Az artériás funkció mérése - jelentősége és lehetőségei

Bojnice, 2010.október 22.

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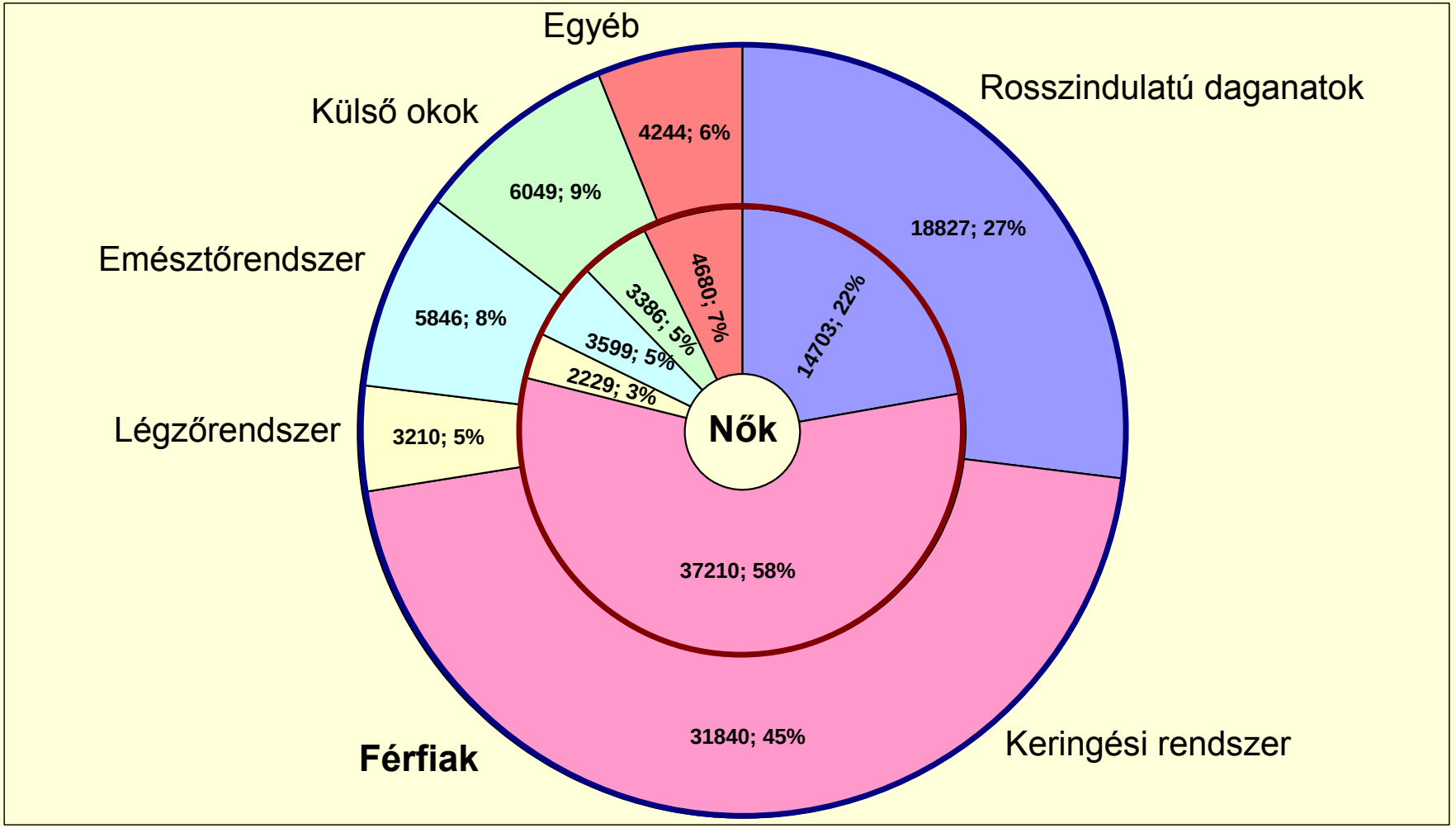
Illyés Miklós Md, PhD munkája alapján

