Arterial Pressure in CKD5 - ESRD Population

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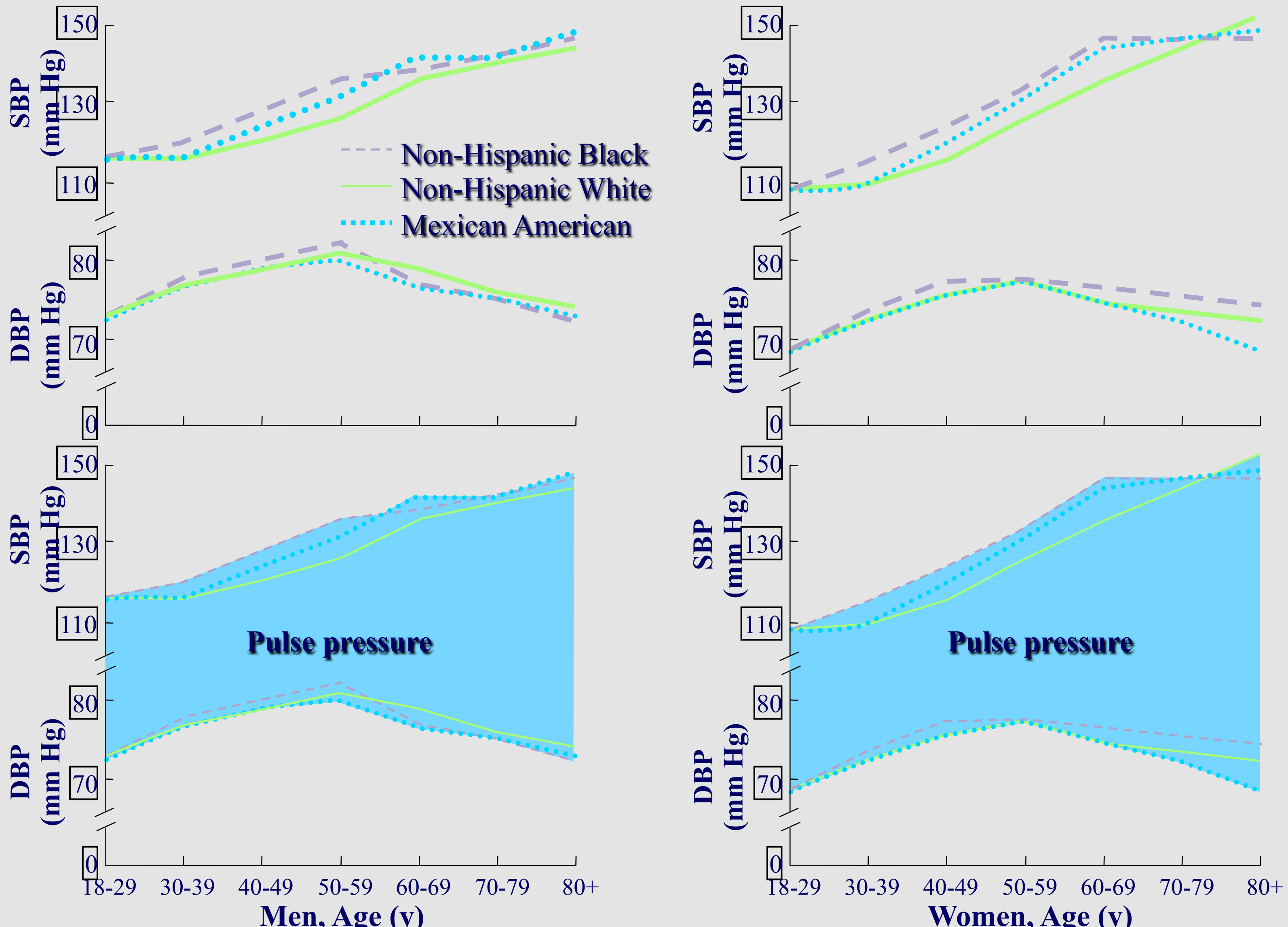
INSERM U970

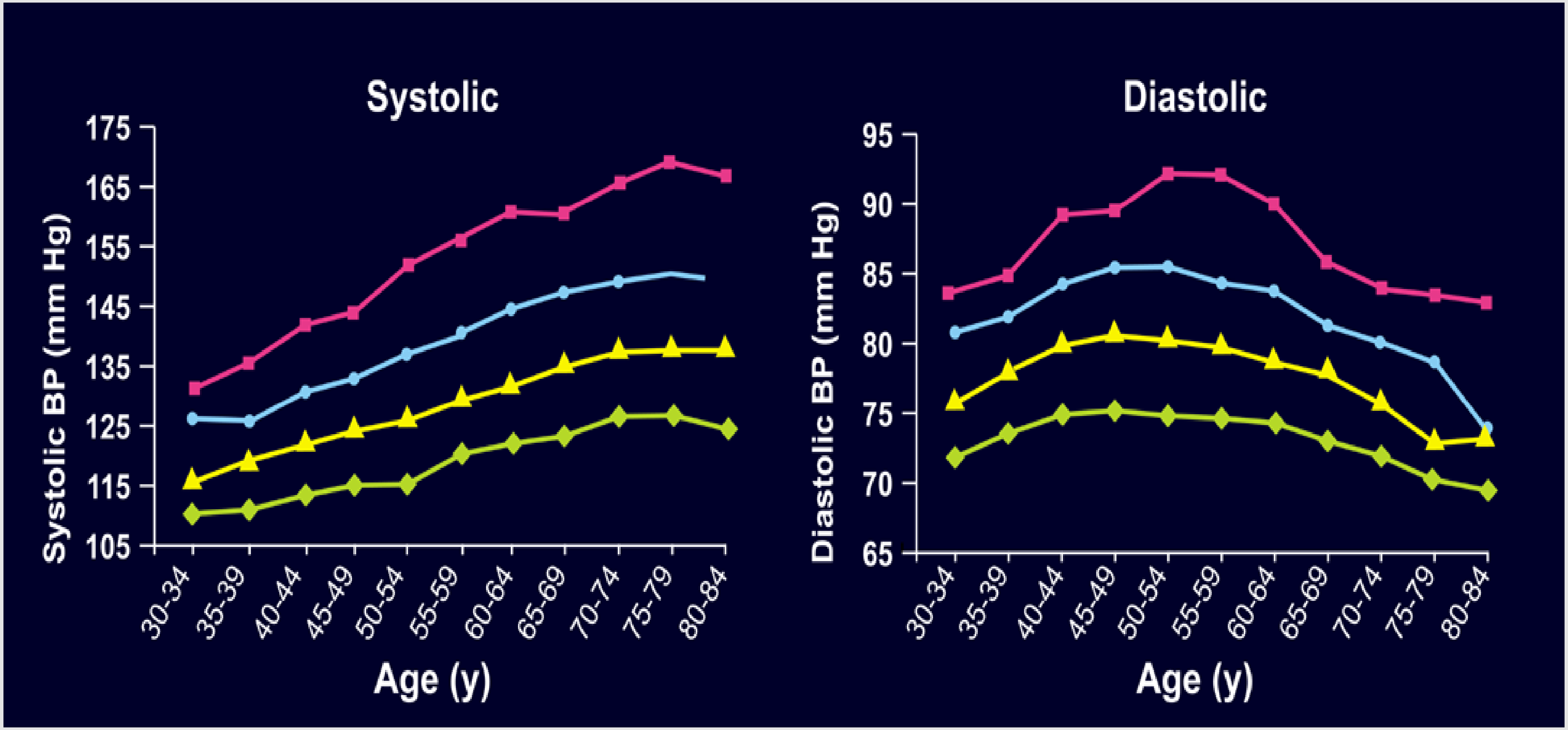
Paris

SBP & DBP by Age, Ethnicity &Gender
(US Population ≥Age 18 Years, NHANES III)



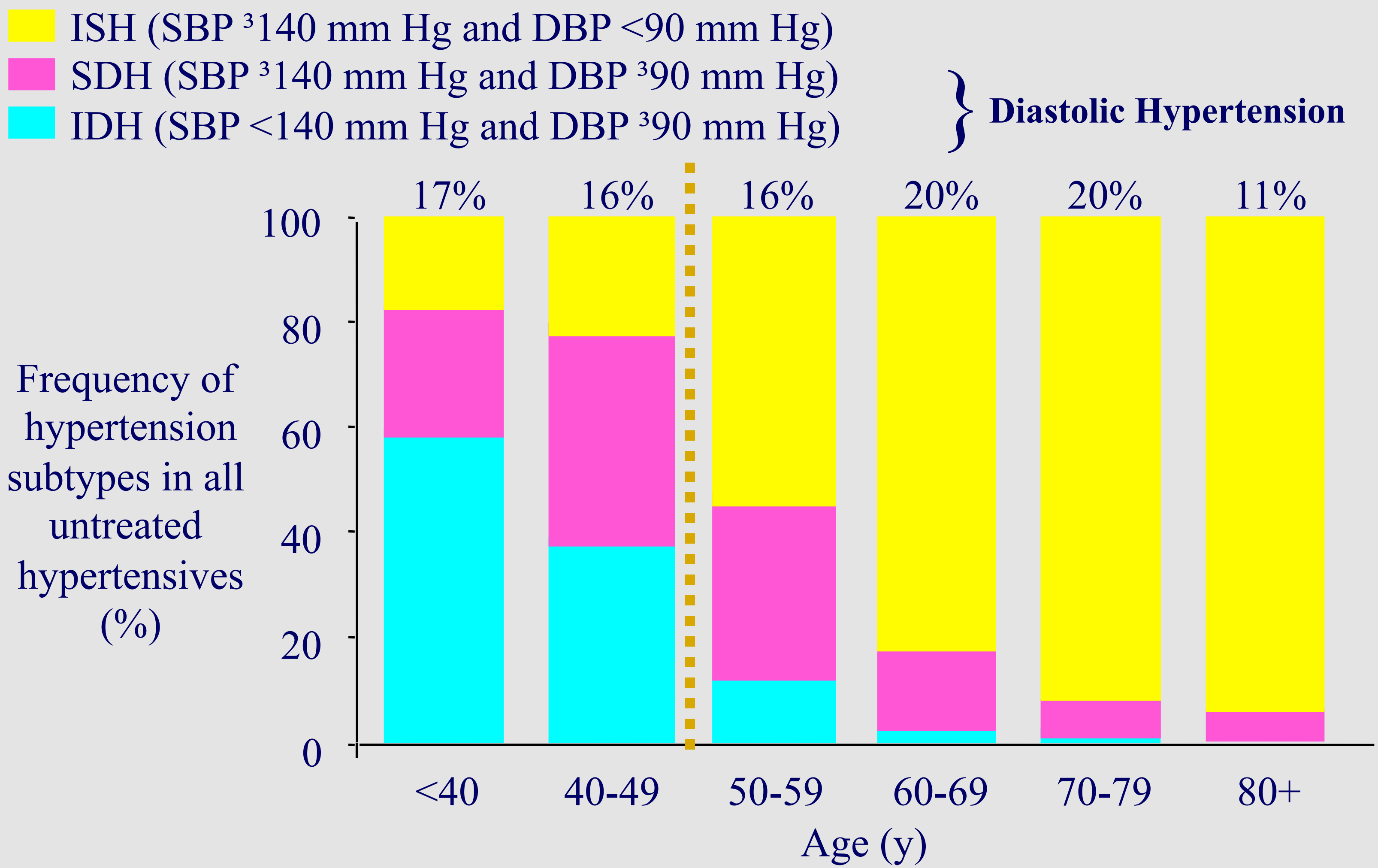
Burt VI, et al. *Hypertension*. 1995;25:305-313.

Evolution of Untreated Systolic and Diastolic BP: The Framingham Heart Study. Adapted from Franklin et al. *Circulation* 1997;96:308.



≥160
140-159
120-139
<120

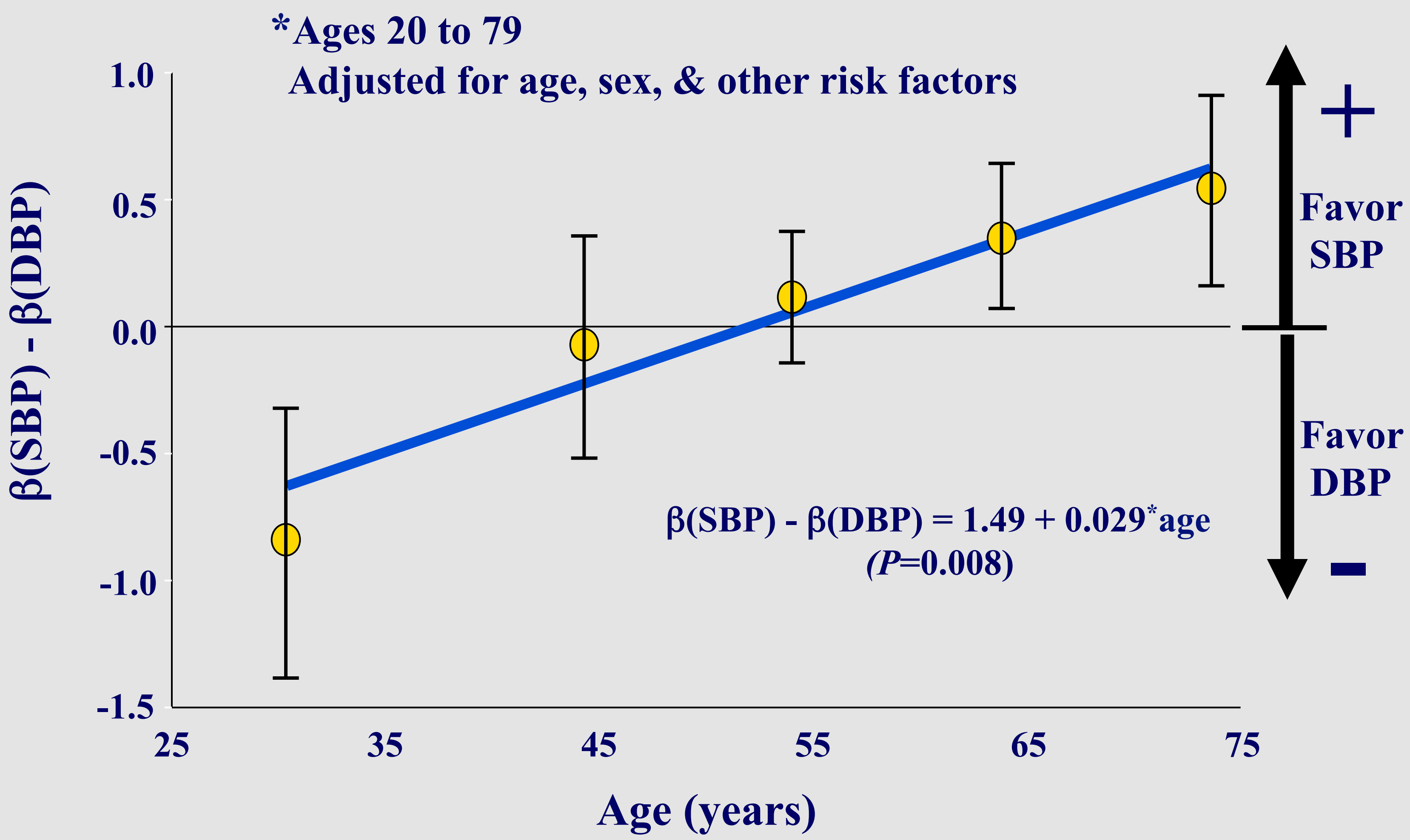
Distribution of Hypertension Subtype in the untreated Hypertensive Population in NHANES III by Age



Numbers at top of bars represent the overall percentage distribution of untreated hypertension by age.

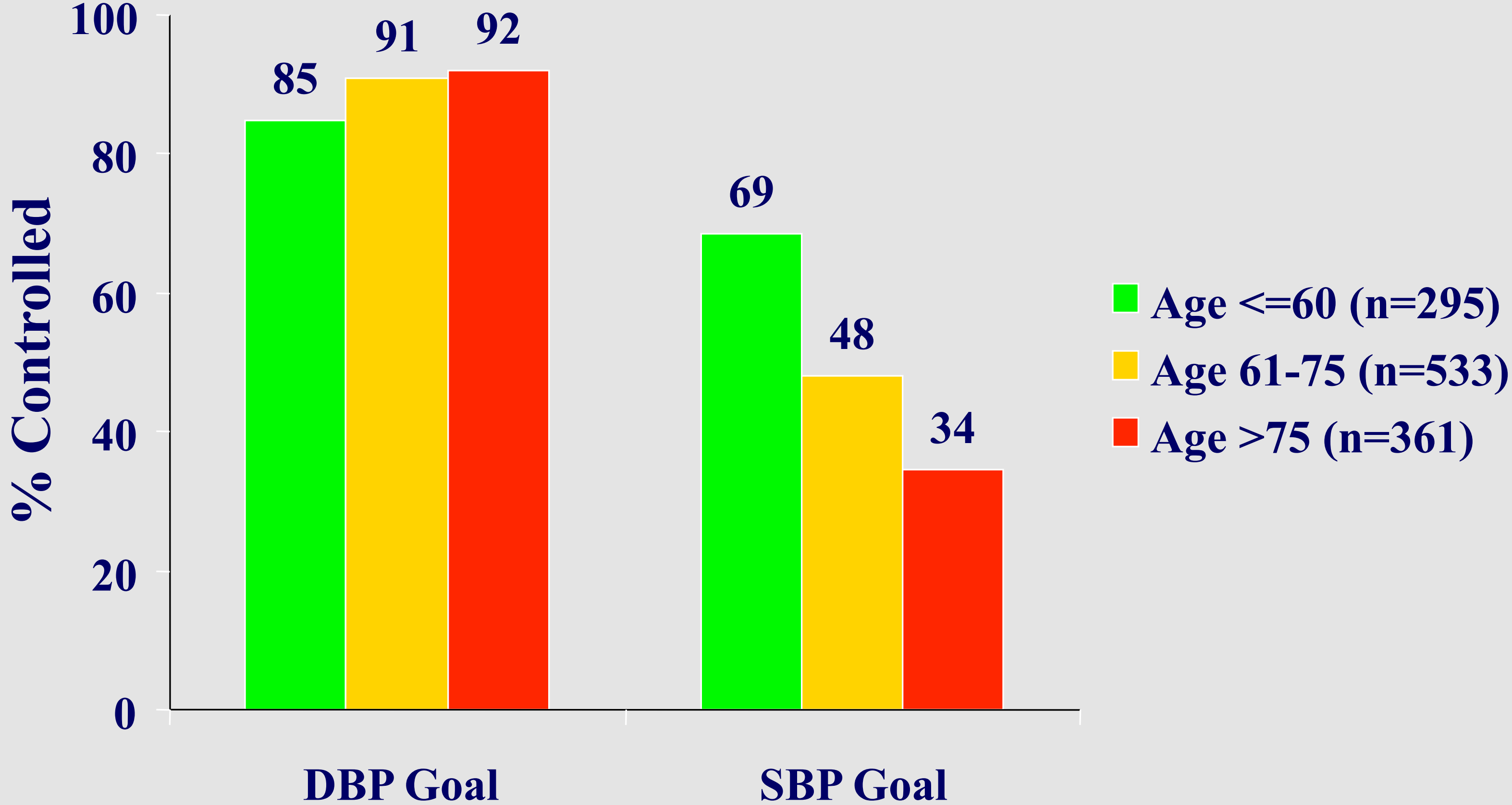
Franklin et al. *Hypertension 2001;37: 869-874.*

