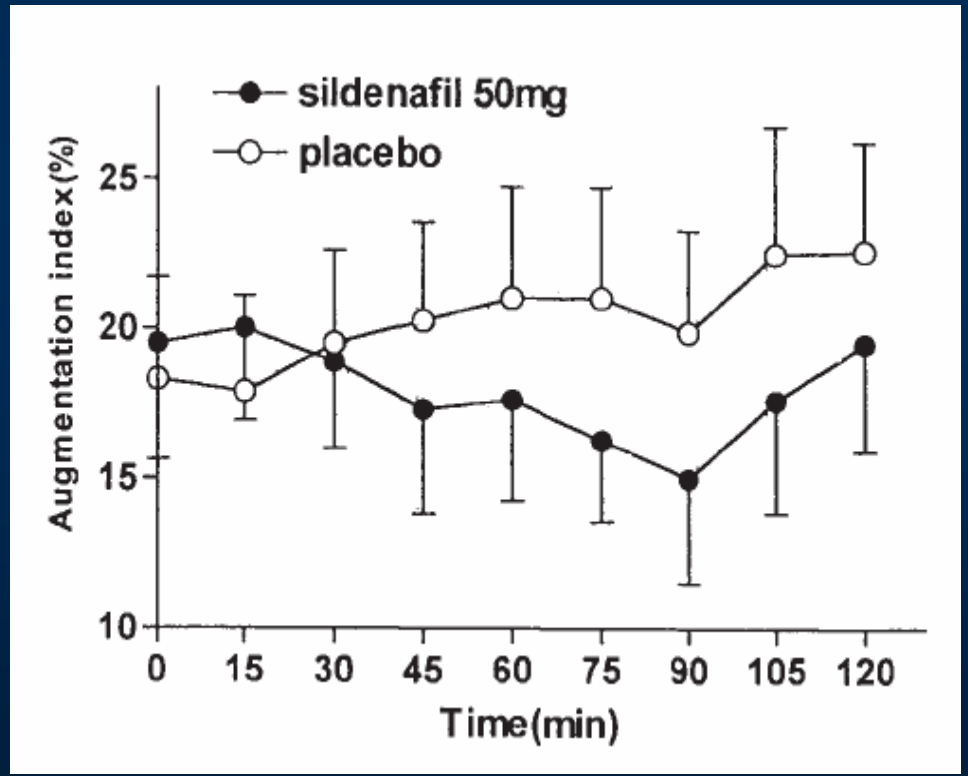
www.nature.com/jhh

ORIGINAL ARTICLE

Effect of sildenafil on blood pressure and arterial wave reflection in treated hypertensive men

A Mahmud, M Hennessy and J Feely
Department of Pharmacology and Therapeutics, Trinity Centre and Hypertension Clinic, St. James's Hospital, Dublin 8, Ireland





J Hum Hyperten 2001;**15**, 707-713

Effect of various medications on aortic stiffness

- **ARBs**
- **ACEIs**
- **Nitrates**
- **Statin**

→ favorable ←

- **Salt restriction**

- **VPIs**
- **Spironolactone**
- **Sildenafil**

→ promising ←

- **Exercise**
- **Weight loss**

- **Beta-blockers** → Not effective