Továbbá Vértes András Prof. és Dr. Benczúr Béla ábráival

Főbb halálokok

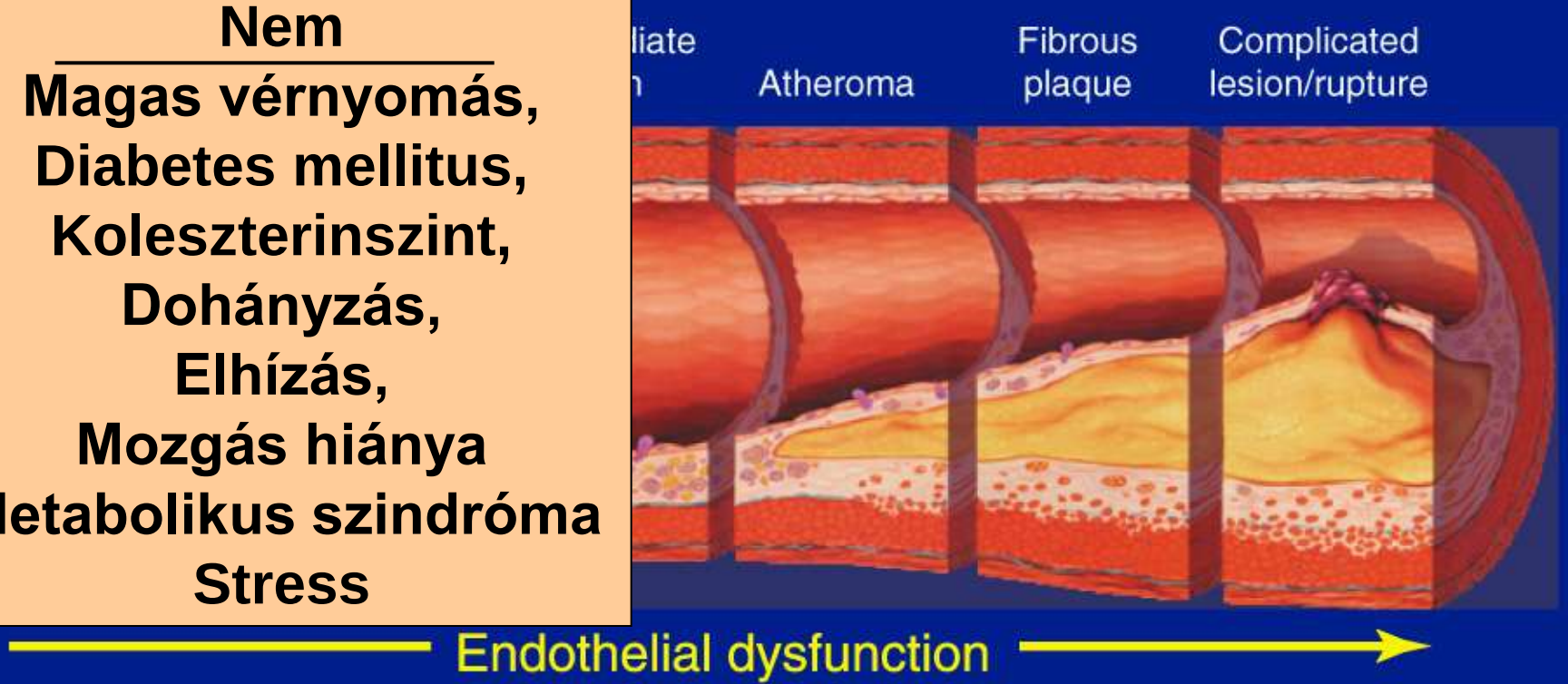


RIZIKÓFAKTOROK

Életkor

Nem

Magas vérnyomás,
Diabetes mellitus,
Koleszterinszint,
Dohányzás,
Elhízás,
Mozgás hiánya
Metabolikus szindróma
Stress