Difference Between SBP and DBP in CHD Prediction, as a Function of Age*



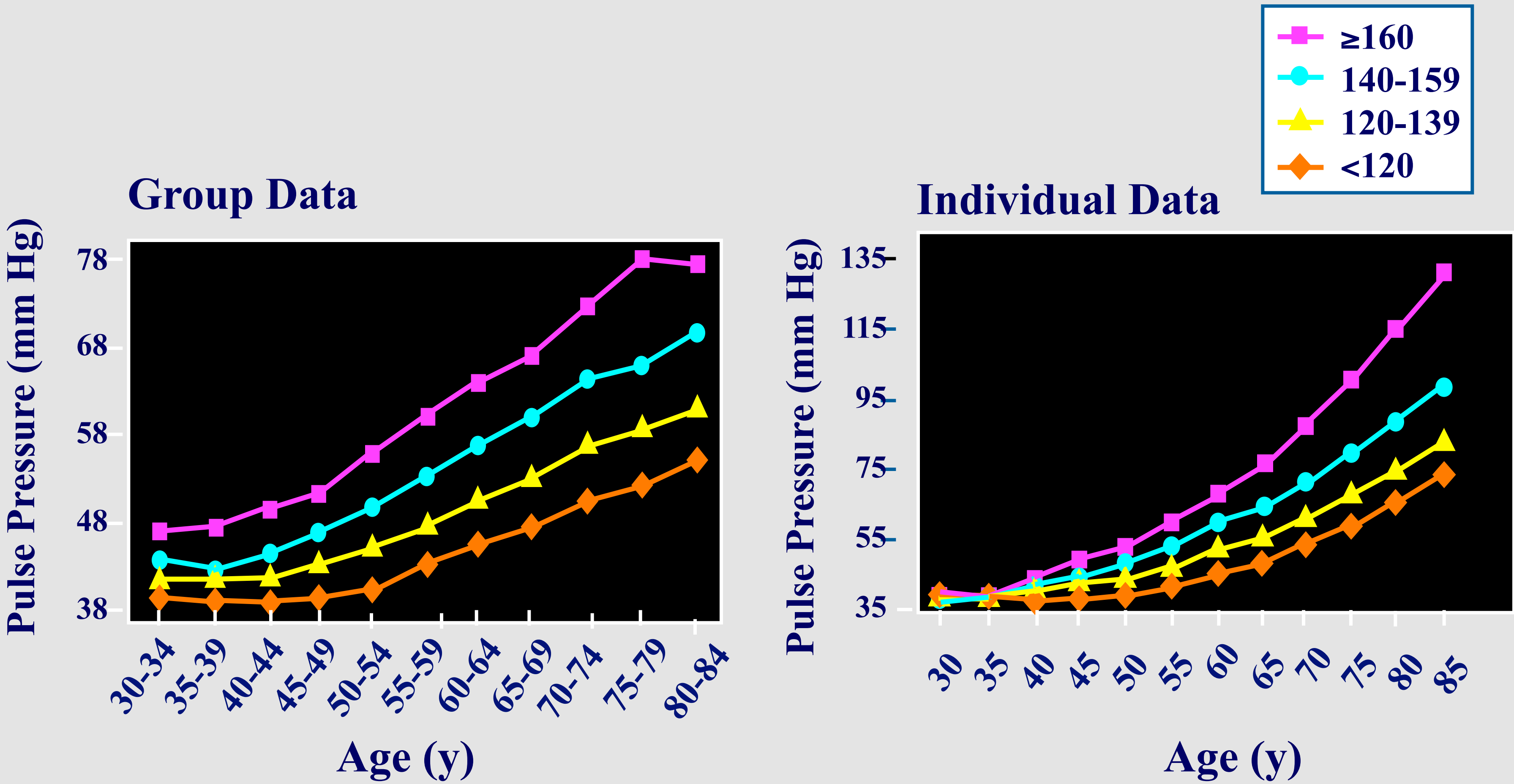
Franklin et al. *Circulation* 2001;103:1245-1249

Hypertension Control by Age Group



Cross-sectional analysis among 1189 treated hypertensive subjects from Framingham
Lloyd-Jones Hypertension 2000;36:594

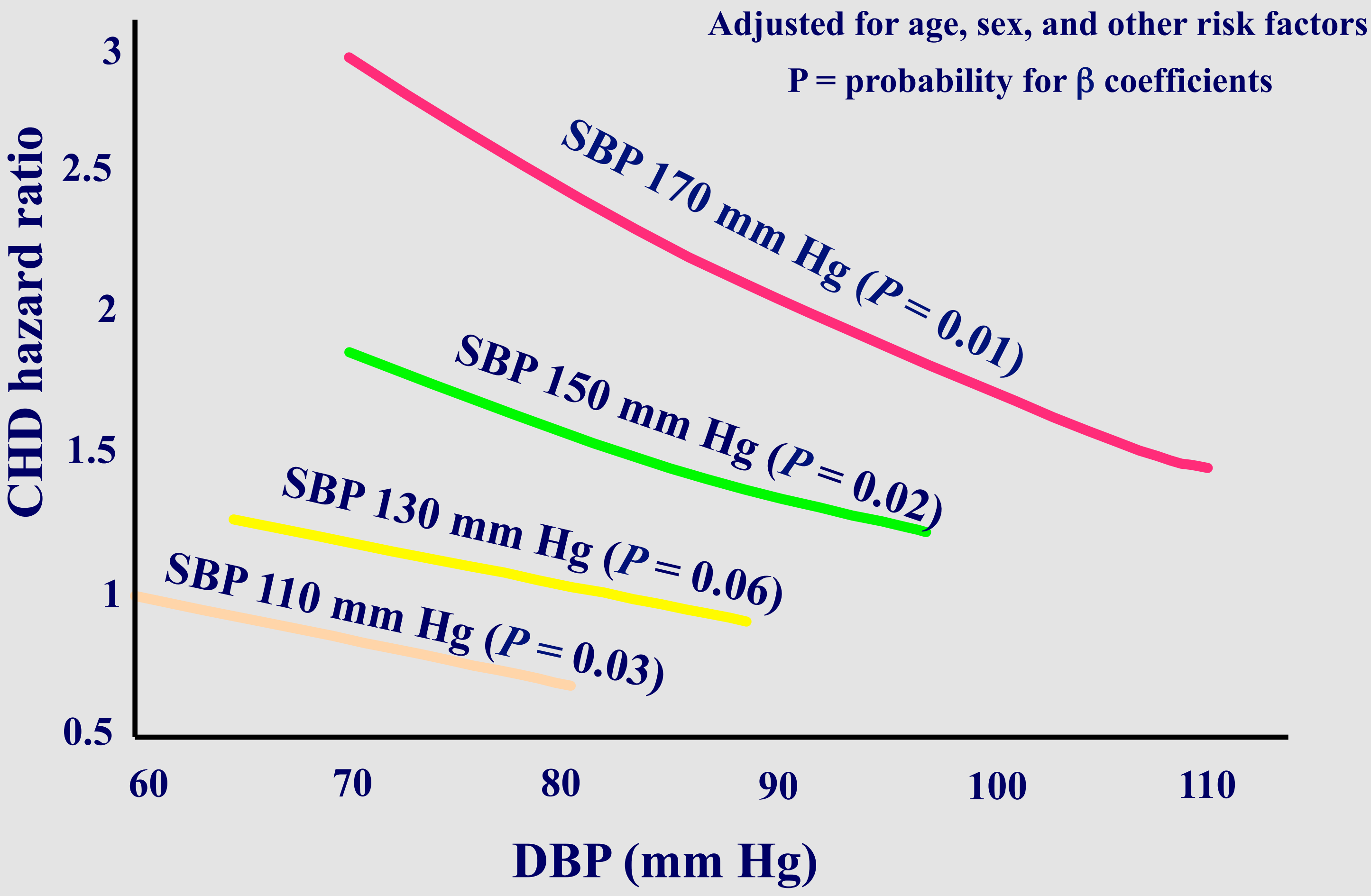
Steep Rise in Pulse Pressure With Increasing Age
Data From the Framingham Study



n=2036

Franklin SS et al. *Circulation* 1997;96:308-315.

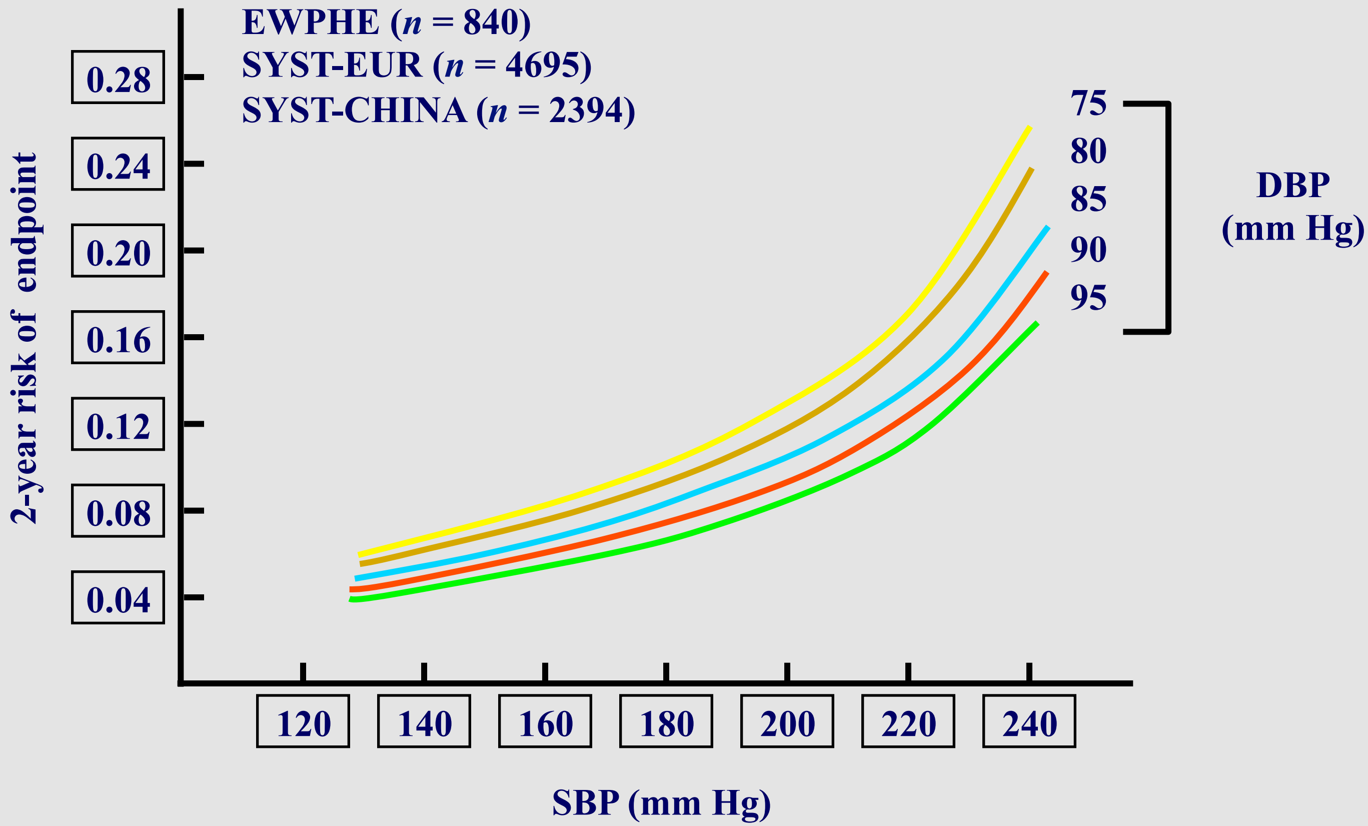
Relationship of SBP and DBP to risk for CHD in a dual component model: The Framingham Heart Study



Franklin SS, et al. *Circ.* 1999;100:354.

Mean age = 61 years (range: 50-79), n = 1924

Cardiovascular Risk Associated with Increasing SBP at Fixed Values of DBP



Two-year risk adjusted for active treatment, sex, age, previous CV complications, and smoking by multiple Cox regression.

Staessen, et al. *Lancet.* 2000;355:865–872.

Blood Pressure and CHD Risk
Dual BP Component Models

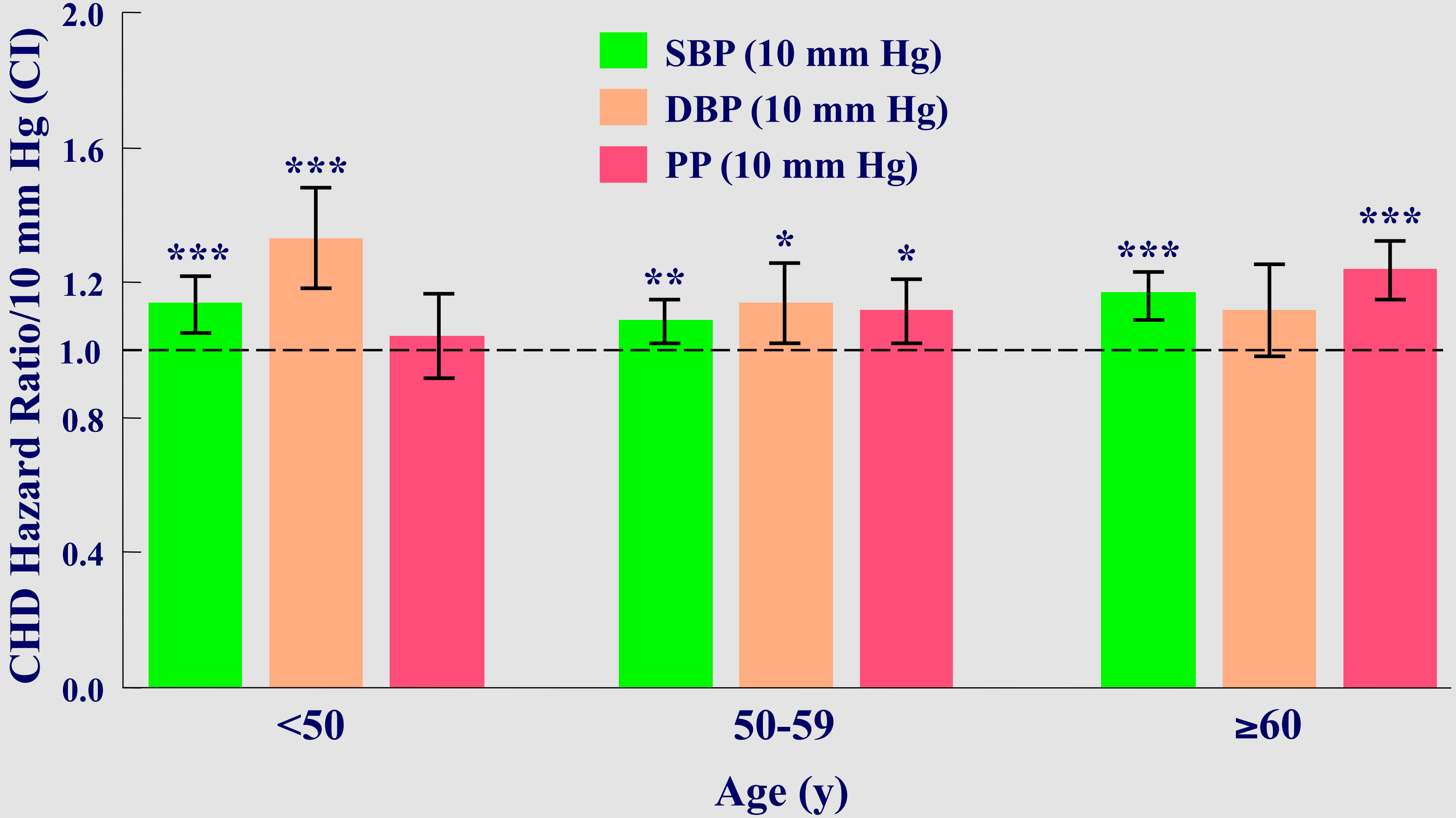
	Chi Sq.	Hazard Ratio	P Value
Model 1			
SBP	35.6	1.22 (1.15-1.30)	<0.001
DBP	5.2	0.86 (0.75-0.98)	<0.05
Model 2			
DBP	0.7	1.04 (0.94-1.16)	NS
PP	35.6	1.22 (1.15-1.30)	<0.001

Hazards per 10 mm Hg increment

Adjusted for age, sex, smoking, ECG-LVH, BMI, glucose intolerance, total/HDL cholesterol

Franklin et al. Circulation 1999;100:354

Blood Pressure and Risk for CHD by Age Groups: Results of a Single BP Component† Model



† Adjusted for age, sex, and other risk factors   ****P*<0.1, ***P*<0.01, ****P*<0.001

Franklin SS, et al. Circulation 2001;103:1245-1249.

Evolution of Systolic and Diastolic BP in CKD patients

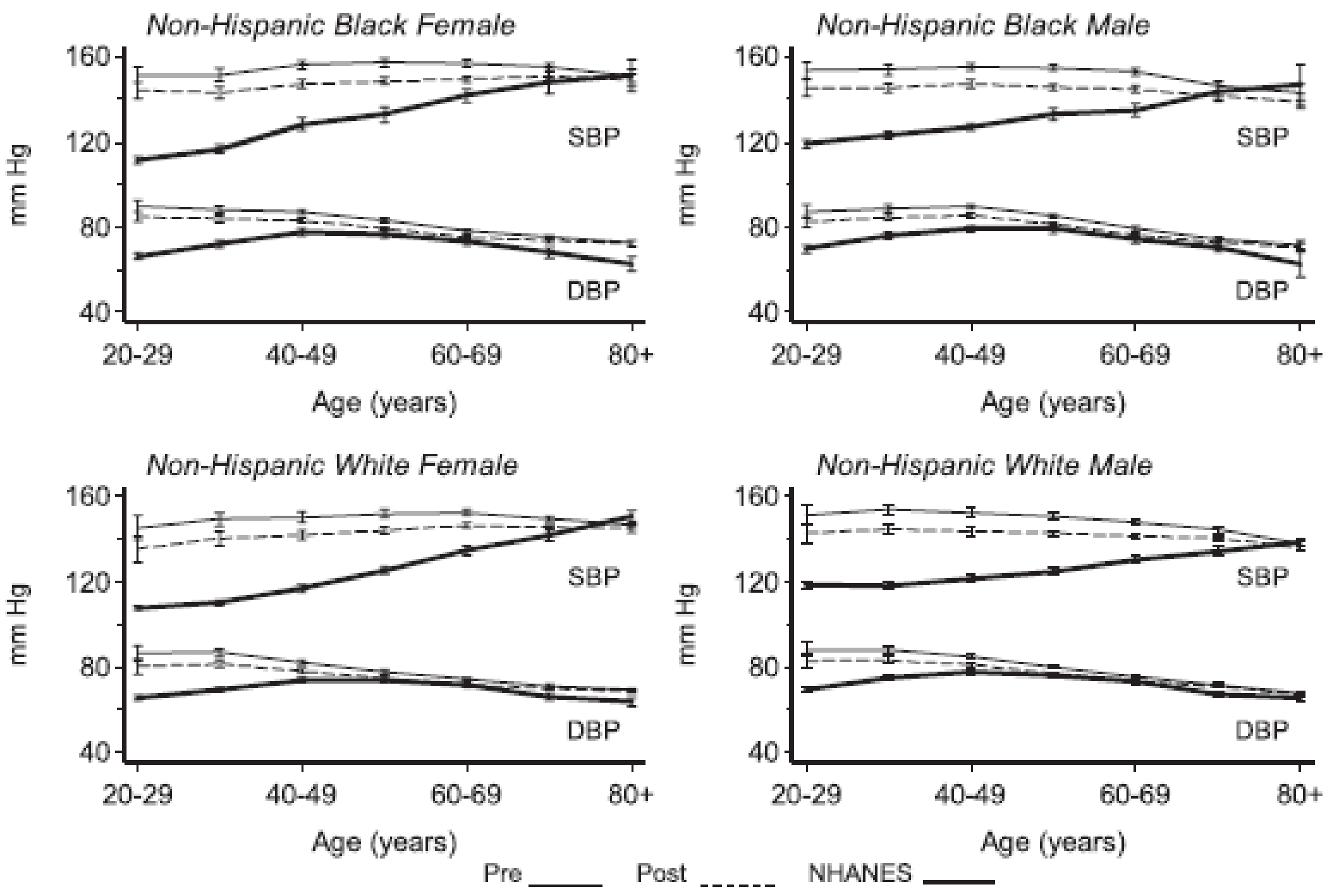


Figure 1. Systolic and diastolic BP *versus* age in the DCI and NHANES populations.

Rohrscheib MP et al CJASN 2008;3:1407

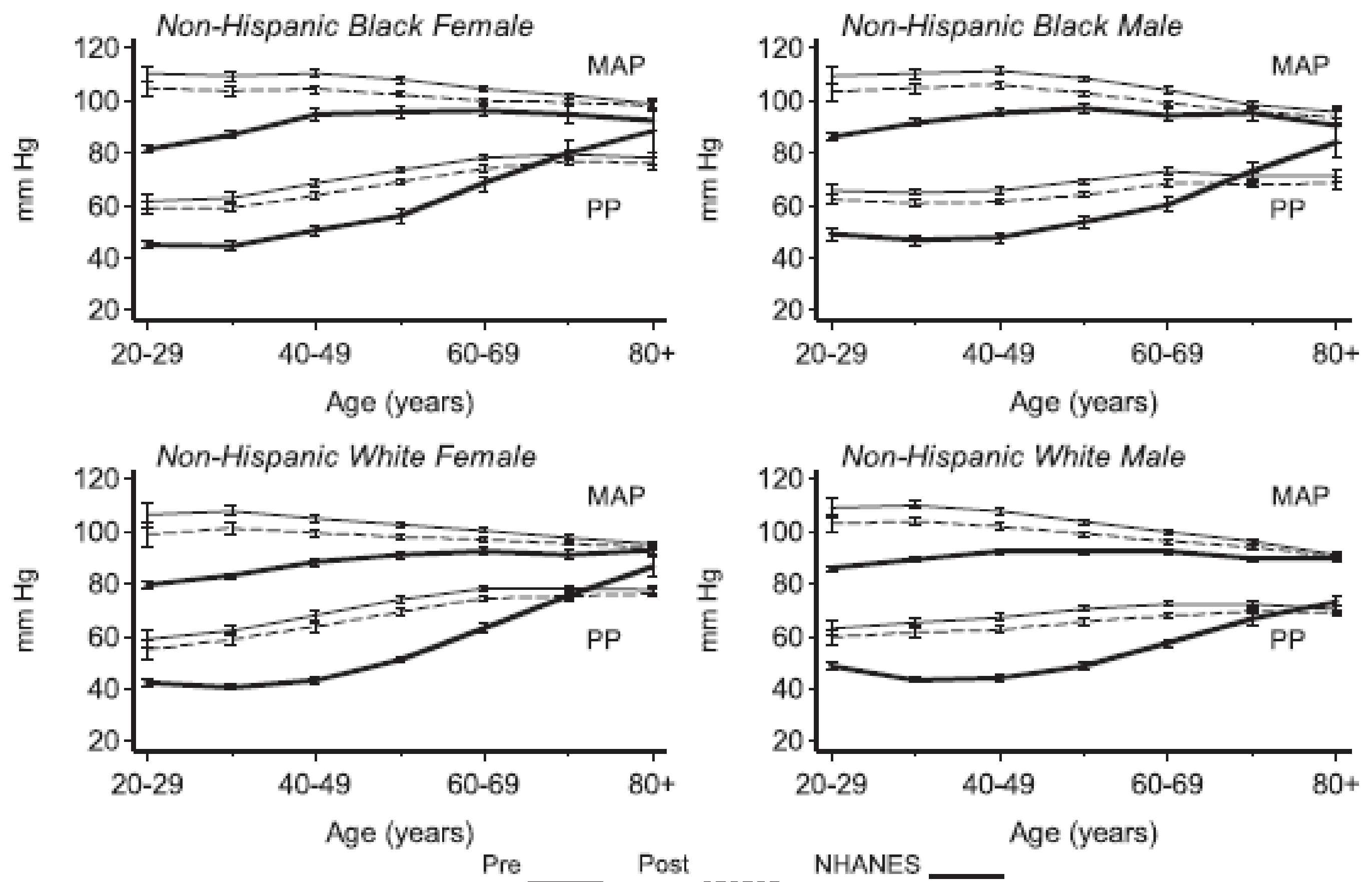


Figure 2. MAP and PP *versus* age in the DCI and NHANES populations.