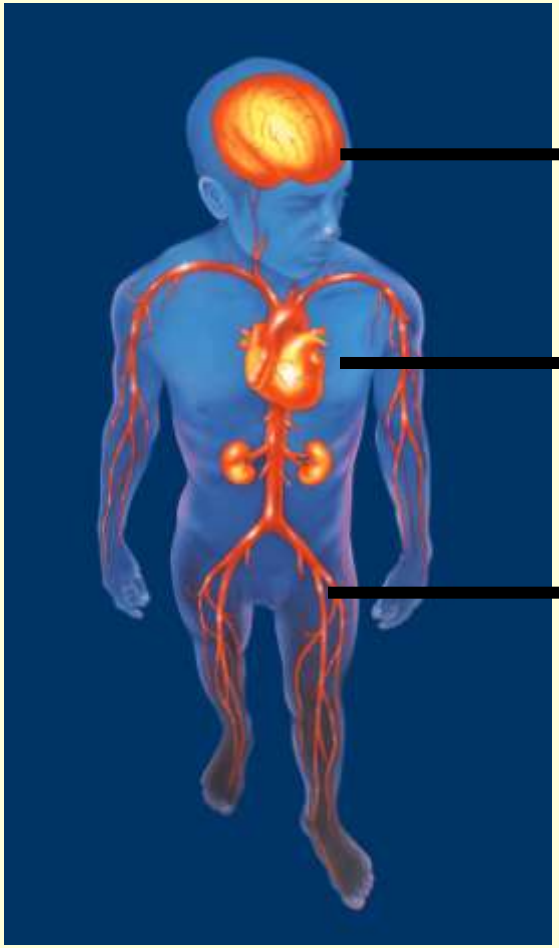
CÉLSZERVKÁROSODÁS

Balkamra hipertrófia,
Carotis plaque,
Aorta érfali merevség

MAJOR ESEMÉNYEK

Szívinfarktus,
Agyvérzés,
Perifériás érbetegség

Az érelmeszesedés klinikai megjelenési formái



Agyi érkatasztrófa, stroke

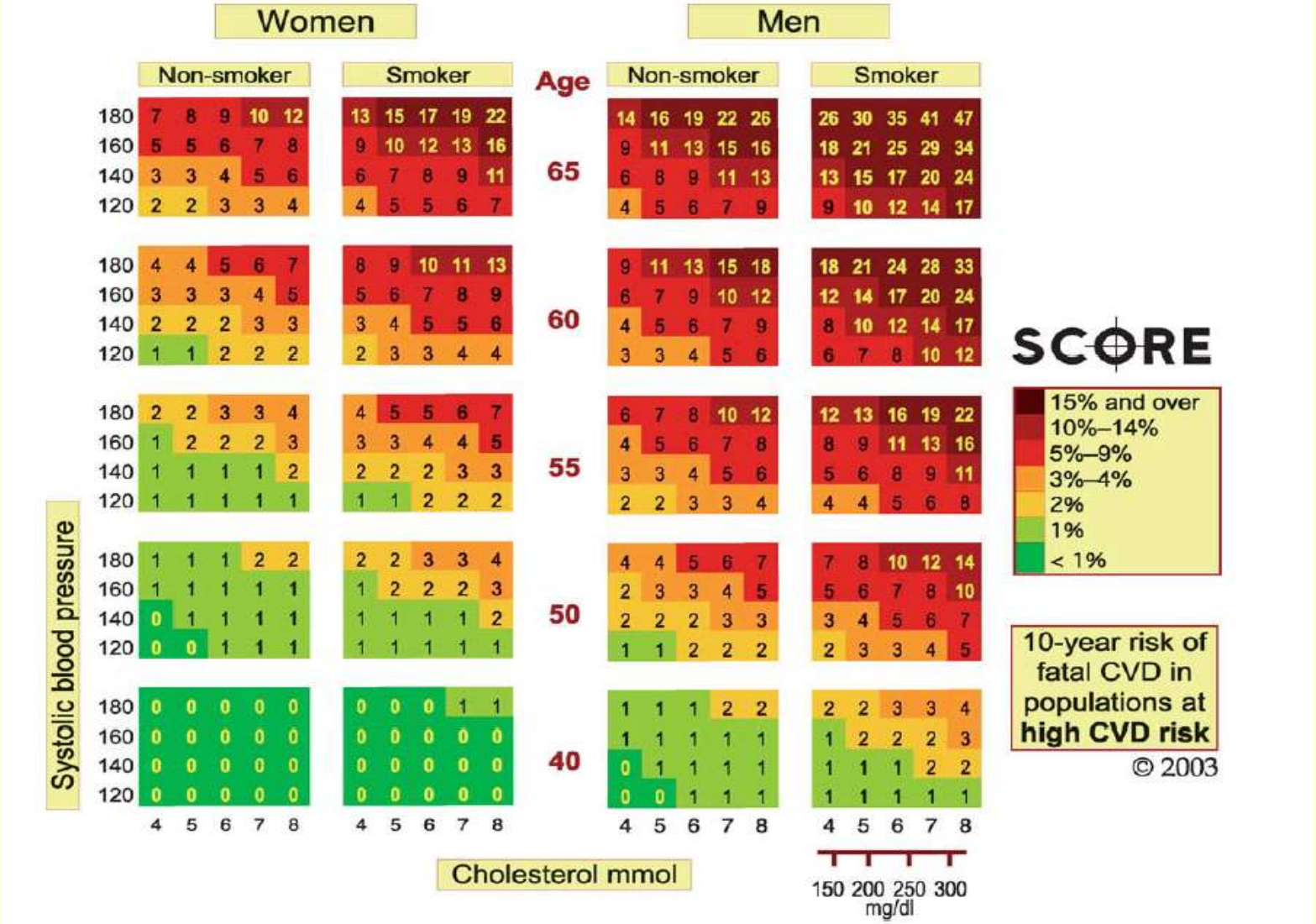
Koronáriabetegség, szívinfarktus

Perifériás érbetegség

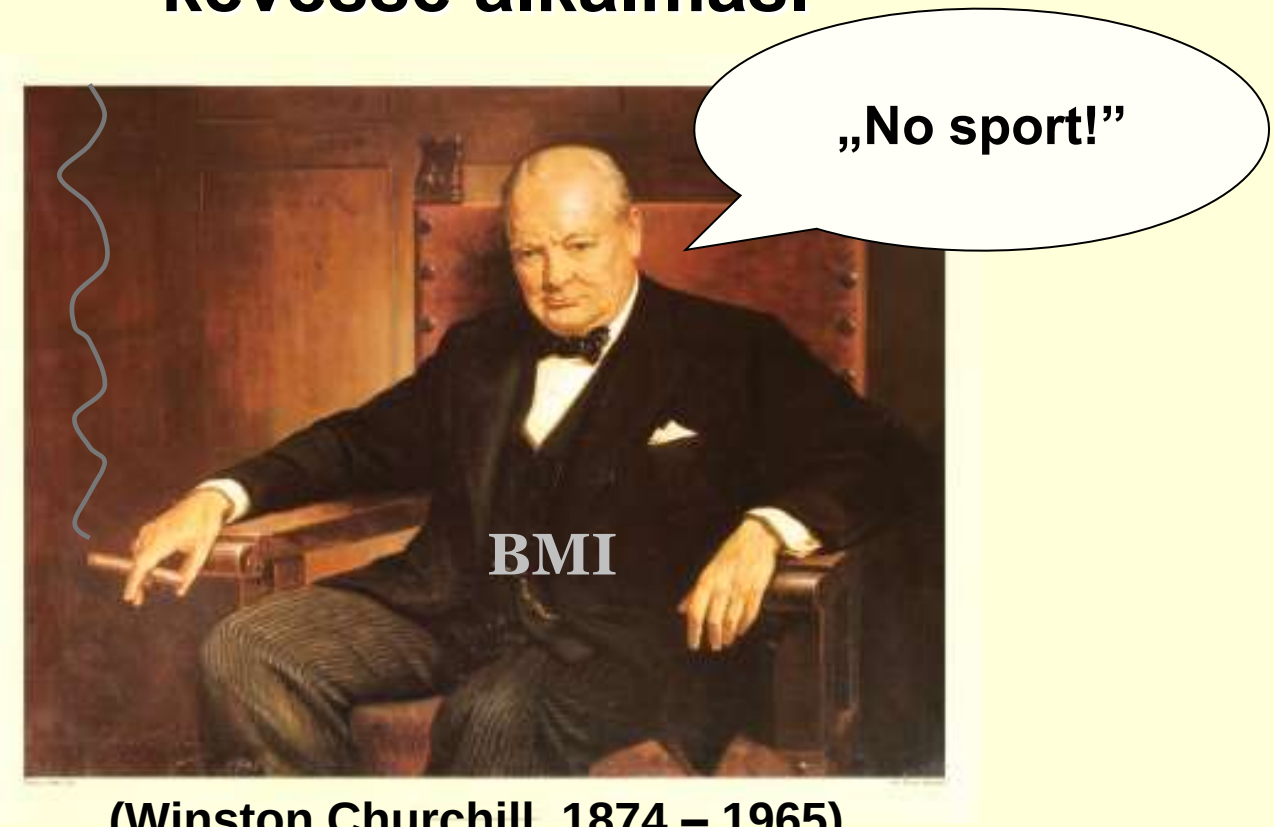
Major CV események

A kardiovaszkuláris megbetegedések eseteinek kb. 30%-ában sajnos az első tünet egyben az utolsó is!

CV Rizikófelmérés, Európa (SCORE)



A Framingham és a SCORE populációs szinten kiválóan alkalmazható, ellenben az egyéni rizikó megállapítására kevéssé alkalmas.



(Winston Churchill, 1874 – 1965)

A hagyományos rizikófelmérés hátrányai
(SCORE, Framingham)

- **Nem vesznek figyelembe bizonyos, igazolt rizikófaktorokat**
  (elhízás, diabetes, családbeli major CV esemény előfordulása, rendszeres fizikai aktivitás hiánya, pszichoszociális faktorok, etc.)

- **Többnyire a fatális és nem-fatális koronária-betegségekre fókuszálnak, nem vették figyelembe a stroke-ot**

- **Nem veszik figyelembe az etnikai hovatartozást**

- **A kardiovaszkuláris betegségek 80%-a az alacsony- és közepes jövedelmű országok lakói közül kerülnek ki, ezek a tanulmányok nem ezen országok lakóit veszik figyelembe**

Simon, A. and Levenson, J.: *May subclinical arterial disease help to better detect and treat high-risk asymptomatic individuals?* J Hypertens 2005, 23: 1939-1945

„....although traditional risk factors may account for 90% of the attributable cardiovascular risk, their prediction of CVD is weak probably because the susceptibility to CVD varies grea

A hagyományos rizikófaktorok prediktív értéke önmagában gyenge, mert az egyéni érzékenységet nem veszi figyelembe.

Egyéb, új rizikófaktorok szükségesek a tünetmentes populáció szűrésére.

„The k
facto gh-
risk ential
risk n of
high-risk asymptomatic subjects."

Simon, A. and Levenson, J.: ***May subclinical arterial disease help to better detect and treat high-risk asymptomatic individuals?*** **J Hypertens 2005, 23: 1939-1945**

Performance of Subclinical Arterial Disease Detection as a Screening Test for Coronary Heart Disease

Alain Simon, Gilles Chironi, Jaime Levenson

Abstract— Traditional risk factors are poor screening tests for coronary heart disease, whereas clinical arterial disease

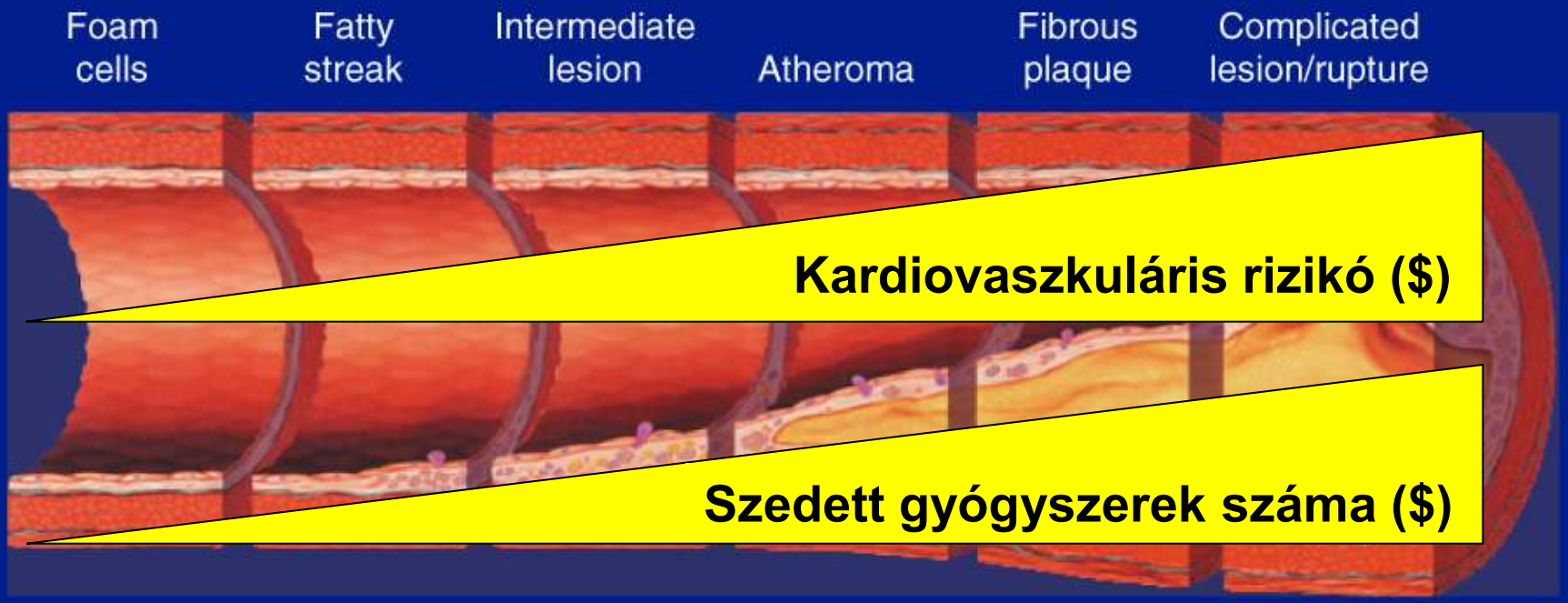
A hagyományos rizikófaktorok nem elegendőek a rizikóbecslésre.