Rohrscheib MP et al CJASN 2008;3:1407

Table 1. Description of Clinical Cohort*

Variable	Study Population: All	Study Population: Complete Follow-up	Study Population: Partial Follow-up	Excluded
Total number of patients	37 069	31 176	5893	7000
Sex, %				
Men	51.3	51.0	52.8	51.9
Women	48.7	49.0	47.2	48.1
Age, y	60.1 (15.1)	60.5 (14.8)	58.0 (16.3)	60.3 (15.6)
Race, %				
White	49.9	48.5	56.9	53.2
Black	43.4	44.6	36.9	38.4
Asian	1.1	1.3	1.5	1.1
Native American	0.7	0.7	0.7	0.5
Other	4.9	4.7	4.0	6.8
Diabetes mellitus, %				
Present	47.9	48.1	46.9	46.6
Absent	52.1	51.9	53.1	53.4
Duration of dialysis prior to study entry, y	3.4 (3.6)	3.5 (3.7)	2.8 (3.2)	3.7 (3.9)
Laboratory measurements				
Creatinine, mg/dL†	9.6 (3.3)	9.6 (3.2)	9.5 (3.5)	9.4 (3.4)
Albumin, g/dL	3.9 (0.4)	3.9 (0.4)	3.8 (0.4)	3.8 (0.4)
Hematocrit, %	33.3 (3.3)	33.3 (3.3)	33.1 (3.4)	33.0 (3.4)
Urea reduction ratio, %	68.7 (7.4)	68.8 (7.3)	67.8 (7.9)	68.1 (7.8)
Predialysis pressure, mm Hg				
Systolic	154.3 (20.4)	154.4 (20.4)	153.9 (20.4)	152.7 (19.8)
Diastolic	79.3 (11.2)	79.2 (11.1)	79.8 (11.3)	79.5 (10.9)
Pulse	75.0 (15.0)	75.2 (15.0)	74.1 (15.0)	73.2 (14.4)
Postdialysis pressure, mm Hg				
Systolic	139.6 (19.1)	139.5 (19.0)	140.2 (19.3)	140.0 (18.4)
Diastolic	72.7 (10.1)	72.6 (10.1)	73.5 (10.3)	73.9 (10.1)
Pulse	66.9 (13.9)	66.9 (13.8)	66.8 (14.2)	66.1 (13.4)

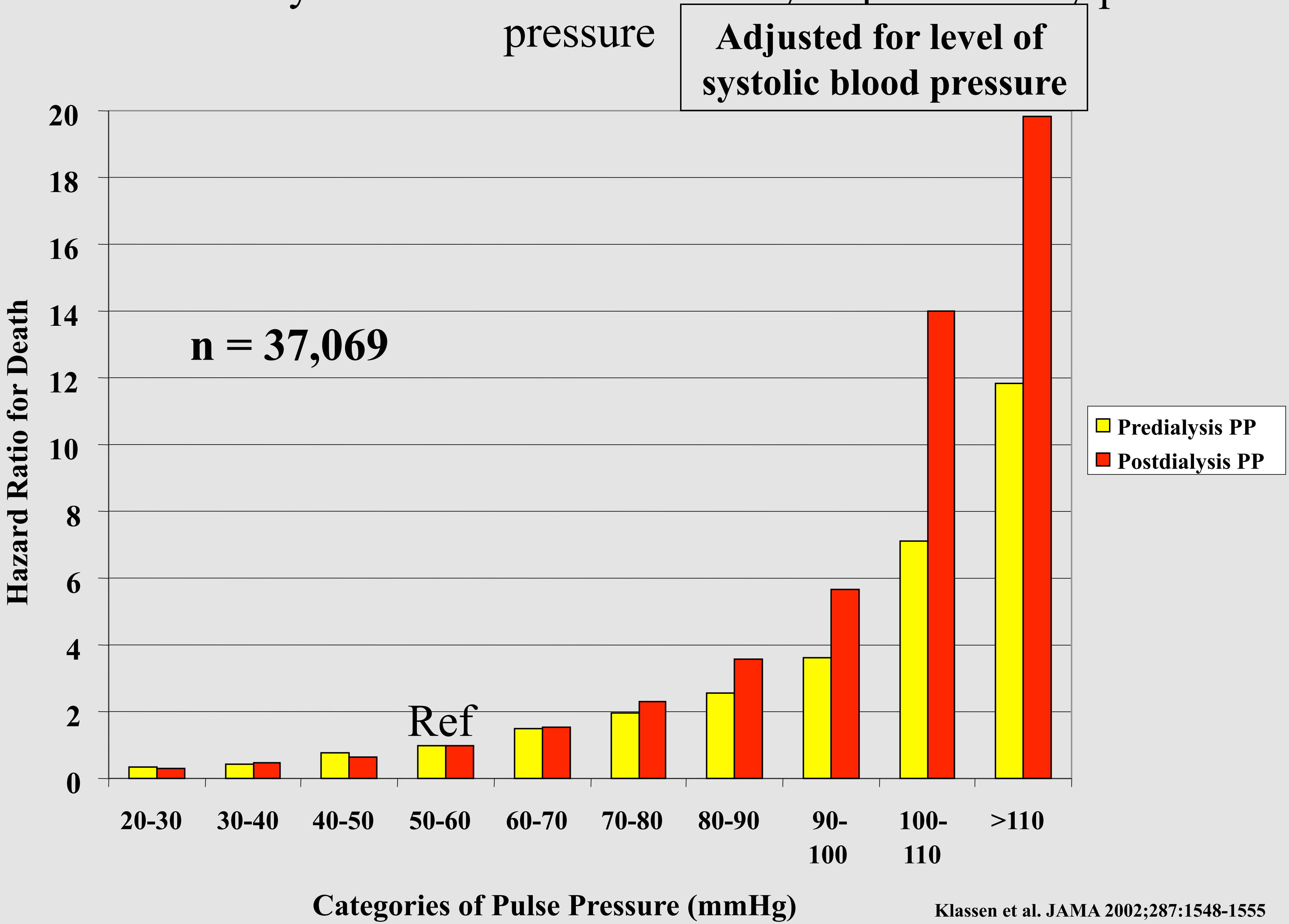
Klassen PS et a l. JAMA 2002;287:1548-55. n=37069

Table 1. Clinical characteristics of dippers and non-dippers

	Dippers ($n=24$)	Non-dippers ($n=56$)	P-value
Age (years)	63±11	59±10	0.51
Sex (males/females)	14/10	26/30	0.28
Duration of HD (years)	4.2±3.6	5.4±5.3	0.08
Diabetes [n (%)]	10 (42)	21 (37)	0.57
Hypertentives [n (%)]	12 (50)	31 (55)	0.84
Current smokers [n (%)]	11 (46)	20 (35)	0.55
Duration of follow-up (years)	3.4±1.8	2.5±1.4	0.02
Ambulatory BP (mmHg)			
Diurnal SBP	160±22	158±21	0.52
Diurnal DBP	83±14	81±12	0.51
Nocturnal SBP	136±21	164±24	<0.0001
Nocturnal DBP	75±12	82±11	0.01
24 h mean SBP	151±19	159±19	0.09
24 h mean DBP	81±10	82±10	0.93
Predialytic/clinic BP (mmHg)			
SBP	163±21	166±25	0.61
DBP	86±13	88±13	0.58
Pulse pressure	76±19	77±21	0.87

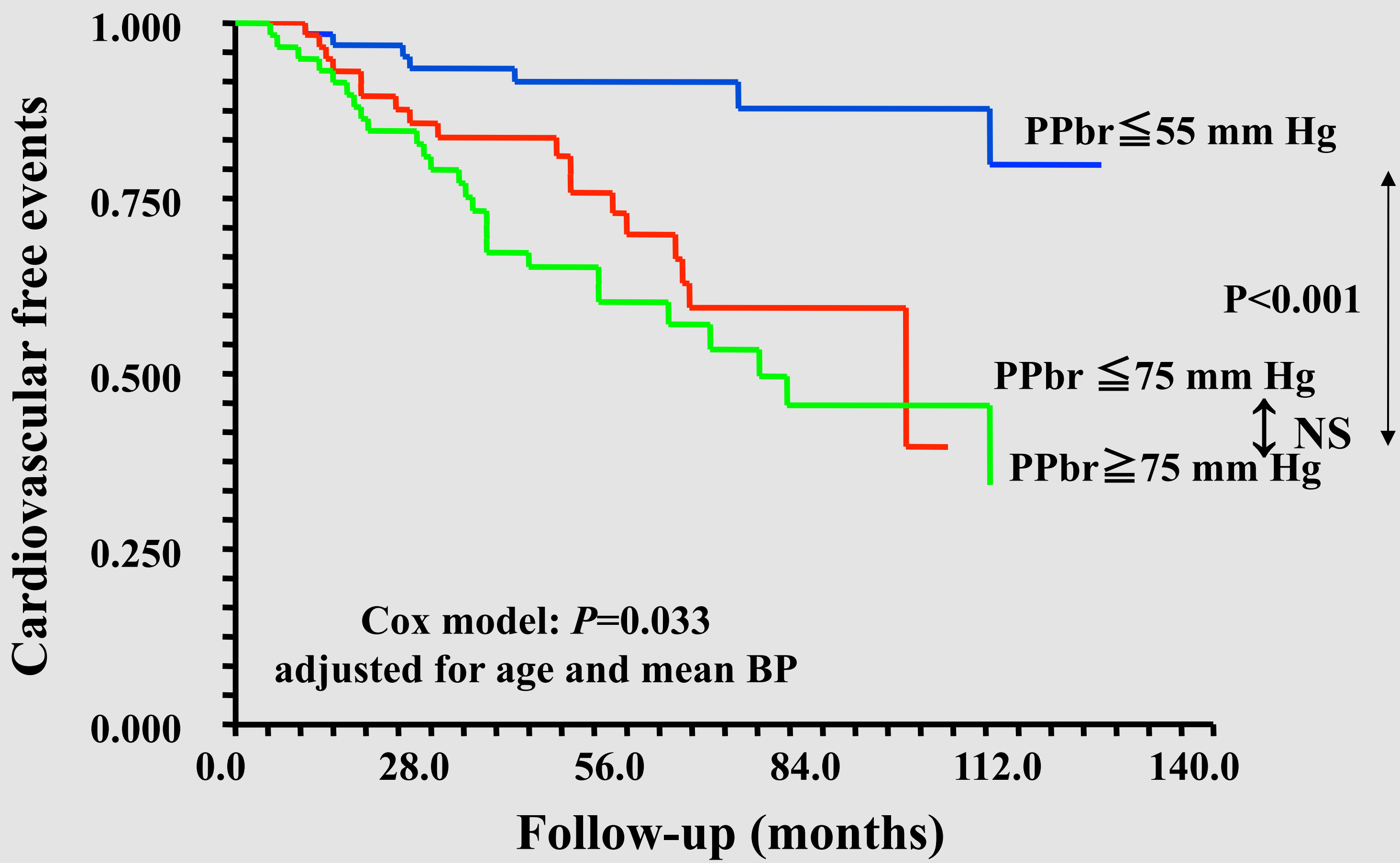
Liu M et al. NDT 2003; 18:563

One Year Mortality for Patients on Hemodialysis predicted by pulse pressure



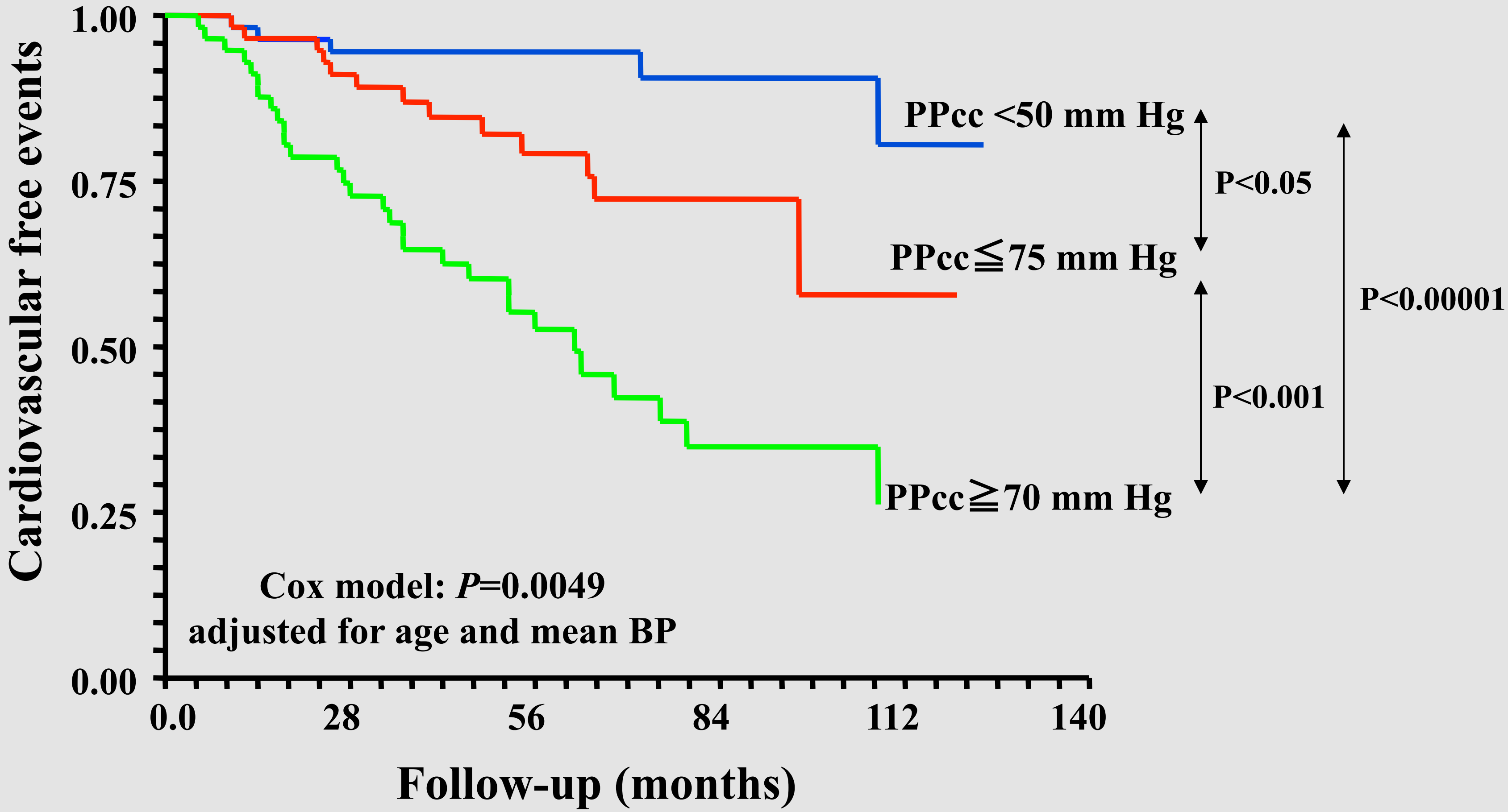
Klassen et al. JAMA 2002;287:1548-1555

Brachial Pulse Pressure and Cardiovascular mortality in ESRD patients



Safar ME et al Hypertension 2002

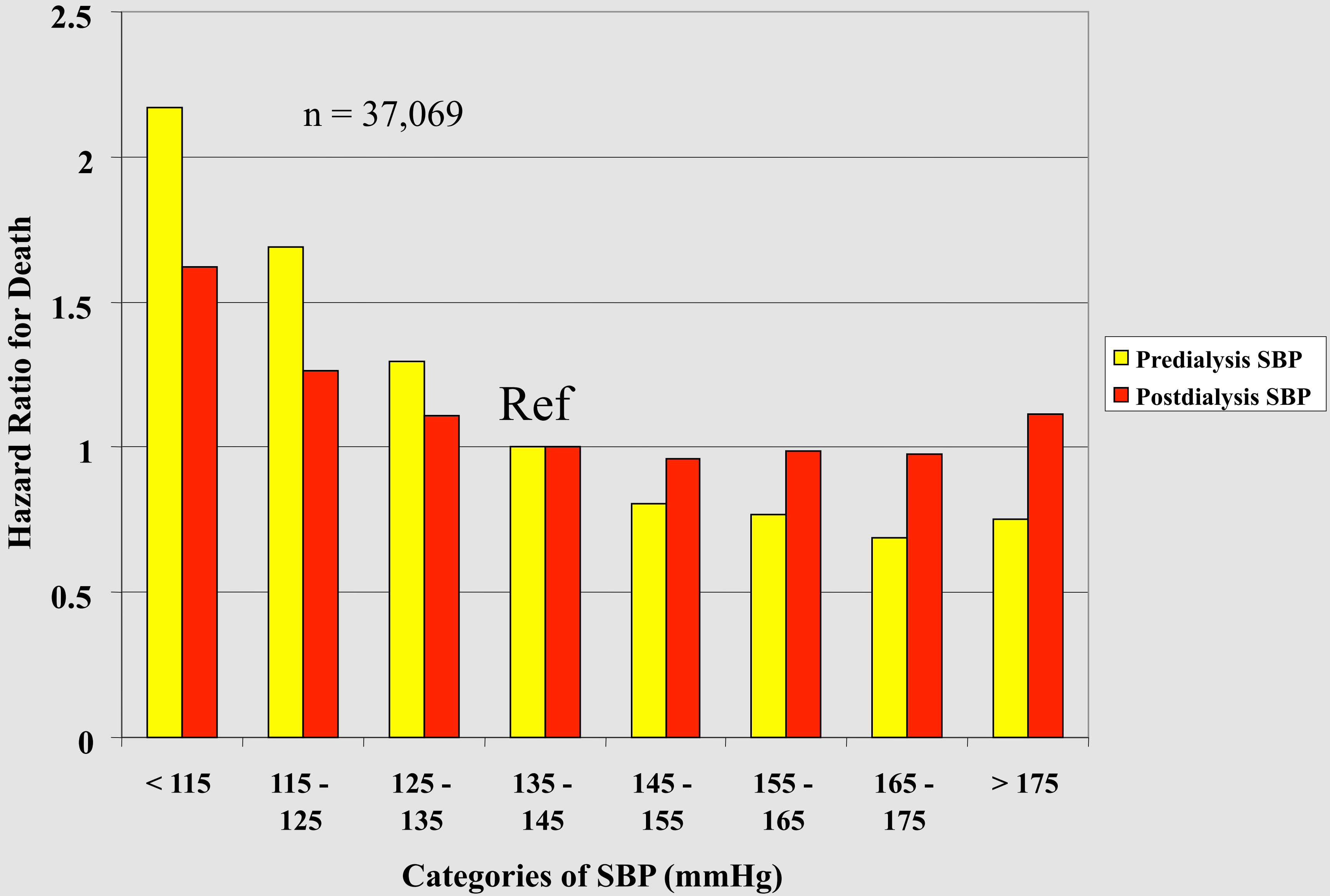
Common Carotid Pulse Pressure and Cardiovascular mortality in ESRD patients