Az artériás megbetegedés diagnosztizálása nem csak klinikai manifesztáció alkalmával, hanem a szubklinikus fázisban is szükséges.

disease, not only clinically overt but also subclinical asymptomatic, is a worthwhile screening test for future coronary event. (***Hypertension*. 2006;48:392-396.**)

Key Words: risk factors ■ coronary heart disease ■ intima-media thickness ■ coronary calcium ■ plaque ■ arterial stiffness ■ prevention

Atherosclerosis timeline



Endothelial dysfunction

From first decade	From third decade	From fourth decade	
Growth mainly by lipid accumulation		Smooth muscle and collagen	Thrombosis, hematoma

Pepine CJ. *Am J Cardiol.* 1998;82(suppl 10A):23S-27S.

Az érfali struktúra vizsgálata (non-invazív)

- Koszorúér kalcium score, stenosis vizsgálata (**CT**)
- Aorta és Carotis plaque-vizsgálat (**MRI**)
- Carotis Plaque vizsgálat (**ultrahang**)
- IMT vizsgálat (**ultrahang**)
  (az említettek közül ez alkalmas a legkorábbi stádium felderítésére)

Közös jellemzők: - Műszer-és eszközigény (**$$** vagy **$$$**)
- Szakorvosi képzettség

Alkalmasak-e szűrővizsgálatra?

Az érfali struktúra vizsgálata (non-invazív)

- Ankle-brachial index (**Boka-fekar index**)
  (boka SBP/felkari SBP=ABI index)

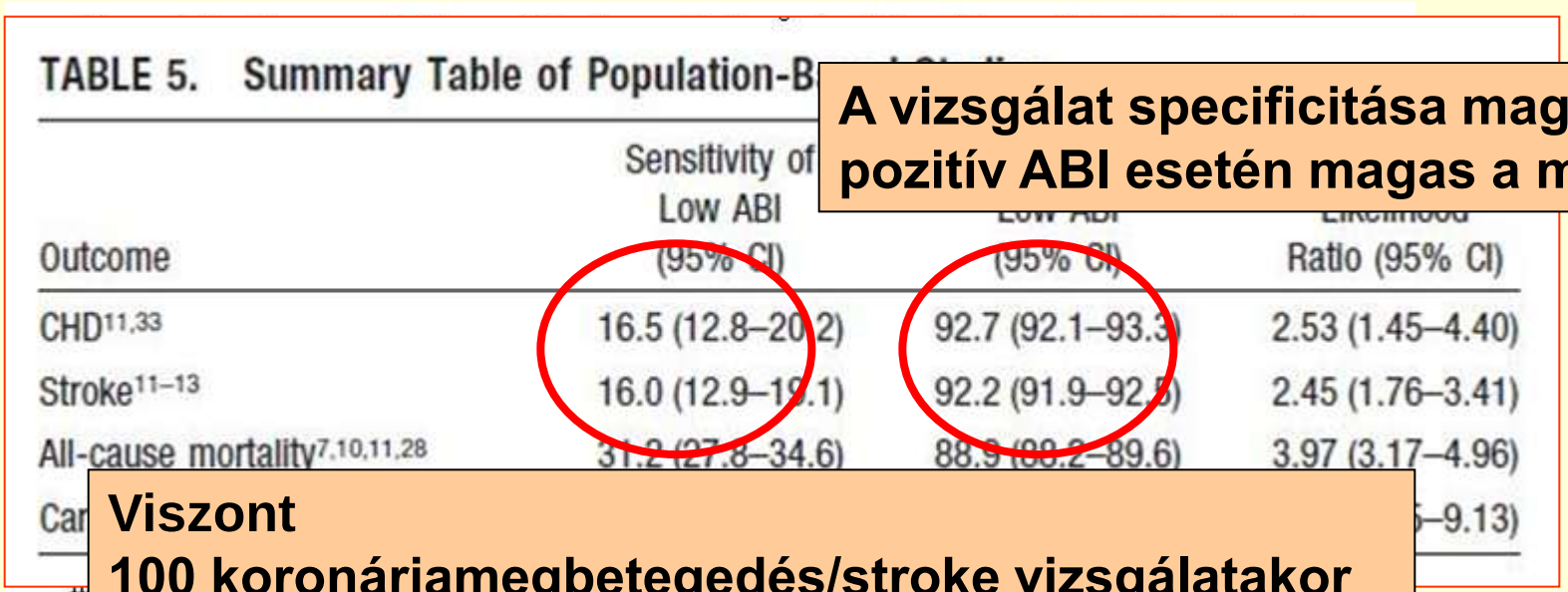


TABLE 5. Summary Table of Population-B

Outcome	Sensitivity of Low ABI (95% CI)	(95% CI)	Ratio (95% CI)
CHD[11,33]	16.5 (12.8–20.2)	92.7 (92.1–93.3)	2.53 (1.45–4.40)
Stroke[11–13]	16.0 (12.9–19.1)	92.2 (91.9–92.5)	2.45 (1.76–3.41)
All-cause mortality[7,10,11,28]	31.2 (27.8–34.6)	88.9 (88.2–89.6)	3.97 (3.17–4.96)
Car			–9.13)

A vizsgálat specificitása magas, azaz pozitív ABI esetén magas a mortalitás.

Viszont
100 koronáriamegbetegedés/stroke vizsgálatakor csak 16% esetében találtak alacsony ABI-t.

Érzékenysége tehát nem elegendő szűrővizsgálatként való alkalmazásához!

22 ABI tanulmány meta-analízise alapján

Az érfali funkcionális vizsgálatok

- A brachialis artéria vazoreaktivitása (**FMD**, flow mediált vazodilatáció)
  Ultrahang, képzettséget igényel, fájdalmas

- **artériás funkcióvizsálat,**
  artériás stiffness vizsgálata

Mi az artériás stiffness, artériás funkció?

„Érfali öregedés”

Elasztin fragmentáció

Fokozott elasztáz aktivitás

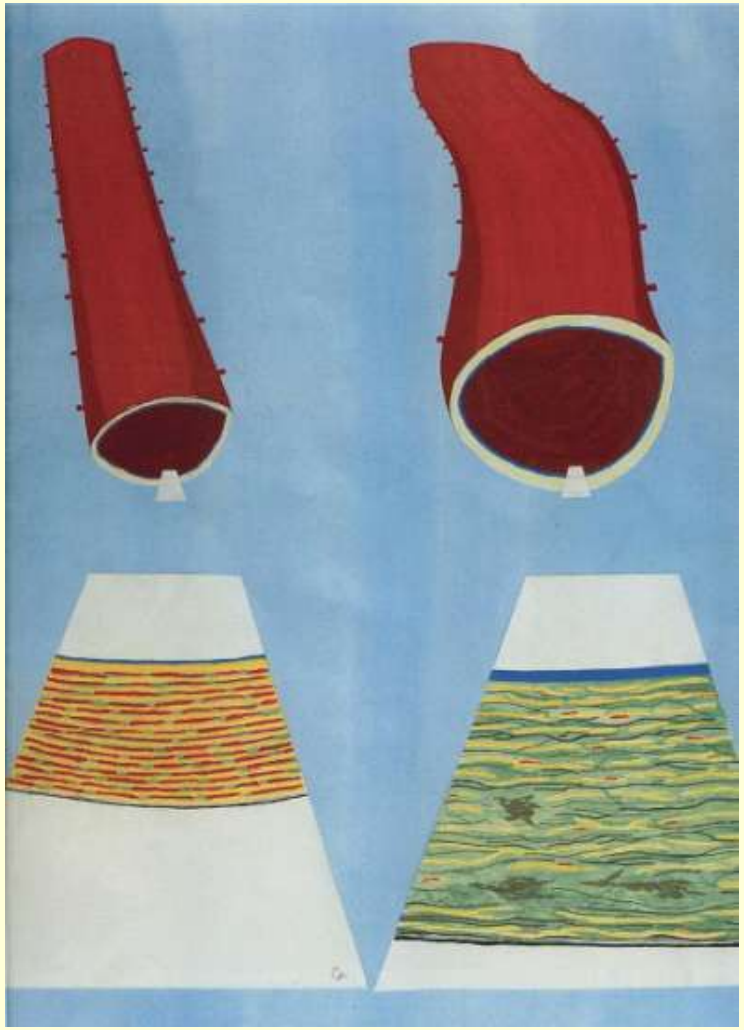
Simaizom sejtek fokozott kollagén termelése

Fokozott keresztkötés képződés a kollagénrostok között

Az aorta és a nagy artériák falának elasztikus modulusának növekedése. Artériás compliance és a disztenzibilitás csökken.

Intima és media vastagságának, ill. az érfal merevségének növekedése.

„Korai vascularis öregedés, EVA”



Normál életkori arteriális változások jelentős felgyorsulása és a pathológiás vasculáris változások rárakodása.