Safar ME et al Hypertension 2002

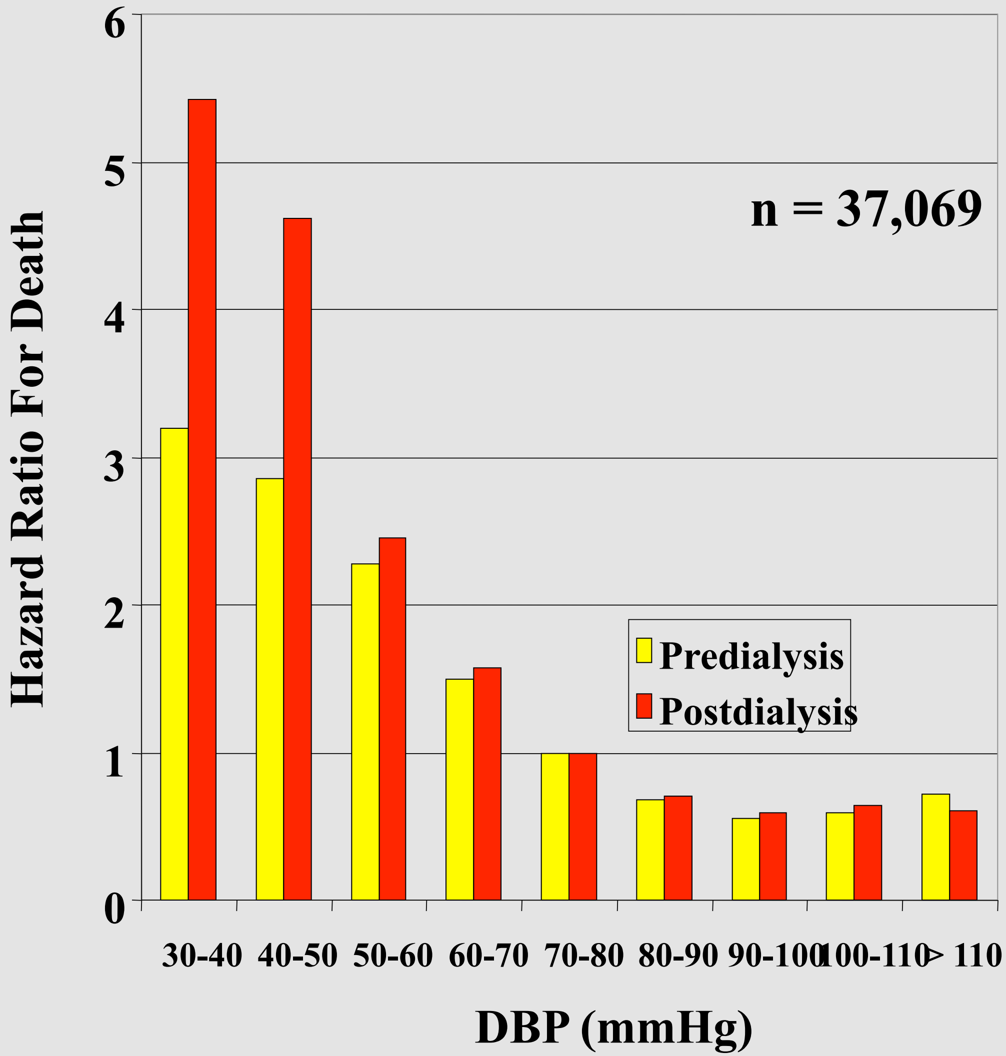
1-year Mortality predicted by SBP

Experience at 782 US dialysis facilities



Klassen et al. JAMA 2002;287:1548-1555

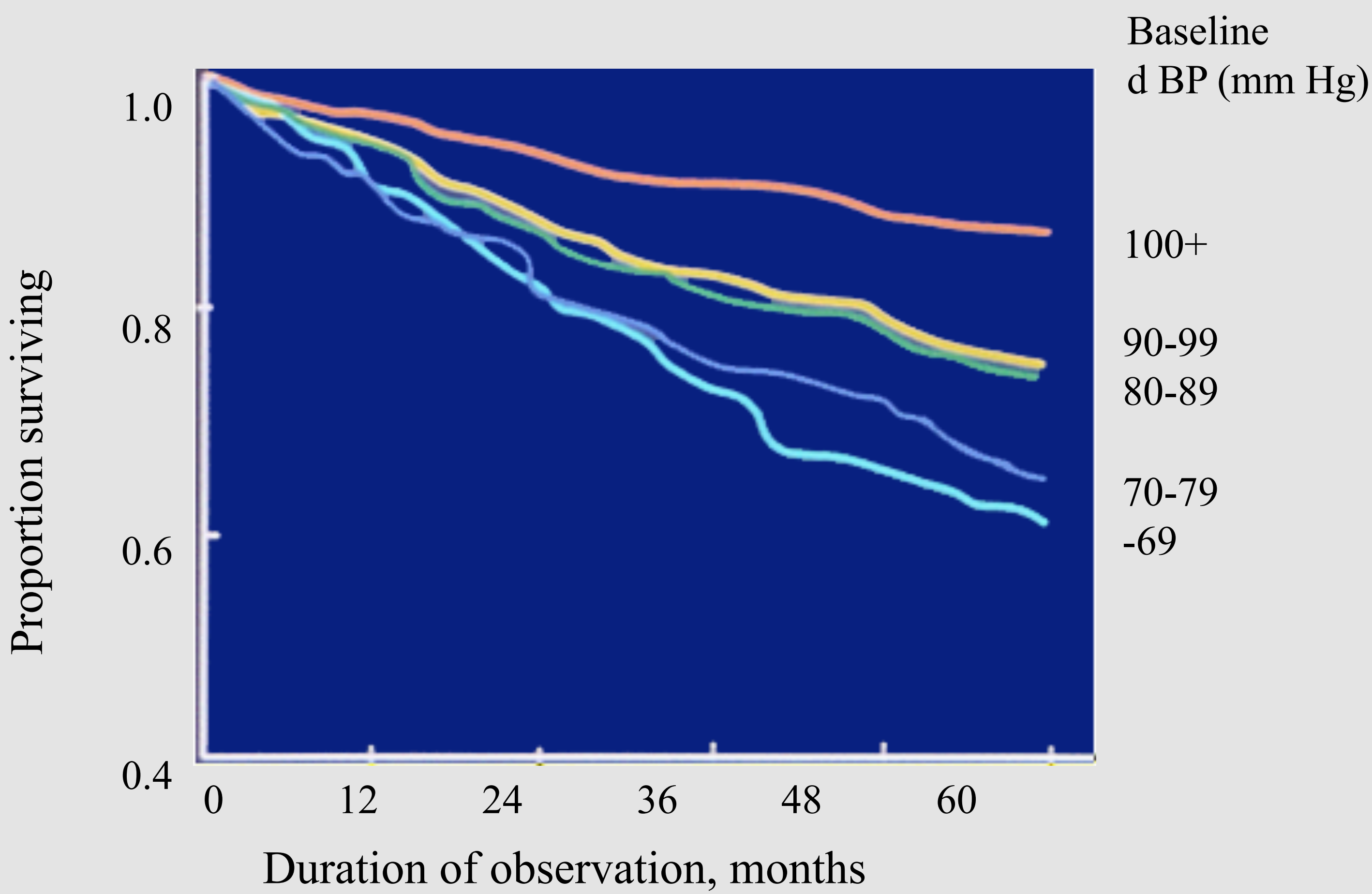
1-year Mortality predicted by DBP
Experience at 782 US dialysis facilities



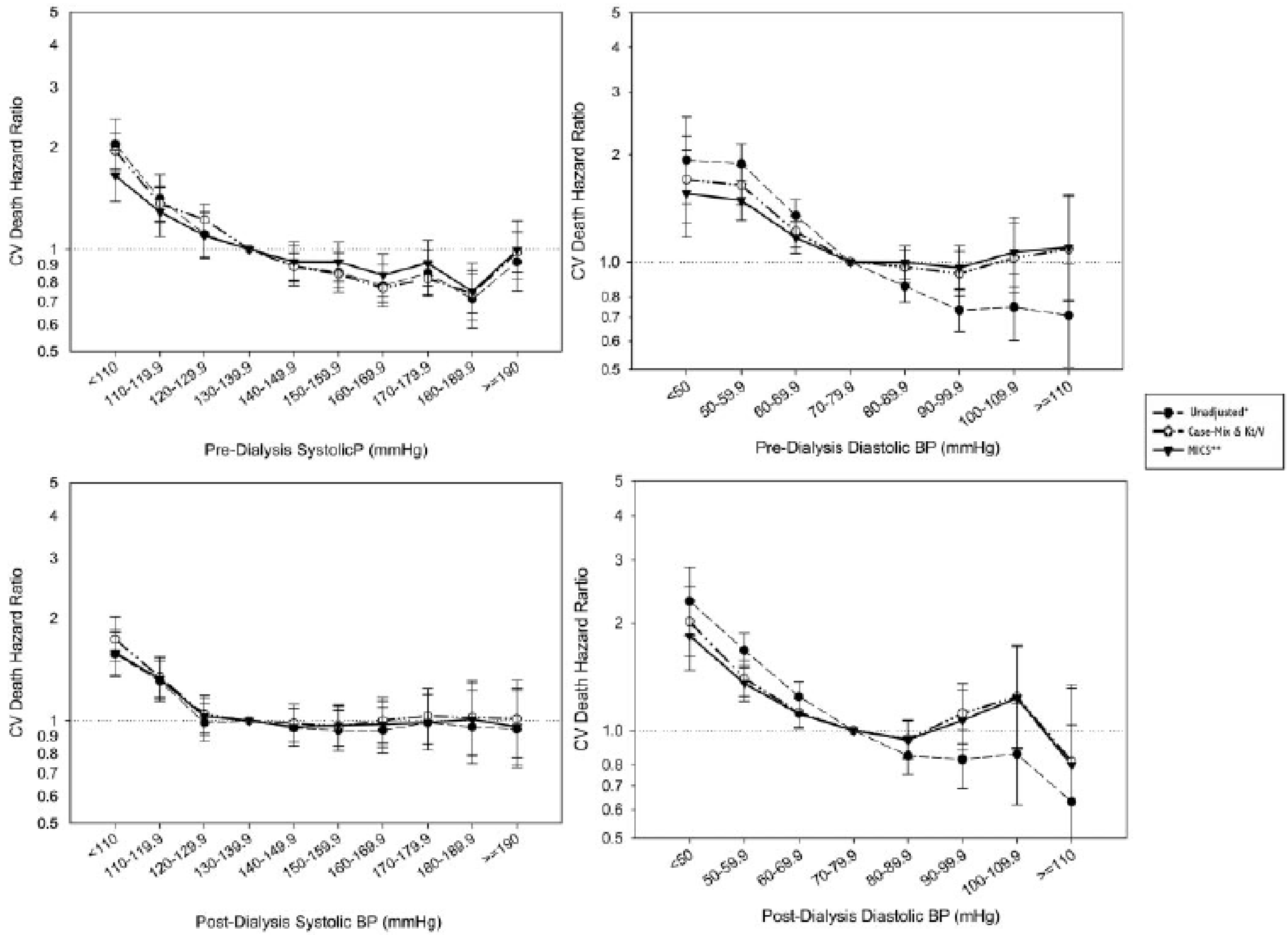
Adjusted for level of systolic blood pressure

Klassen et al. JAMA 2002;287:1548-1555

Survival curves in hemodialysis patients for each baseline level of diastolic BP



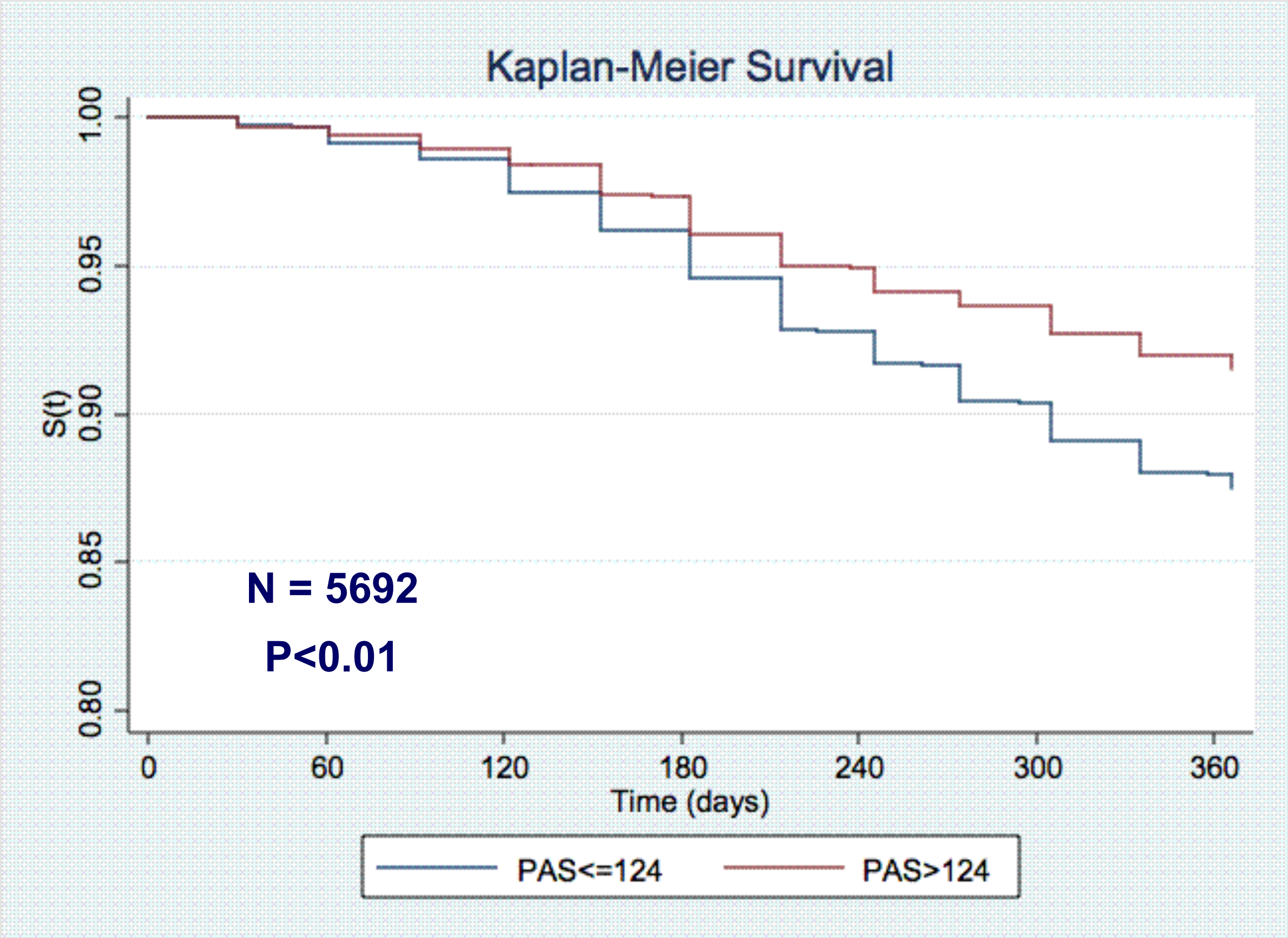
ISEKI K. et al. Kidney Int 1997



Association between BP and 15-month CV death in 40 933 MHD patients (95% confidence interval bars are depicted). Note that the unadjusted models also include entry quarter. **MICS-adjusted models also include all covariates in the previous models.

Hypertension 2005;45:811

All cause mortality according Systolic blood pressure (PAS)

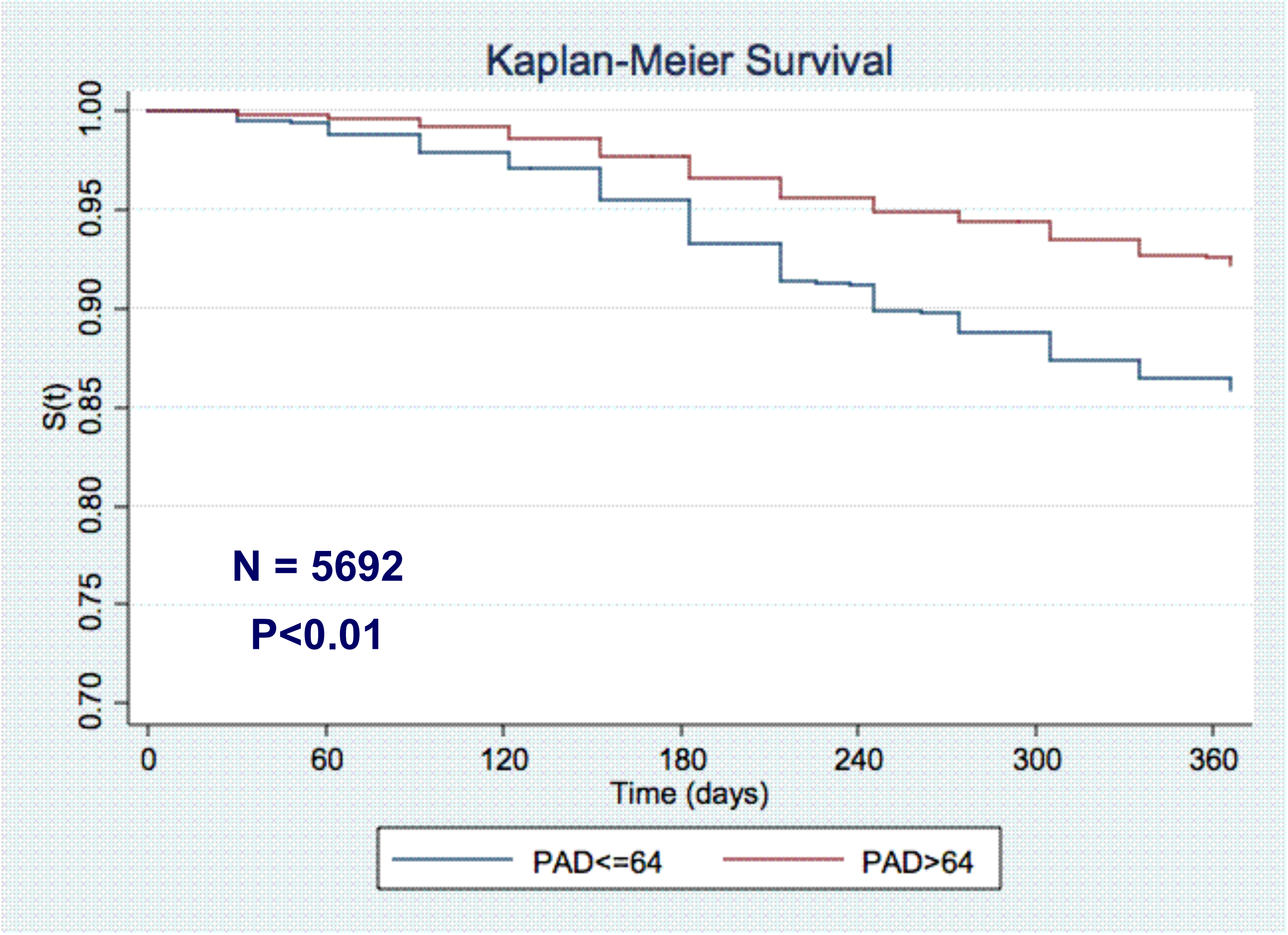


Adjusted Cox Z-value –2.23; p=0.02

0.992 (0.988-0.991) for 1 mmHg increase

Fouque D et al Observatoire National

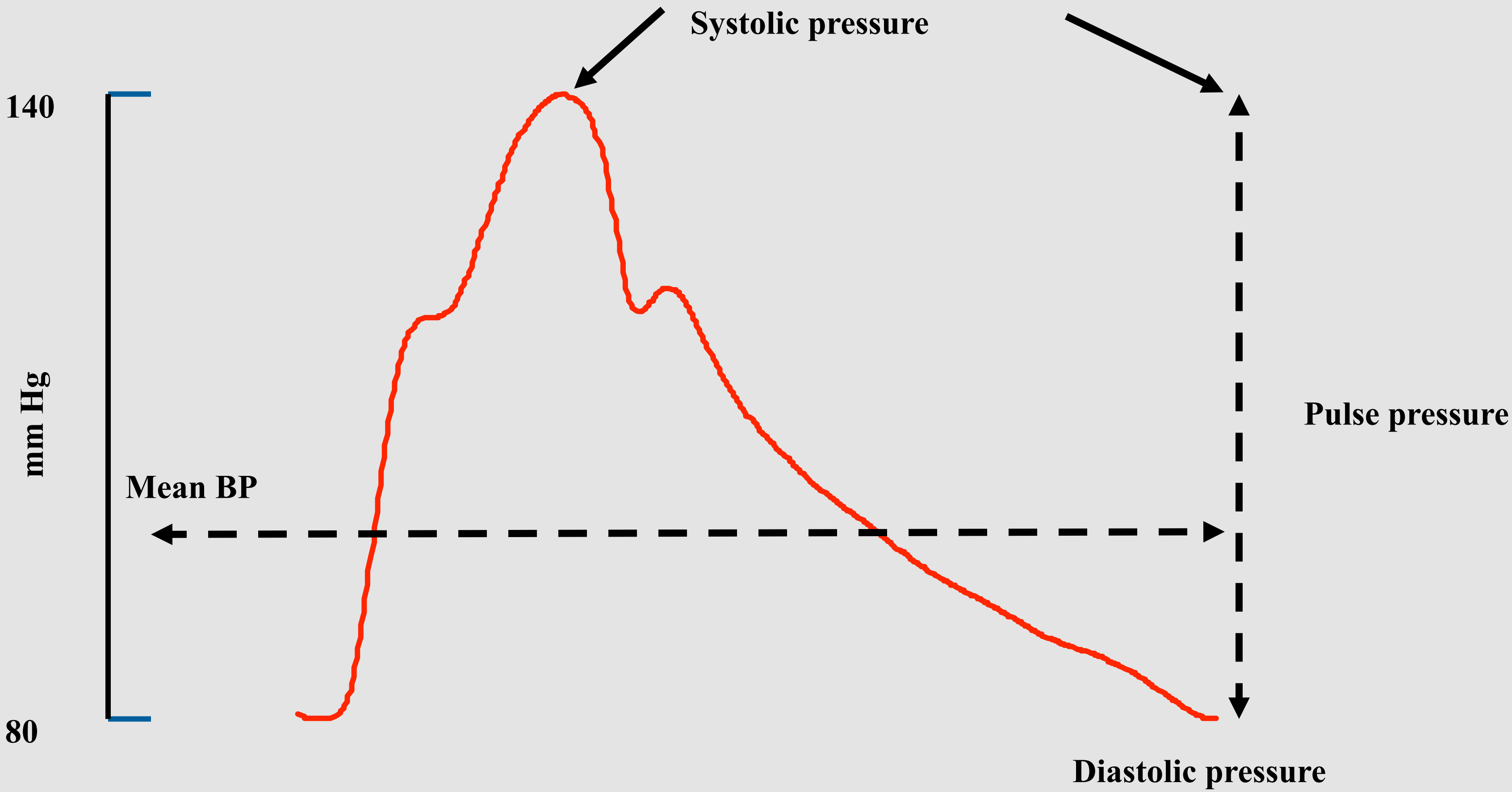
All cause mortality according Diastolic blood pressure (PAd)