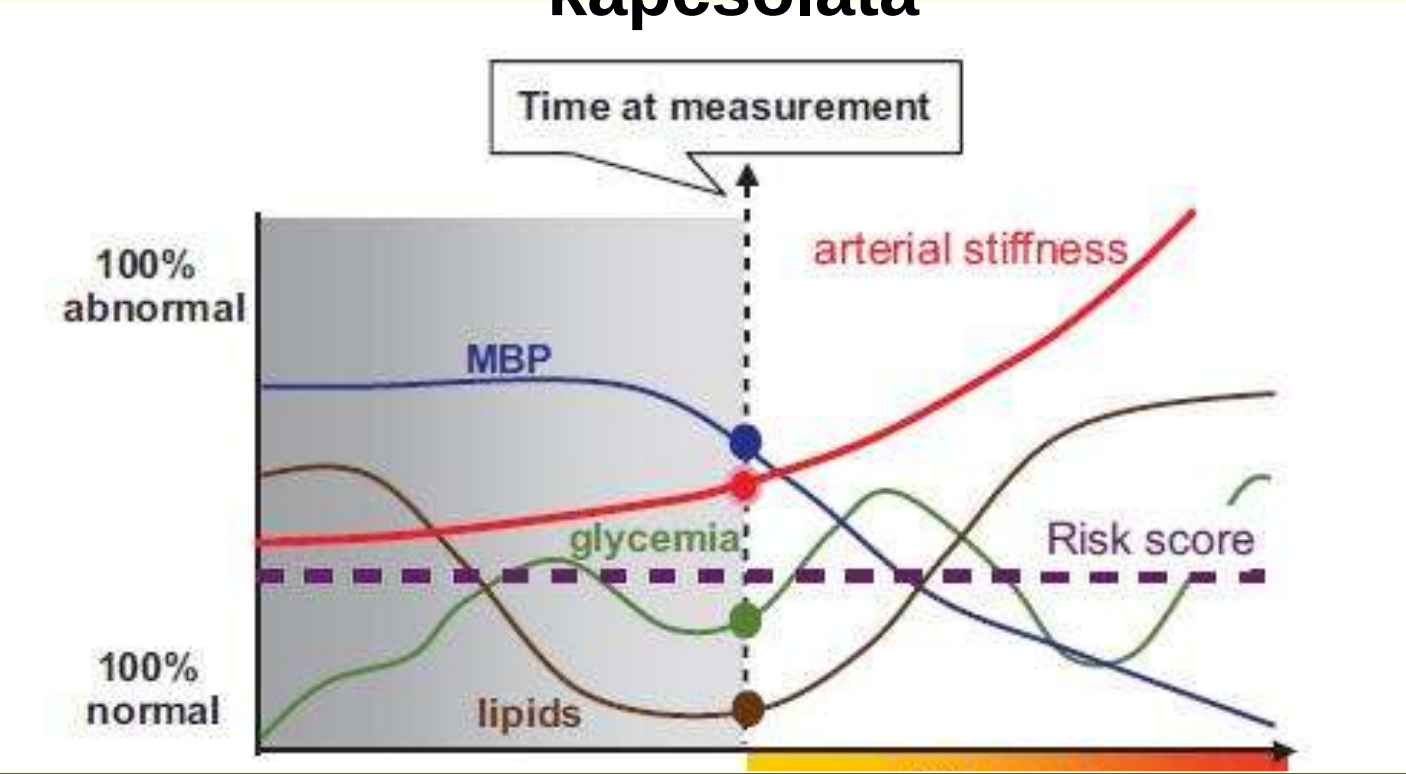
Diagnózis:

non-invazíve, reprodukálhatóan, egyszerűen, biztonságosan.

Carotis-intima-media és

PWV mérése

A klasszikus rizikófaktorok és az arterial stiffness kapcsolata



Az artériás funkció a valós érfali károsodás tükre, mely CV rizikófaktorok hatására alakul ki és a kor előrehaladtával súlyosbodik, míg a vérnyomás, a vércukorszint, vér-lipidszint egyénenként folymatosan fluktuálhat. Az artériás stiffness folyamatos, mindenkori jellemző, még ha az egyéb faktorok pozitív irányban is változnak (így csak egy időpontbeli, nem globális jellemzésre alkalmasak).

Az artériás stiffness konstans állapotot jelző paraméter.

Az artériák merevsége (arterial stiffness) az életkor előrehaladtával fokozatosan növekszik (**ARTÉRIÁS ÉLETKOR**)

Az artériák korai öregedésének leggyakoribb okai:

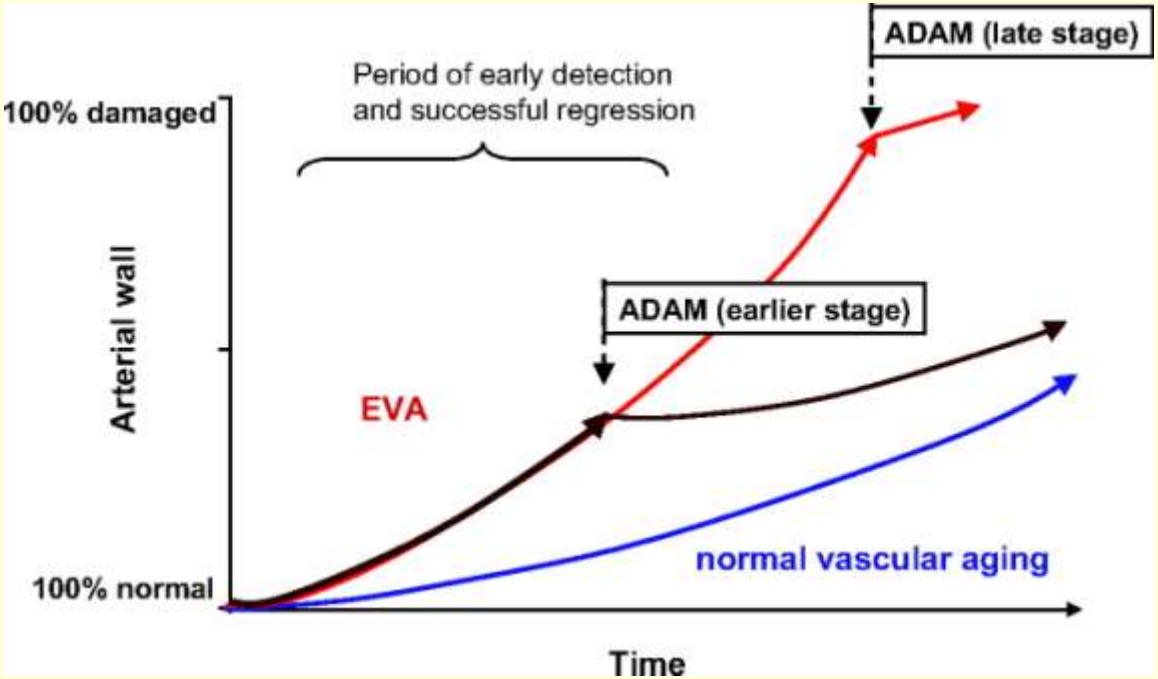
- hypertonia
- obesitas
- diabetes
- dohányzás
- vesebetegség
- dyslipidaemia
- menopausa