Adjusted Cox: Z-value = –6.73; p<0.001

0.977 (0.971-0.984) for 1 mmHg increase

Fouque D. et al Observatoire National

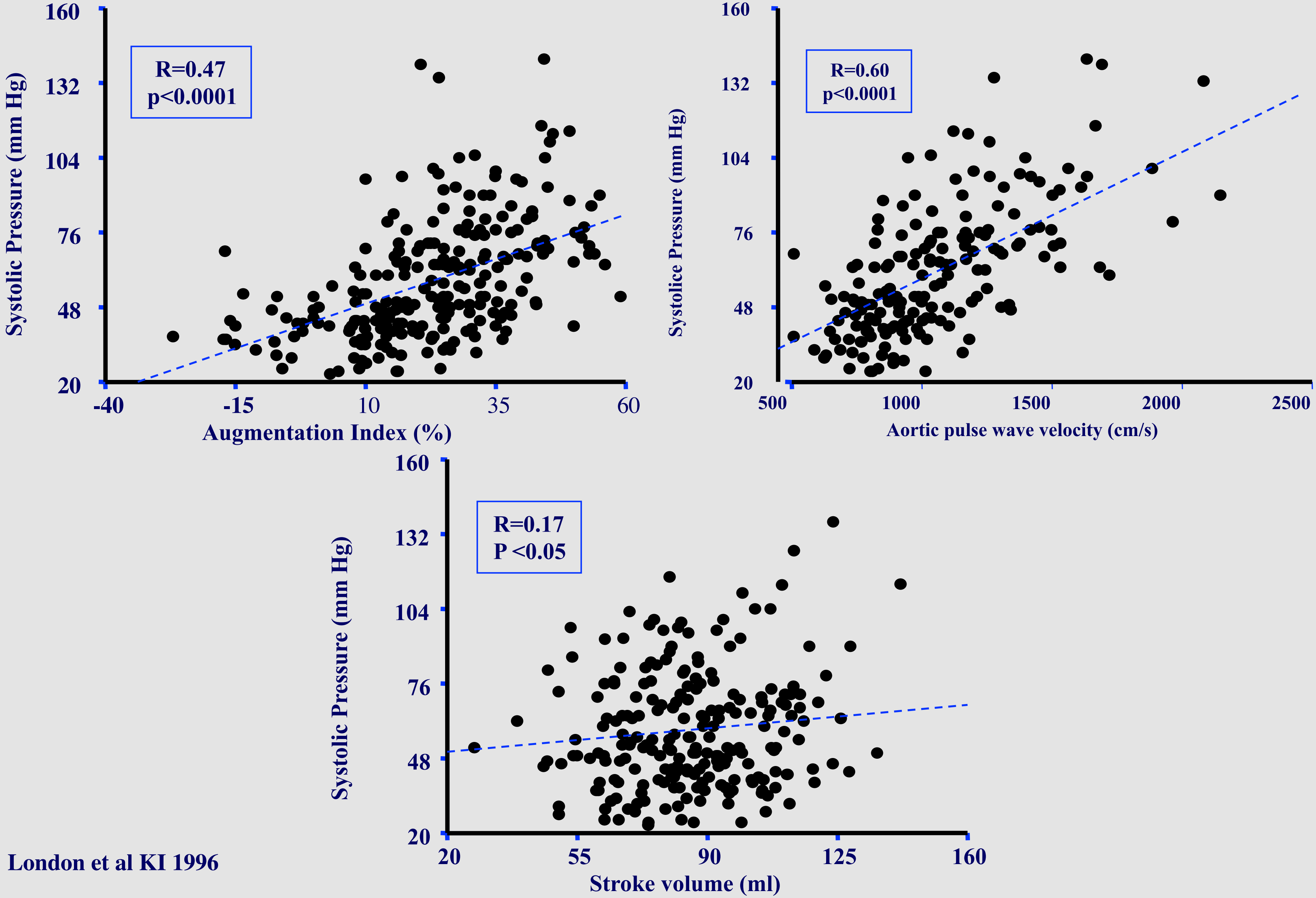


Mean BP: Cardiac output
peripheral resistance

Systolic pressure: ventricular ejection (*stroke volume and ejection time*)
arterial stiffness
wave reflection

Diastolic pressure: arterial resistance
arterial Stiffness
Diastolic decay time

Correlation between arterial pulse pressure, wave reflexion (Augmentation index) aortic pulse wave velocity and stroke volume (n=230)



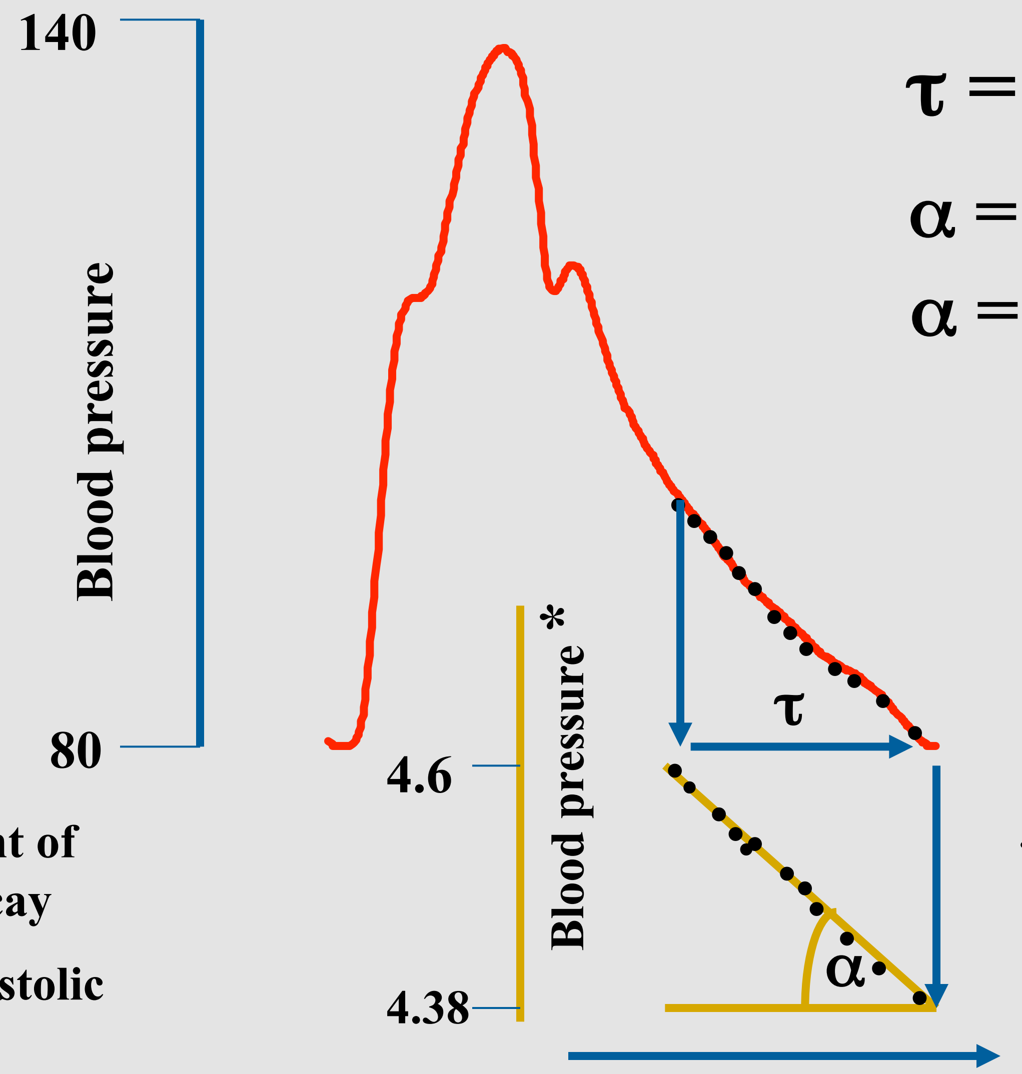
London et al KI 1996

Relationship of Resistance ®, Compliance (C) and Stiffness (S=1/C)with diastolic pressure decay

τ = R.C

α =1/τ = 1/R.C

α =S/R

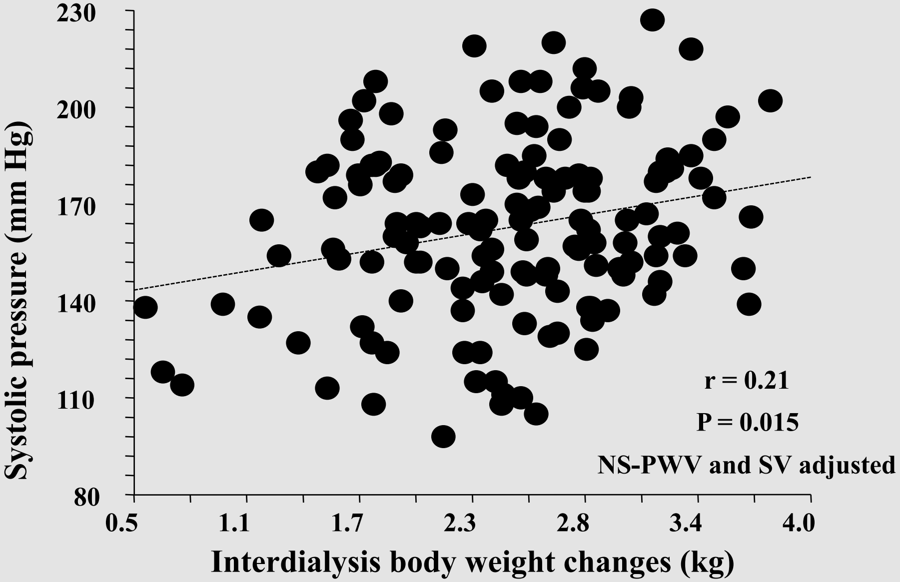


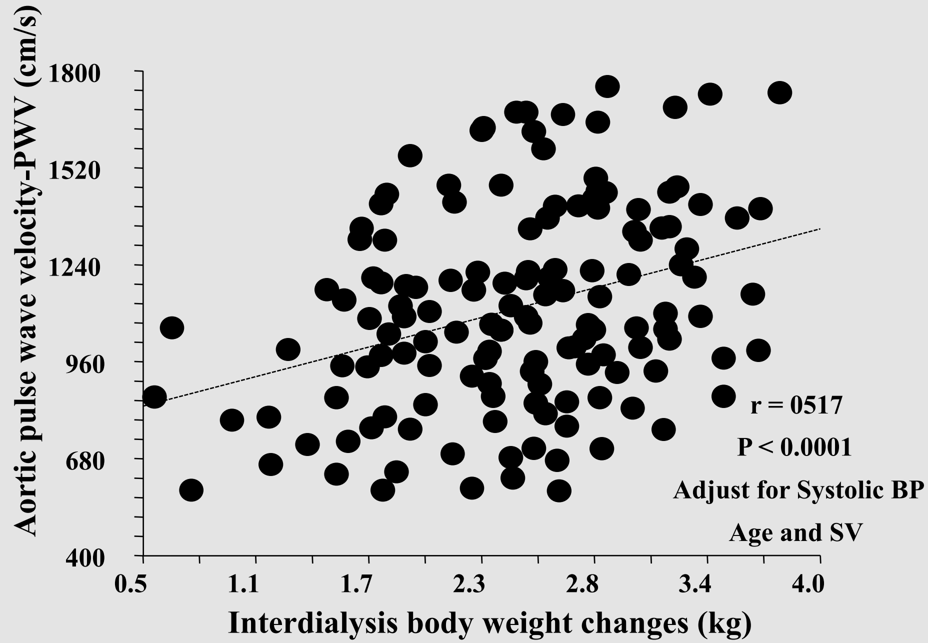
* log scale

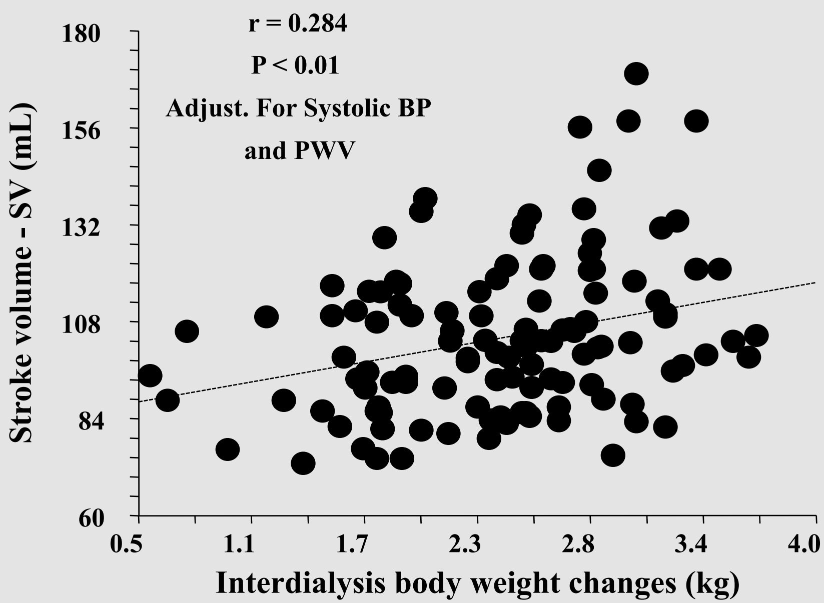
τ-time constant of diastolic decay

α-slope of diastolic decay

Adapted from Simon et al. Am J Physiol 1979

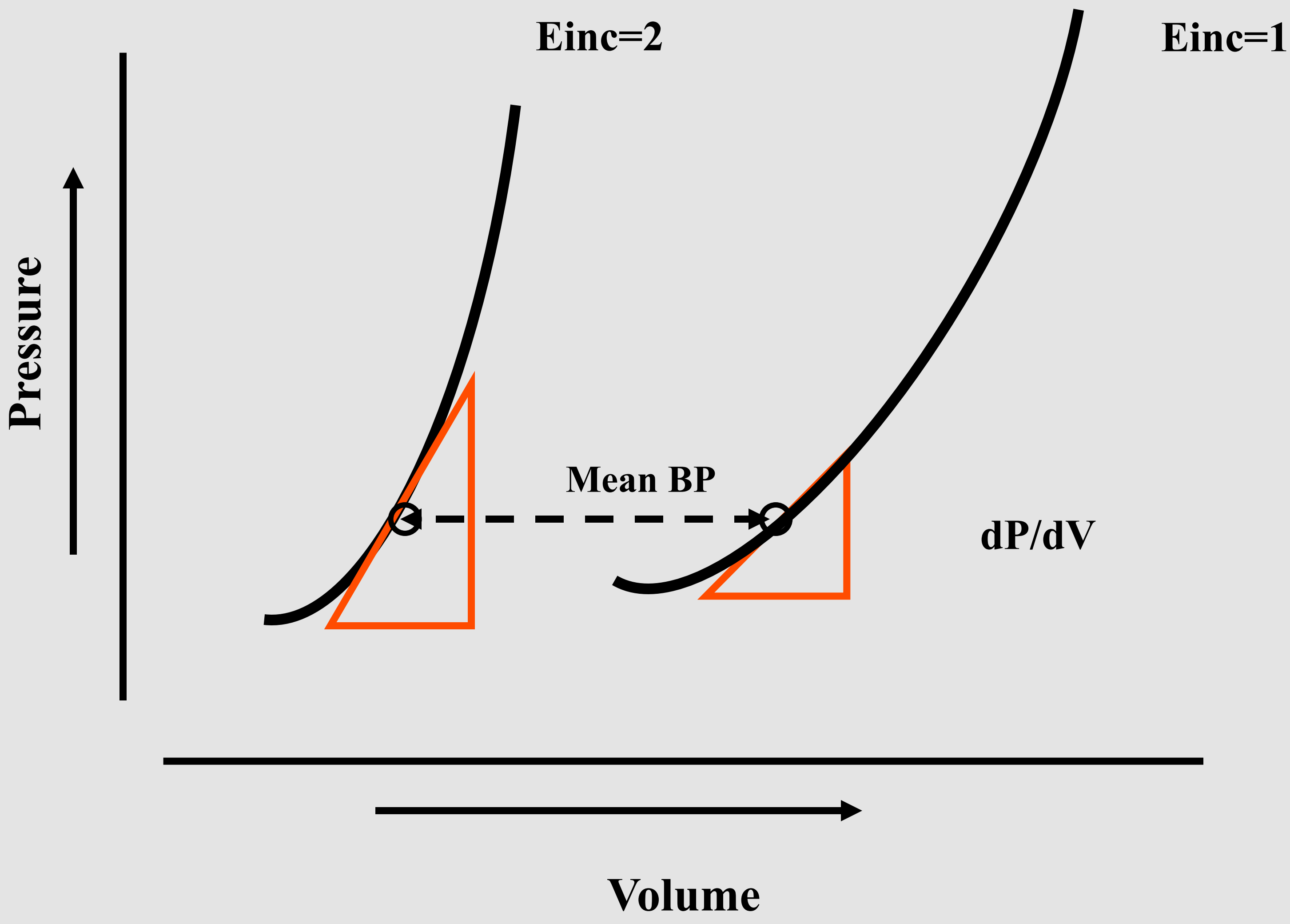




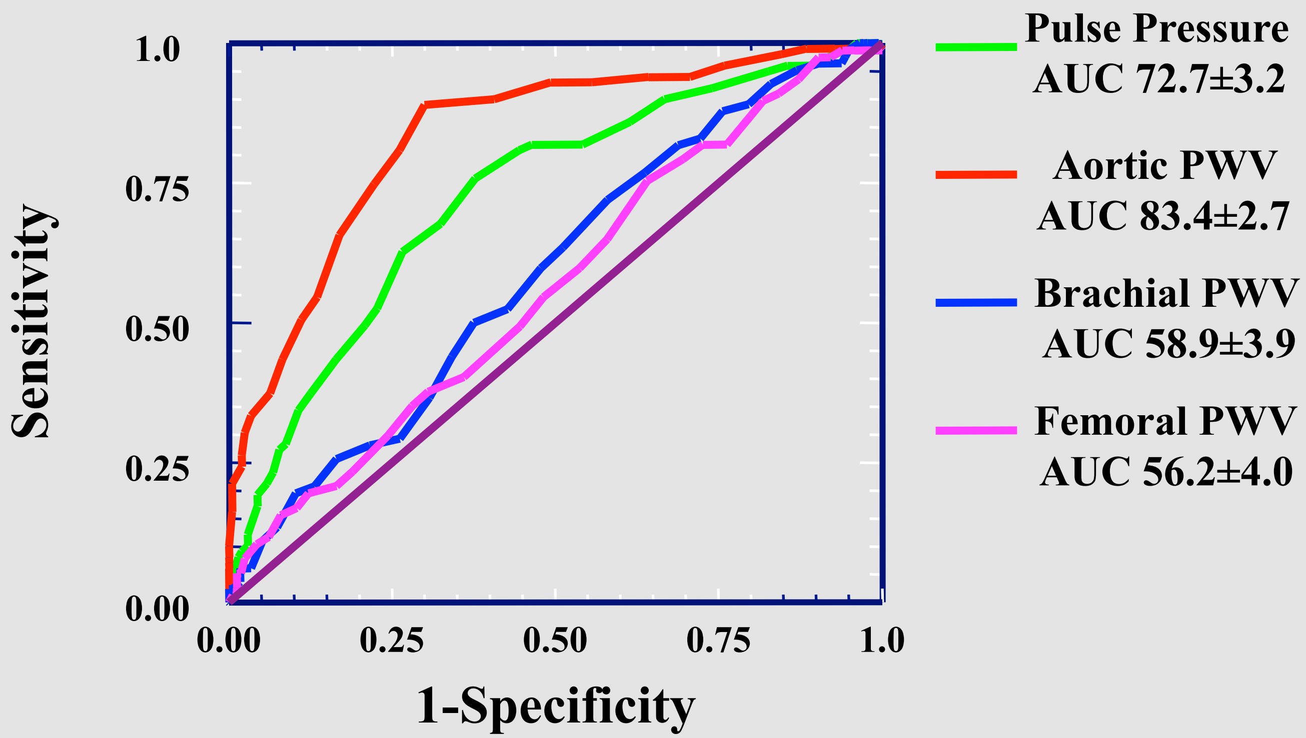


London et al Kidney Int 1989

Diagrammatic representation of pressure-volume relationships

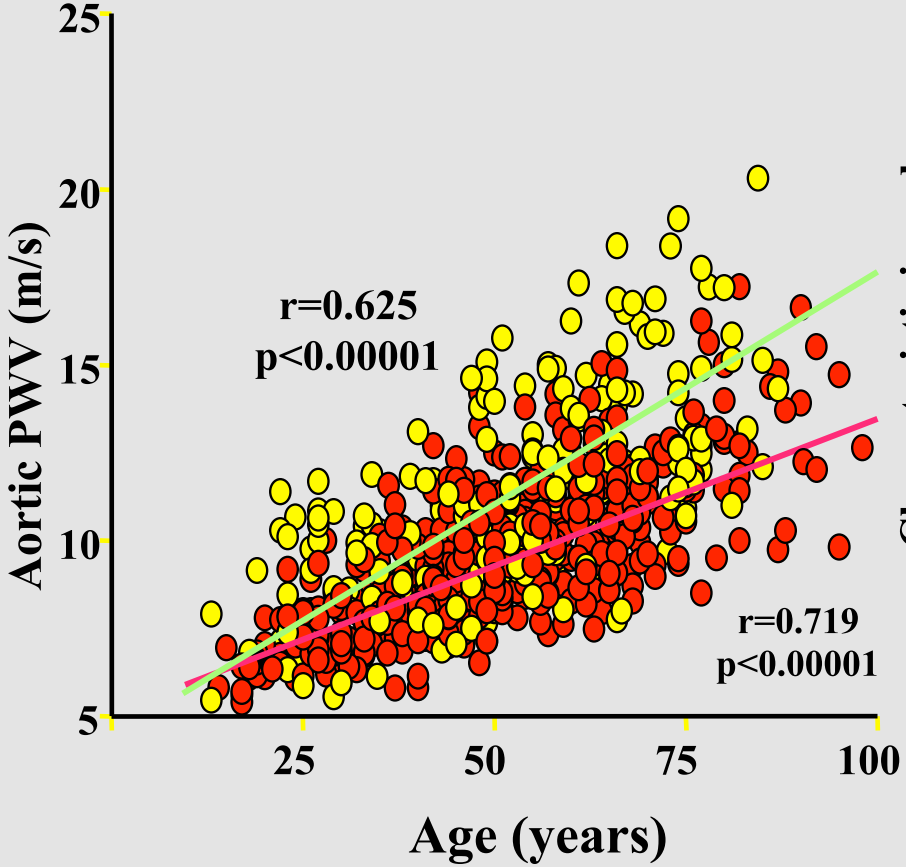


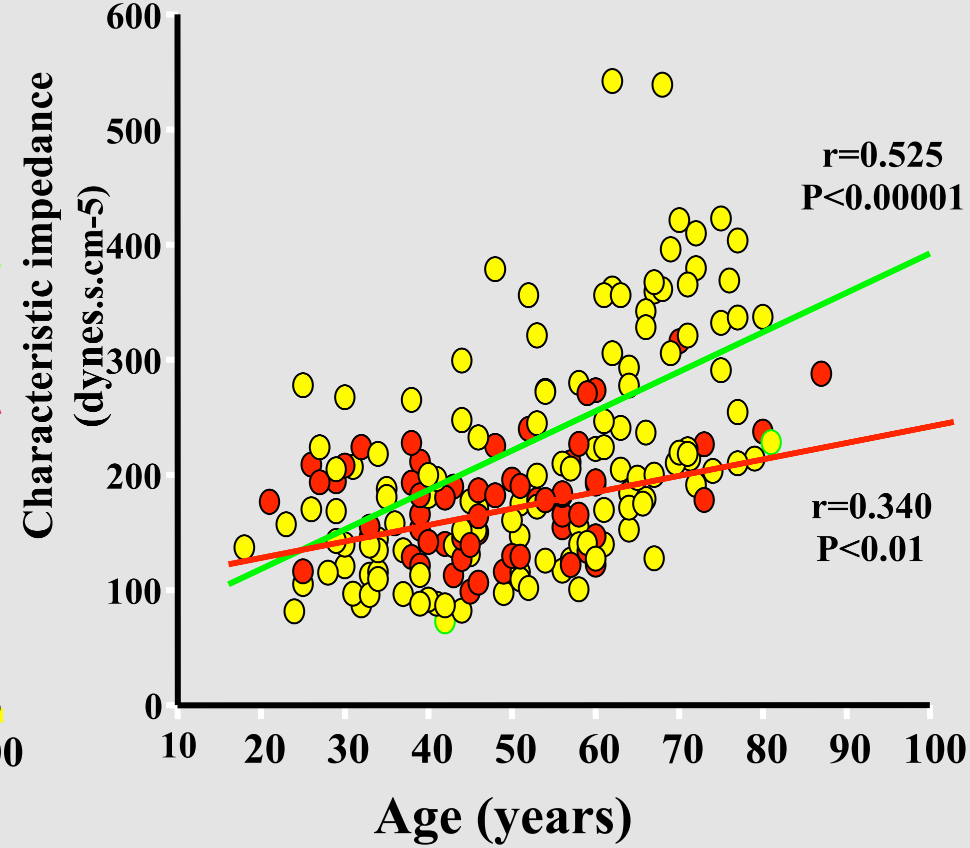
ROC Curves of CVdeath



Pannier B et al Hypertension 2005

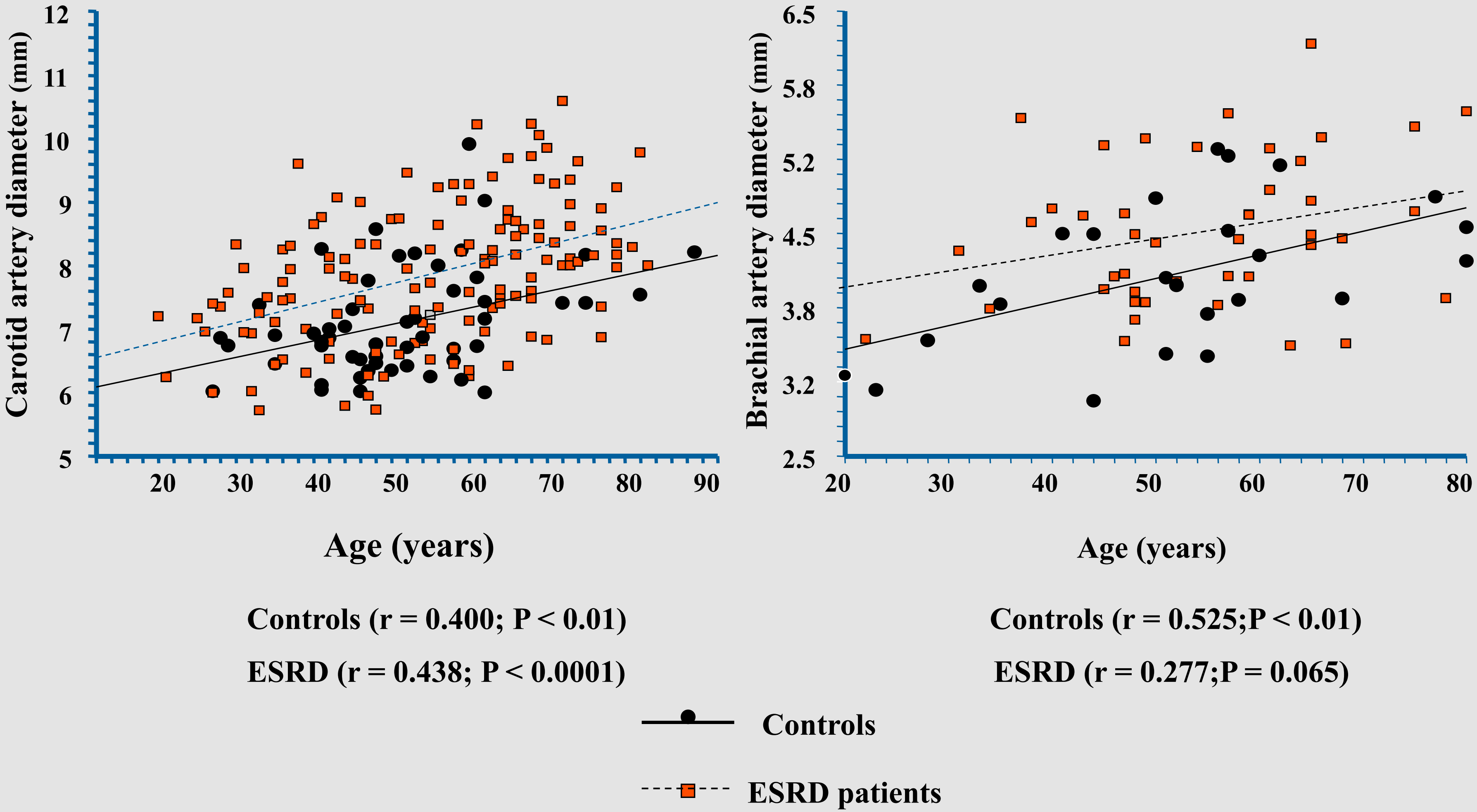
Correlation between Age and Aortic Pulse Wave Velocity in General population ( ) and ESRD patients ( )





Pannier et al Artery 2007;1:78-89

Age related changes in arterial internal diameters



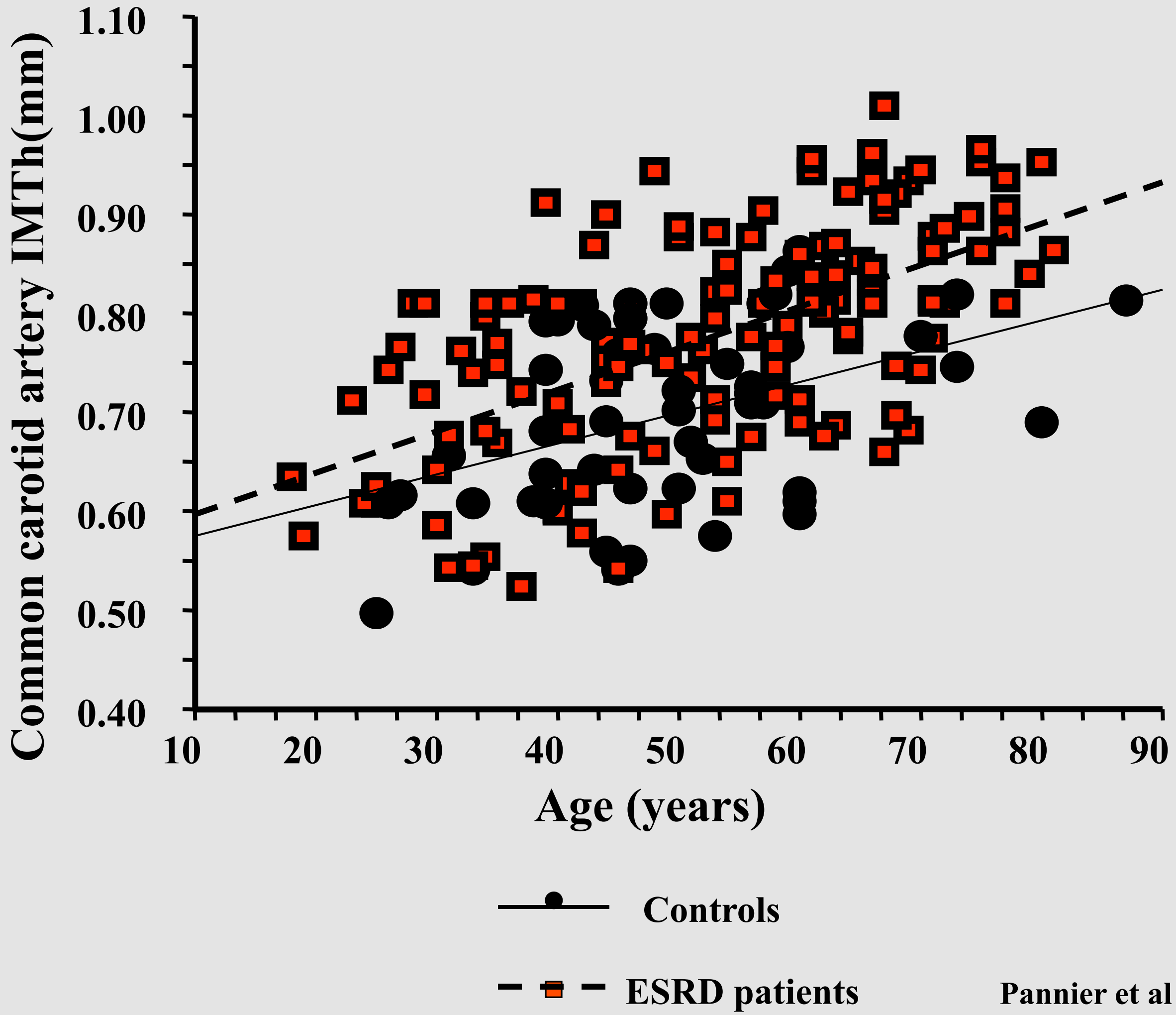
Controls (r = 0.400; P < 0.01)

ESRD (r = 0.438; P < 0.0001)

Controls (r = 0.525;P < 0.01)

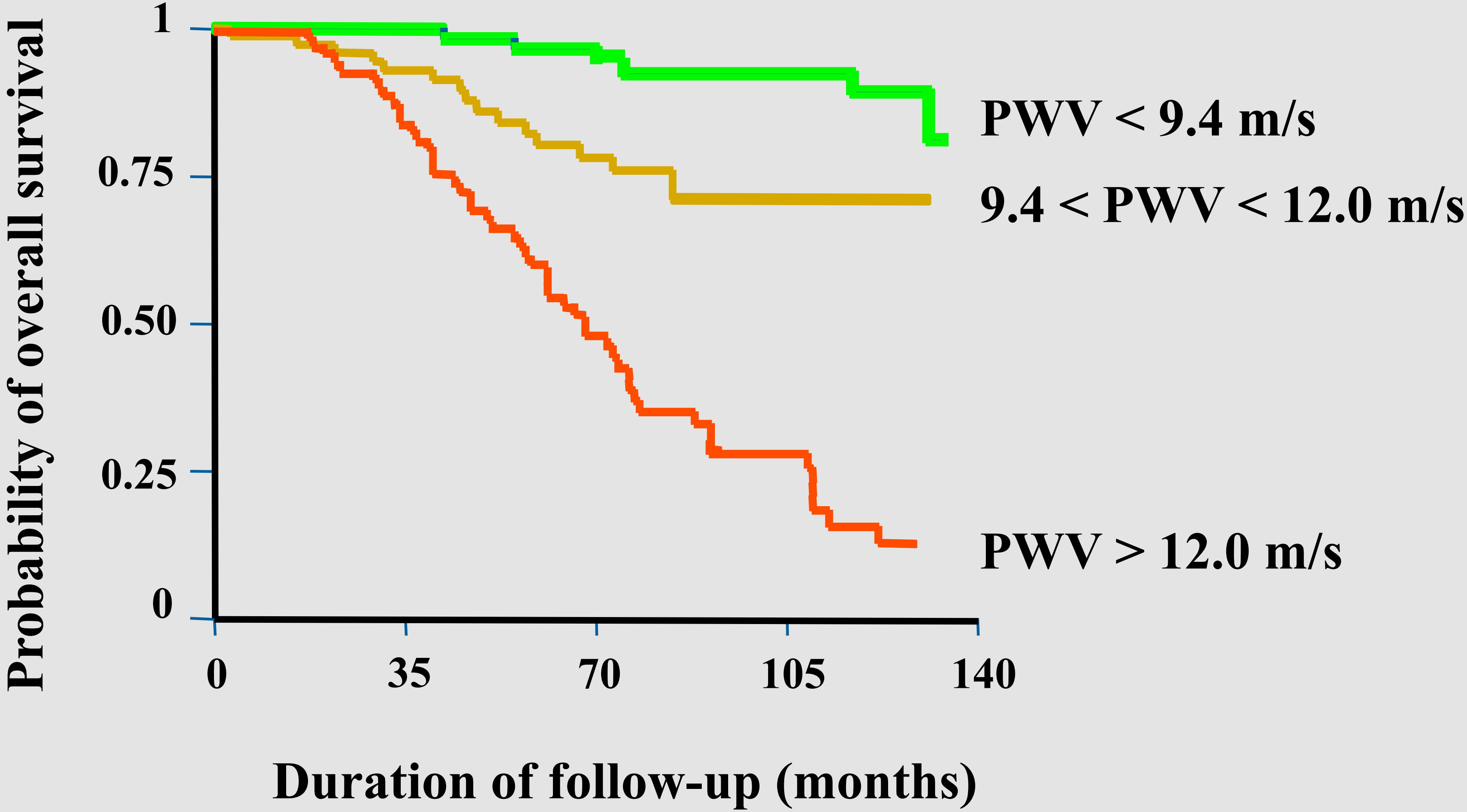
ESRD (r = 0.277;P = 0.065)

Age related changes in Carotid IMTh



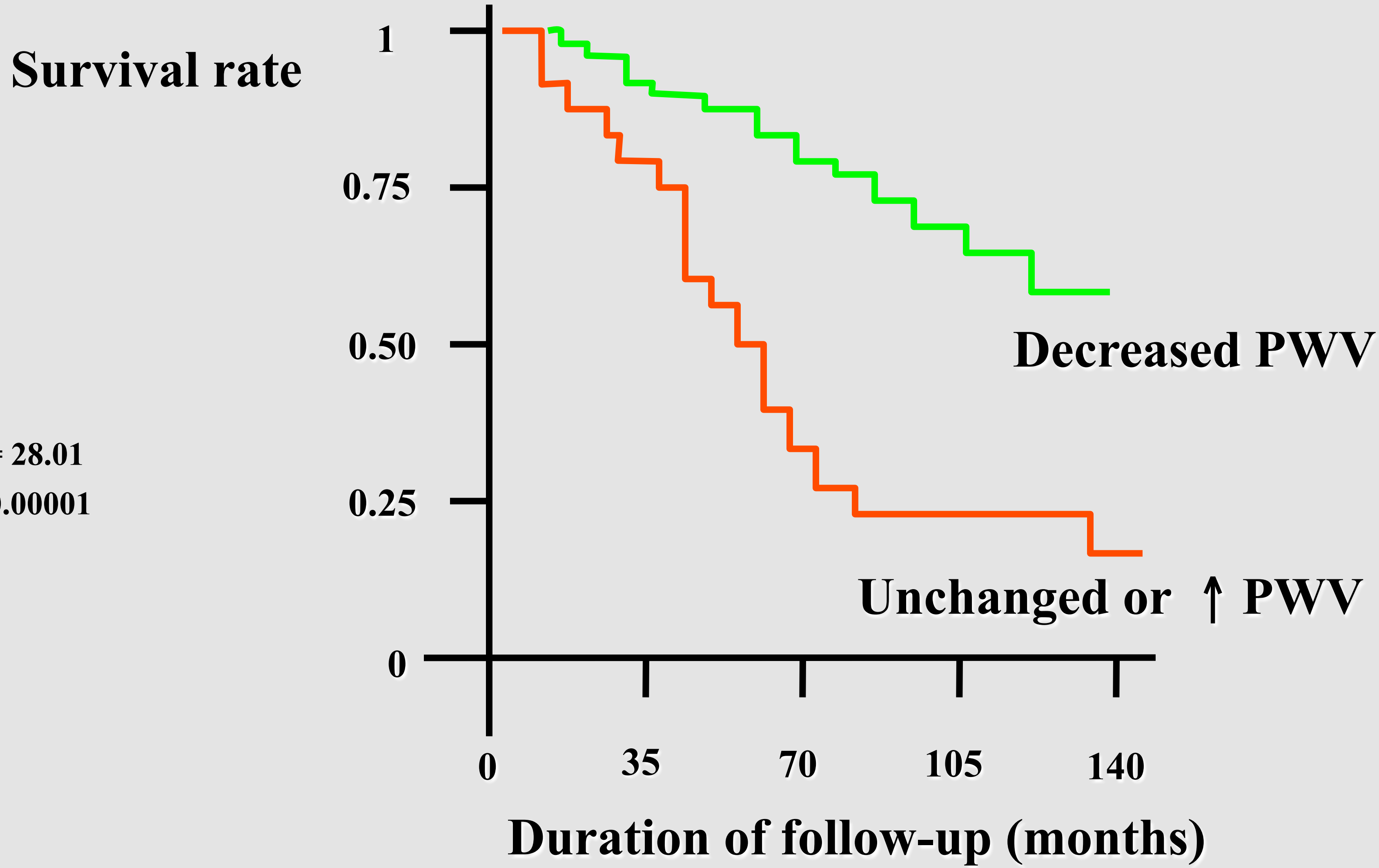
Pannier et al Hypertension 2005

Probability of overall survival in hemodialysis patients according to aortic PWV



Blacher et al. *Circulation*. 1999

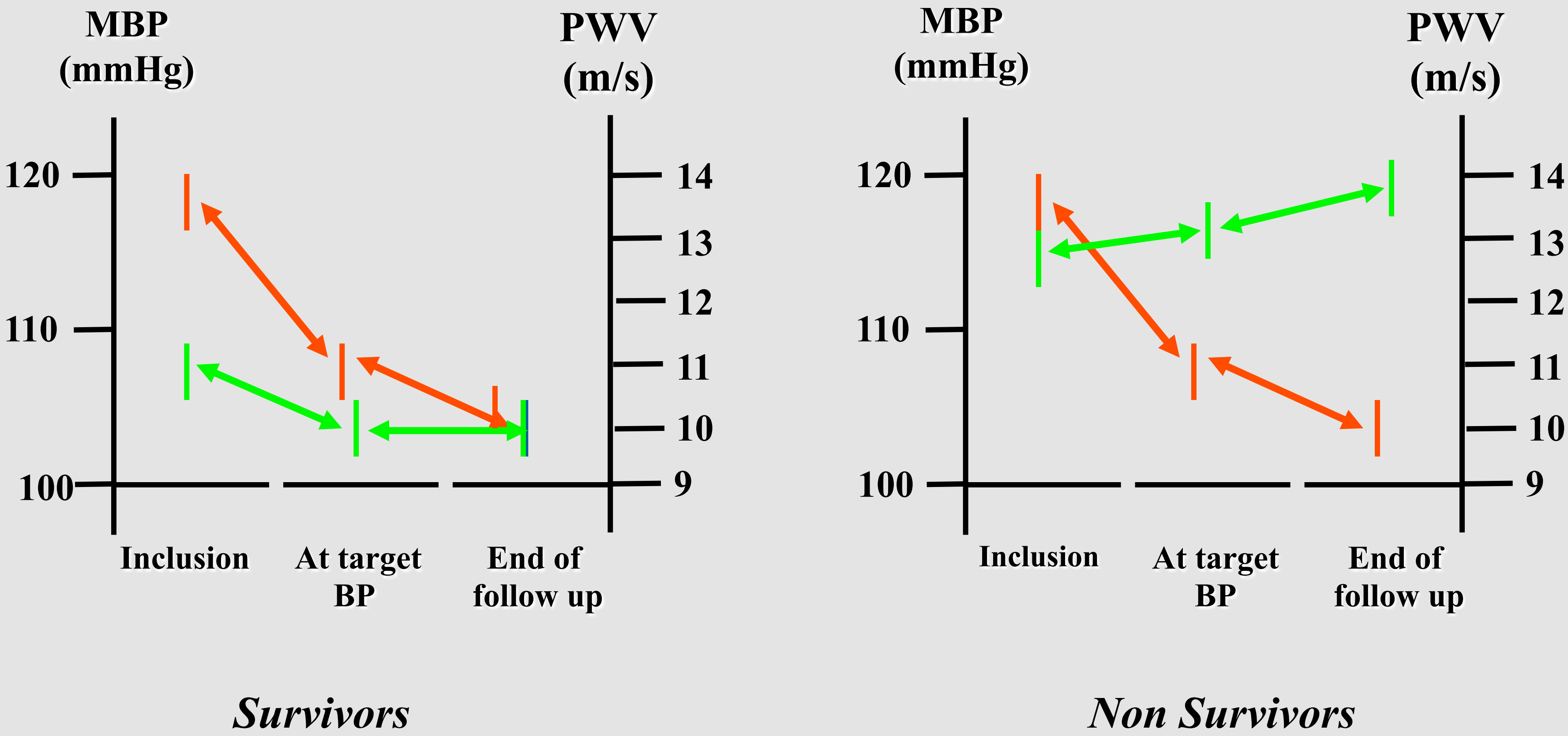
All cause survival according to changes in aortic pulse wave velocity (Δ PWV) in response to BP decrease



$\chi^2 = 28.01$
$P<0.00001$

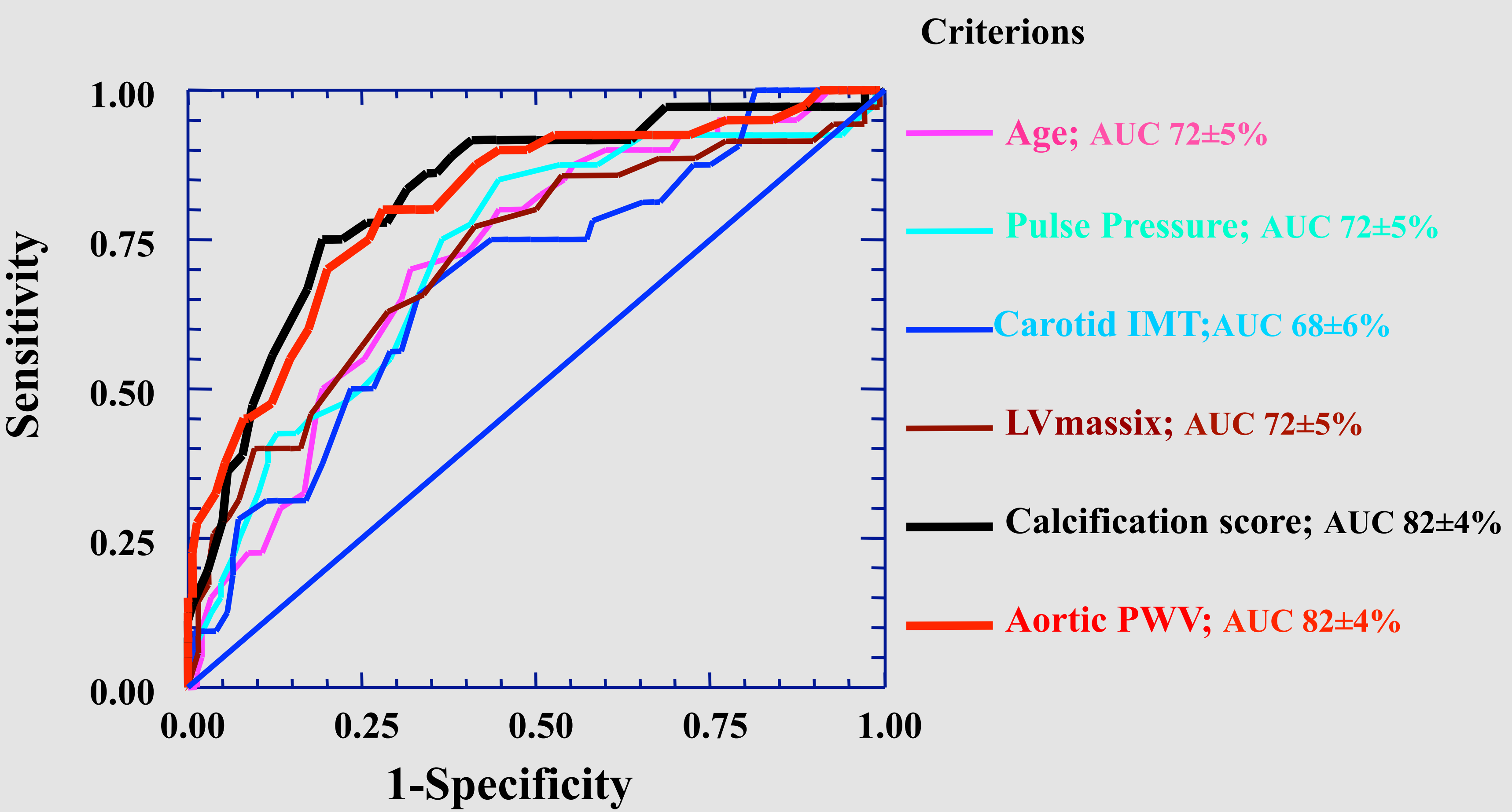
Guérin et al. *Circulation*. 2001.

Changes of mean blood pressure and aortic PWV



Guérin and al. circulation 2001 ; 103 : 987 - 92

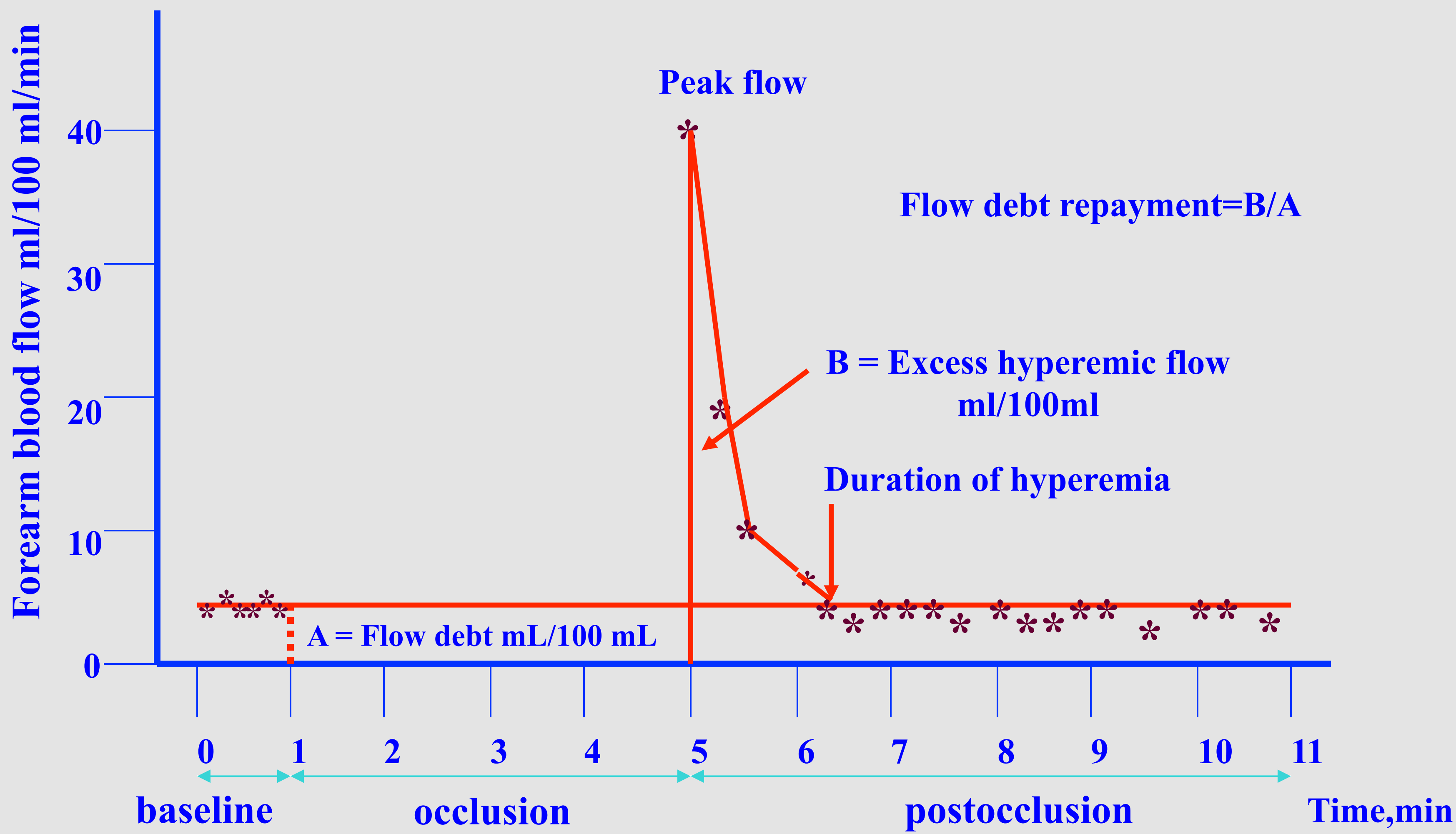
ROC Curve of CV mortality

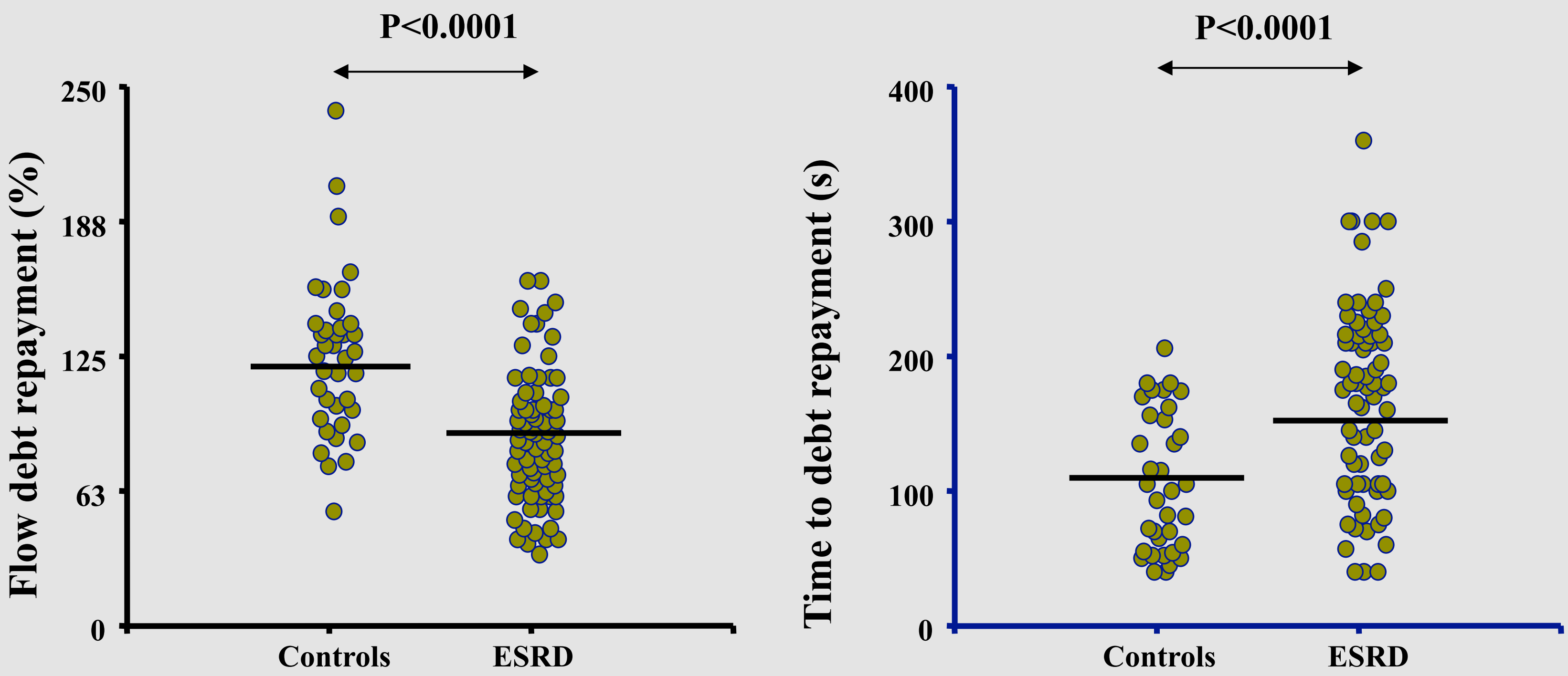


PWV^2 = Einc x arterial IMT/arterial radius wher Einc is incremental elastic modulus

London et al. Cur Op hypertens Nephrol 2006

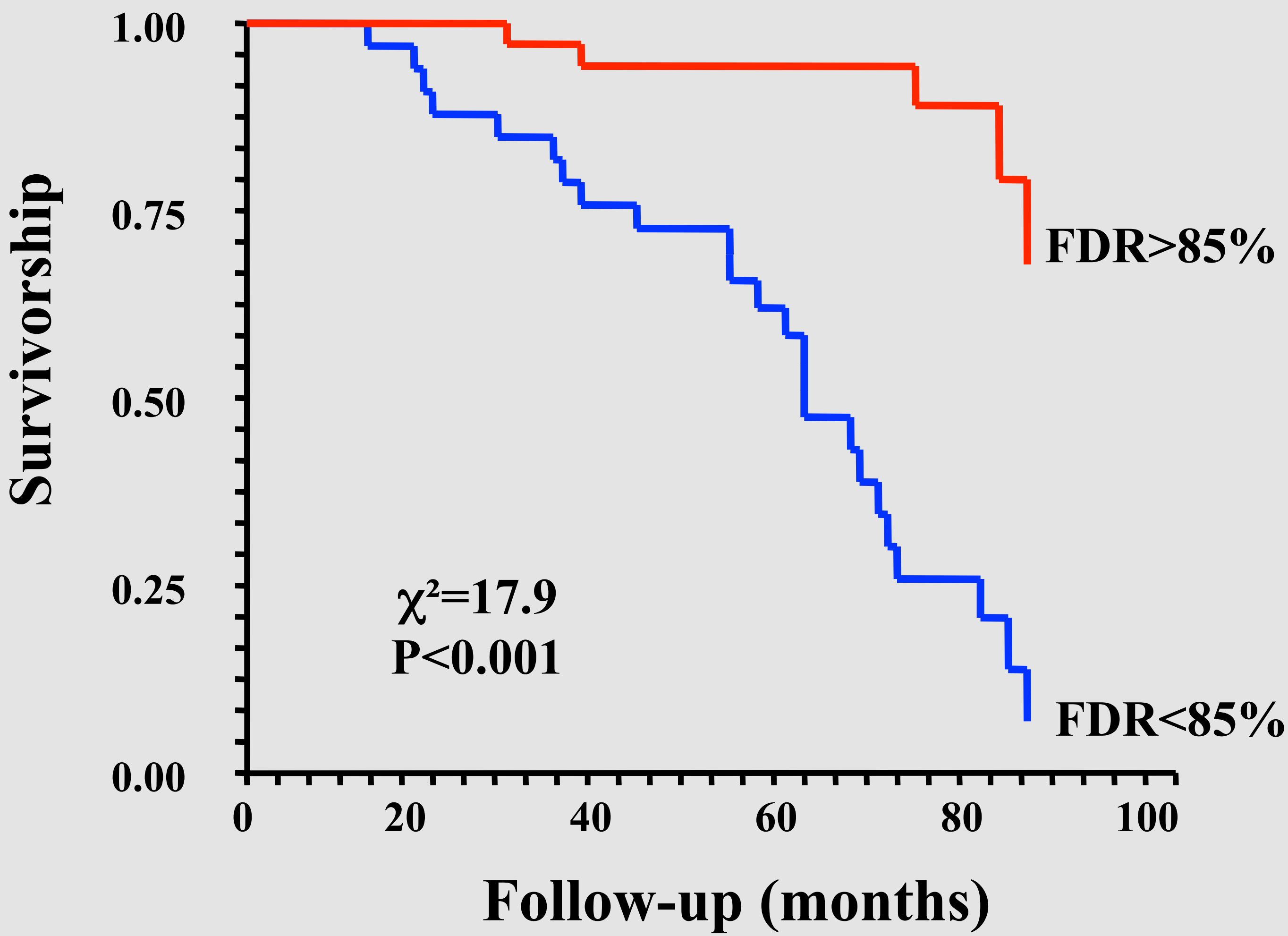
Schematic representation of reactive hyperemic response in the human forearm after five minutes of ischemia





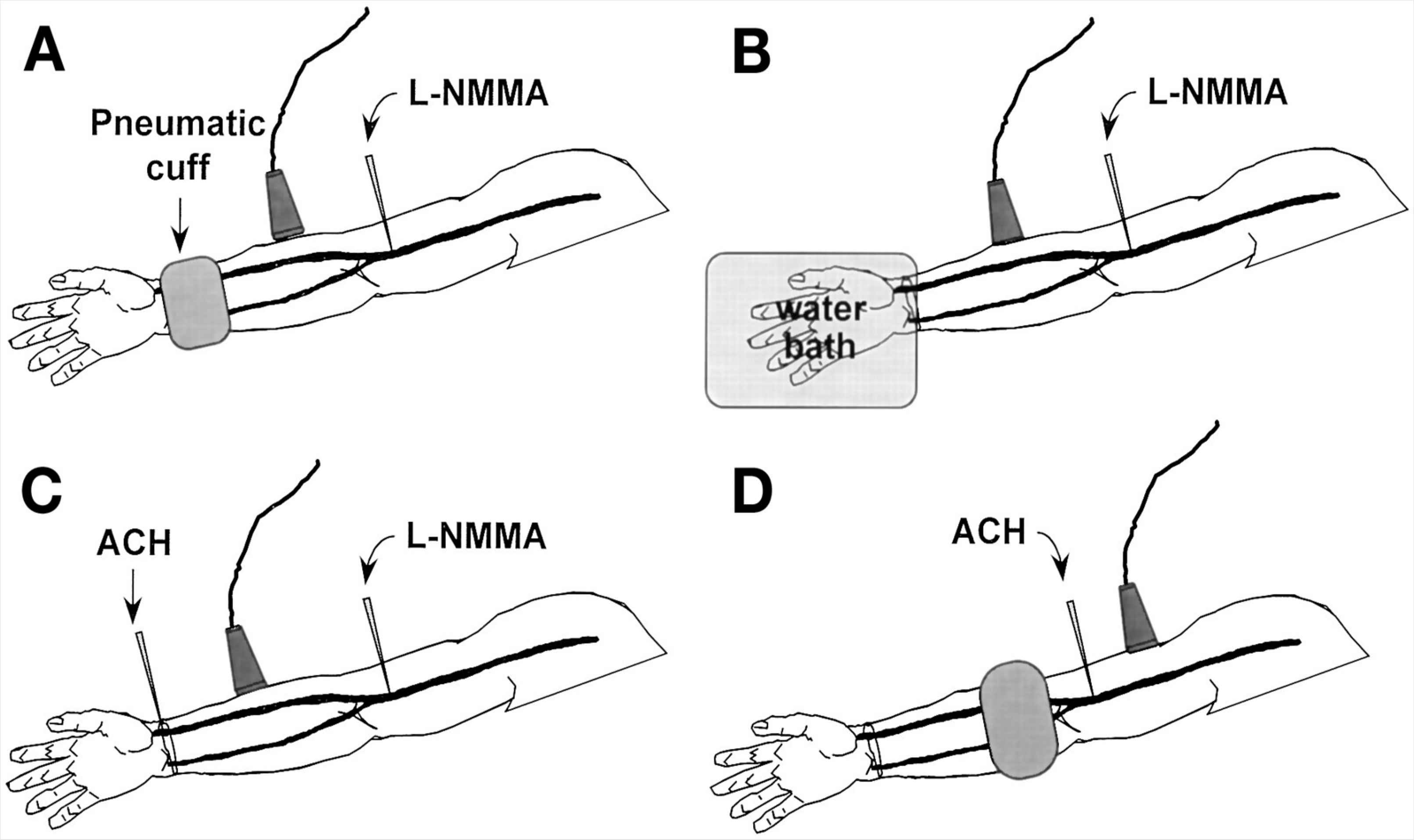
Pannier B et al. Kidney Int 2001

Probability of survival in ESRD patients according to postischemic forearm flow debt repayement (FDR)



London GM et al. Kidney Int 2003

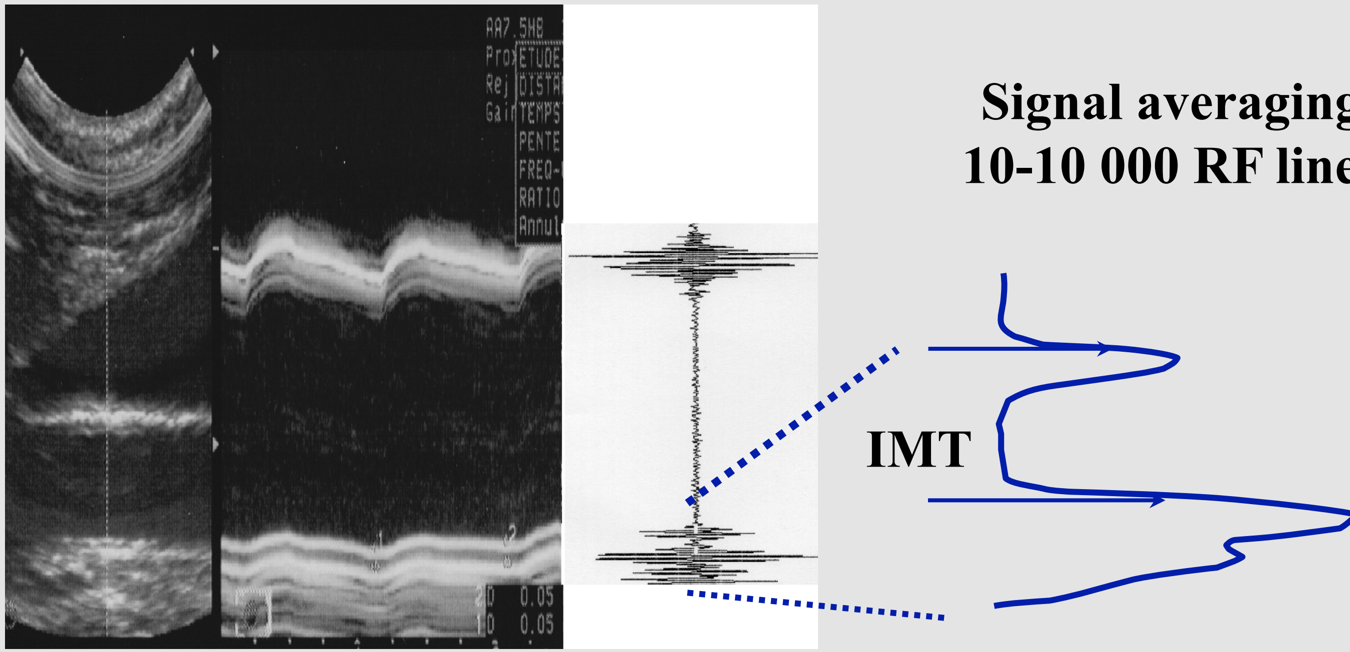
Methods of stimulating increased blood flow



Mullen, M. J. et al. Circ Res 2001;88:145-151

Echotracking is 3 to 10 x more precise than image based techniques

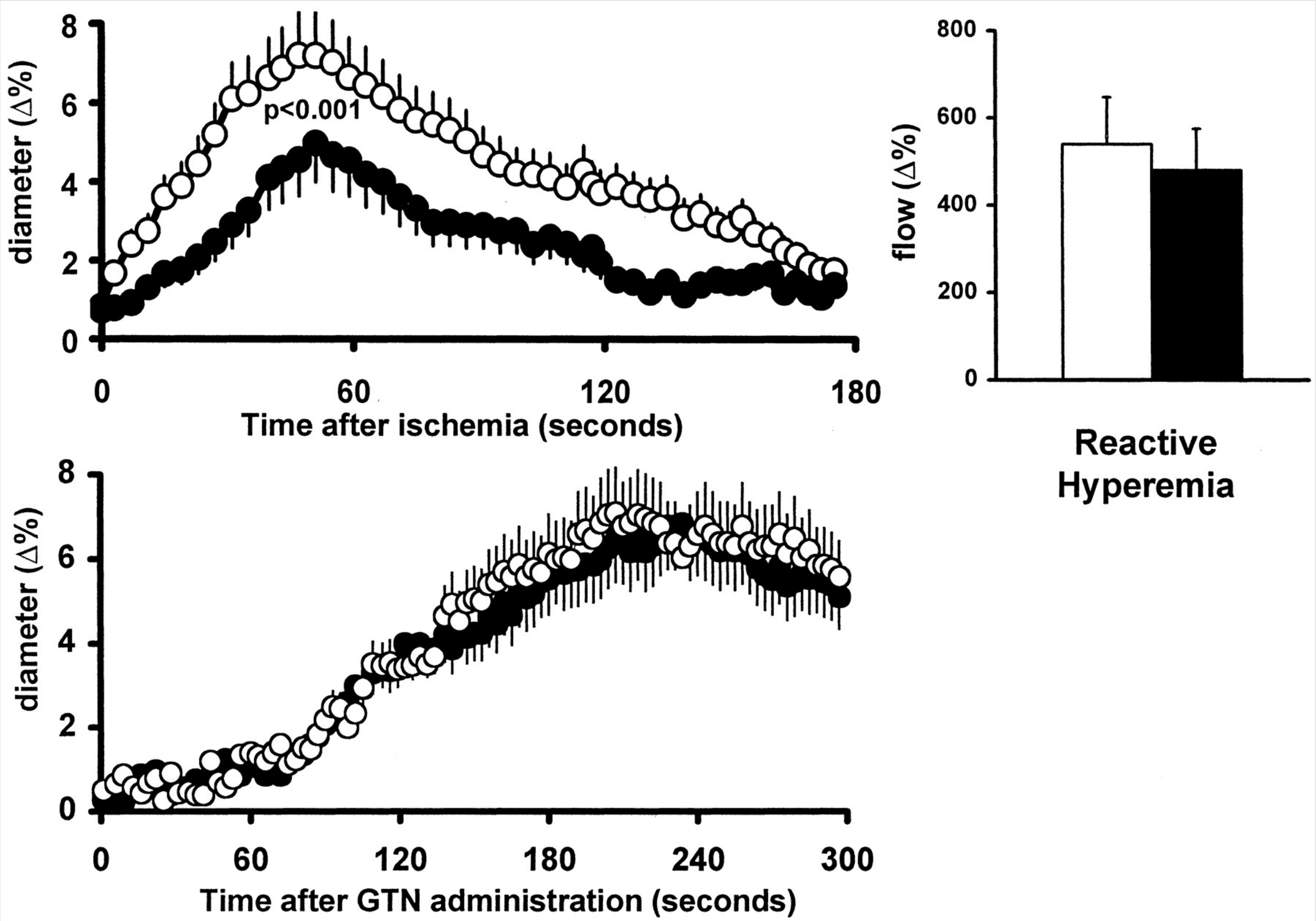
Signal averaging
10-10 000 RF lines



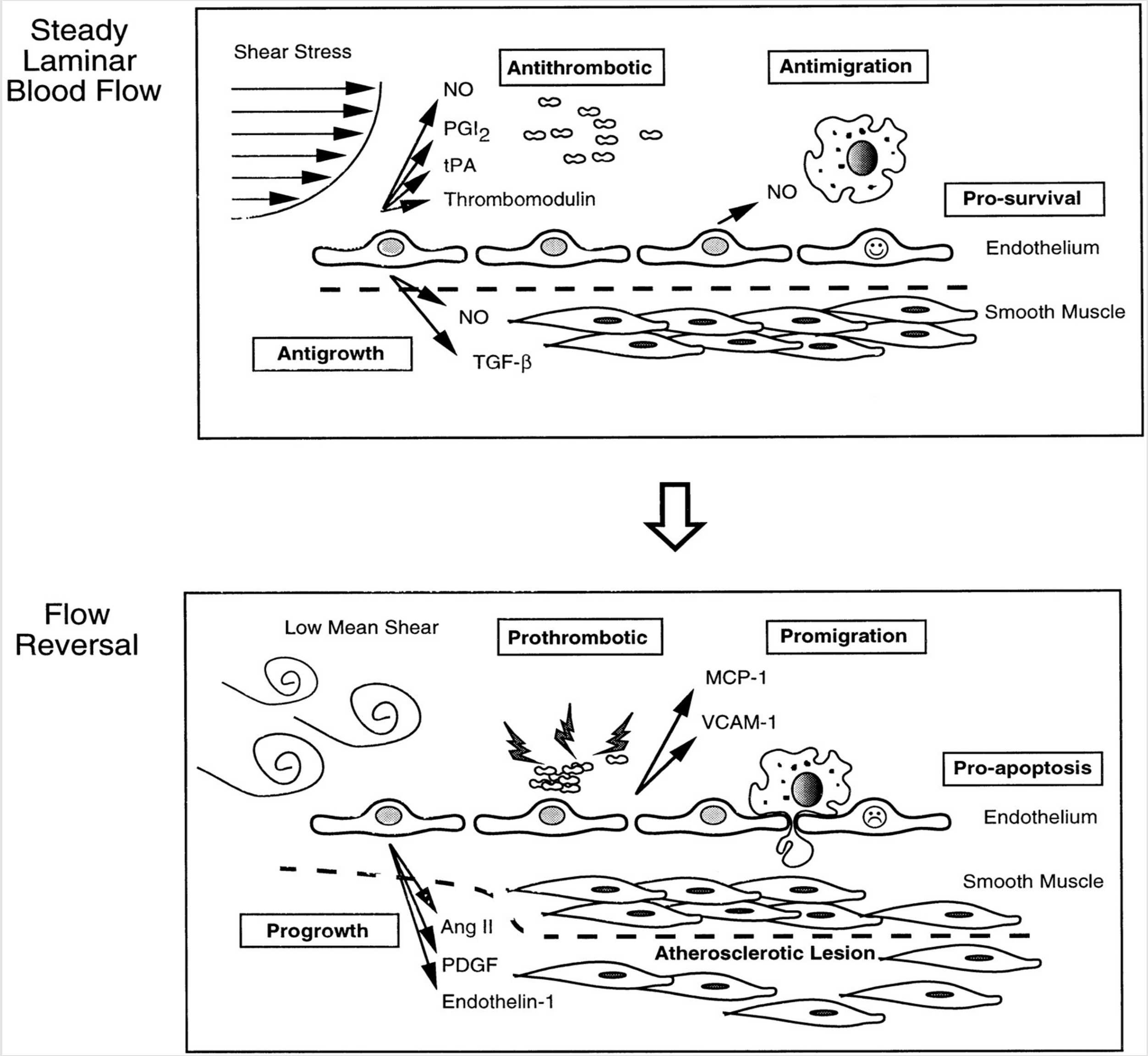
2 D **TM** **RF Signal**

Spatial resolution **200-400 µm** **20-40 µm**

Graphs show FMD, GTN-induced dilation, and RH in normotensive subjects (white circles and bars) and in patients with essential hypertension (black circles and bars)



Ghiadoni, L. et al. Hypertension 2003;41:1281-1286



Traub, O. et al. Arterioscler Thromb Vasc Biol 1998;18:677-685

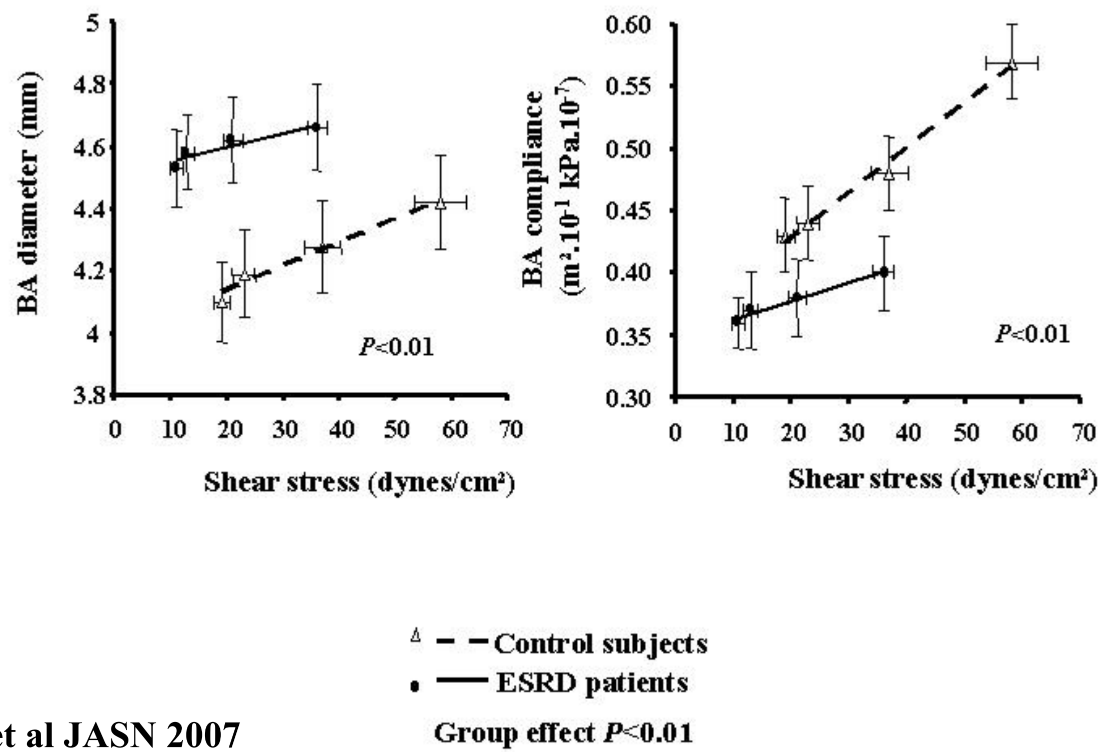
Endothelial cell biology and shear stress

Brachial artery characteristics

	Controls	ESRD	
Baseline BA diameter (mm)	4.12± 0.13	4.56± 0.11	< 0.01
BA compliance ($m^2.kPa^{-1}.10^{-7}$)	0.45± 0.02	0.37± 0.02	< 0.01
BA distensibility ($kPa^{-1}.10^{-3}$)	3.5± 0.22	2.6± 0.19	< 0.001
BA incremental elastic modulus ($kPa.10^{3}$)	3.0± 0.22	5.0± 0.42	< 0.001
BAcircumferential wall stress (kPa)	60± 2.5	65± 1.9	NS
Baseline mean flow velocity (cm/s)	4.6± 0.40	3.4± 0.30	< 0.01
Baseline mean flow (ml/min)	39± 4.6	33± 3.6	NS
Baseline mean SR (s^{-1})	53± 2.9	39± 3.5	< 0.01
Baseline peak SR (s^{-1})	365± 23	324± 26	< 0.05
Whole blood viscosity (cPoise)	3.57± 0.07	2.79± 0.06	< 0.0001
Baseline mean SS ($dynes/cm^2$)	19± 1.15	10.7± 1.0	< 0.001
Baseline peak SS ($dynes/cm^2$)	129± 9	83± 5	< 0.001

Verbeke et al JASN 2007

Relationship in Controls and ESRD patients between brachial artery (BA) diameter and compliance and BA shear stress



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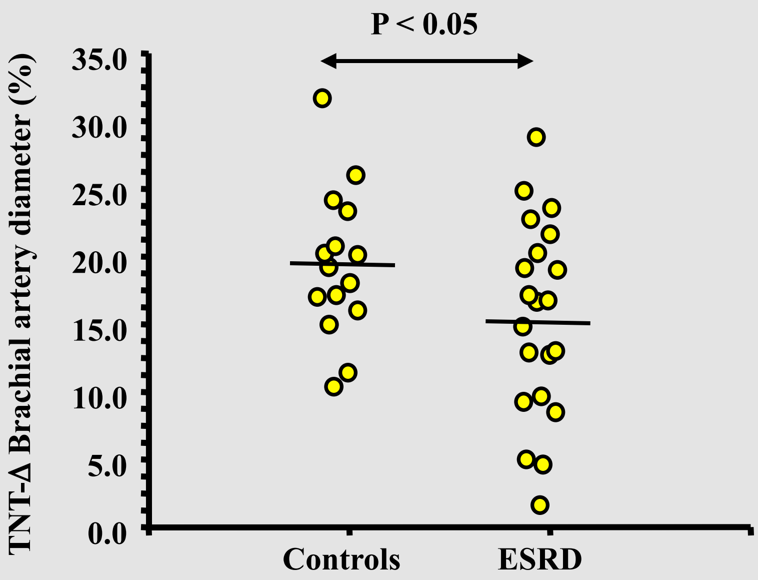

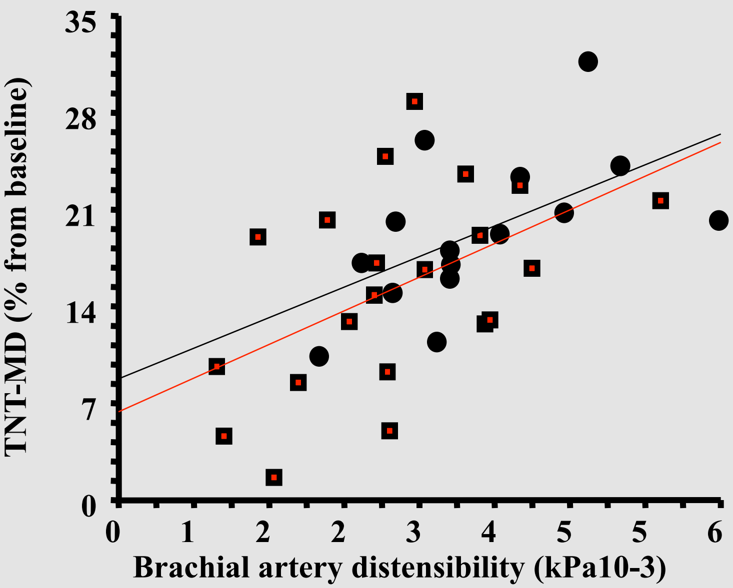

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