Az EVA felelős tényezői:

- Csökkent endothel funkció és vasodilatáció
- Krónikus vasculáris gyulladás
- Intima-media falvaszagság növekedése, korai atherosclerosis
- Hemorrheológiai zavarok
- Rövidebb telomere hossz/alacsonyabb telomer aktivitás
- Csökkent glukóz és lipid metabolizmus
- Inzulin rezisztencia
- Oxidativ stressz
- Artériás kalcifikáció
- Mátrix szubstratok lerakodásának fokozódása
- Kísér degeneráció az agyi és a veseerekben
- Emelkedett balkamrai hypertrophia

Mi a jelentősége a CV prevencióban a „korai vascularis öregedés” felismerésének?

A korai vascularis öregedés felismerése segítséget nyújthat a klinikusnak a CV megbetegedések korai felismeréséhez, még abban a periódusban, amikor van lehetőség a folyamat visszafordítására. Legfontosabb meghatározni a magas rizikójú, tünetmentes egyéneket.



Hypertension. 2009;54:3-10

Mi az artériás stiffness, artériás funkció?

A „Stiffness” egy elasztikus test ellenállása külső behatásra (nyújtás, hajlítás)

Arterial Stiffness **= az artériák rigiditása, rugalmasságuk csökkenése**

Artériás funkció **= az artériák compliance-jének, az érfali (endothel) működésnek megtartása**

Az Artériás funkció
több paraméterrel jellemezhető:

Augmentációs index

Centrális vérnyomás

Pulzushullám-terjedési sebesség

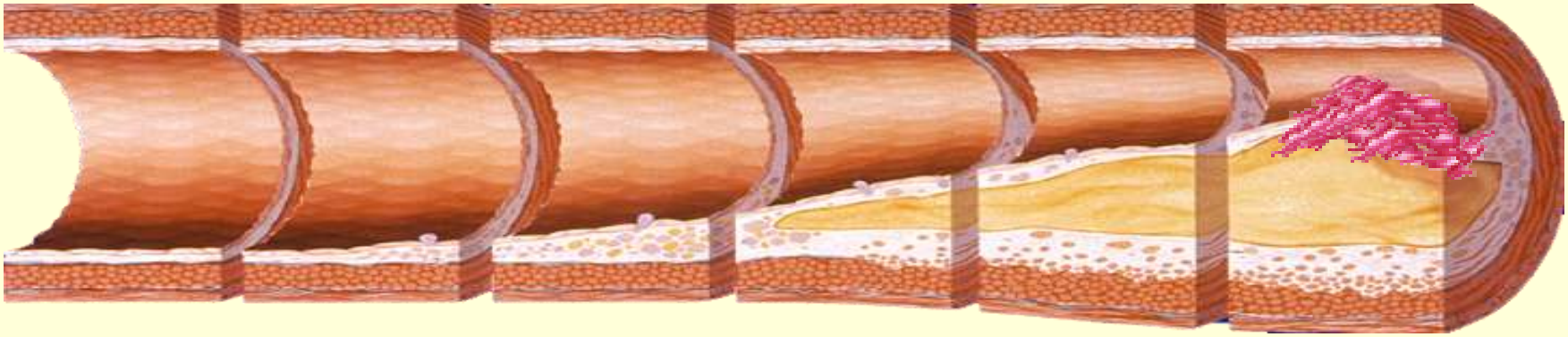
Mindegyik a kardovaszkuláris morbiditás és mortalitás egyedi és független előjelzője!

„….az érfali merevség az érelmeszesedést megelőző állapot, és annak rizikótényezője is egyben.”

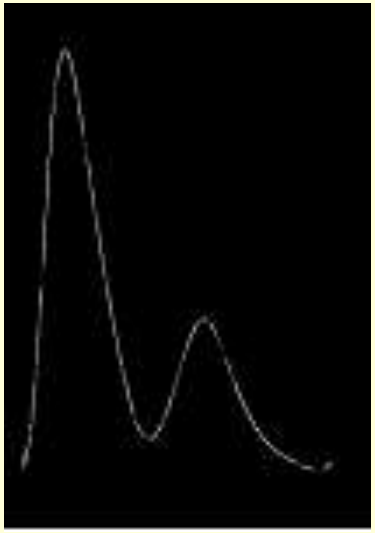
„…tanulmányok egyértelműen rámutatnak arra a tényre, hogy a PWV és az augmentációs index az érelmeszesedás strukturális változásaival összefüggő jellemzők.”

Davies, J.I., Struthers, A.D.:
***J Hypertens** 21:463-472; 2003*

Artériás pulzus: ablak az érpályára

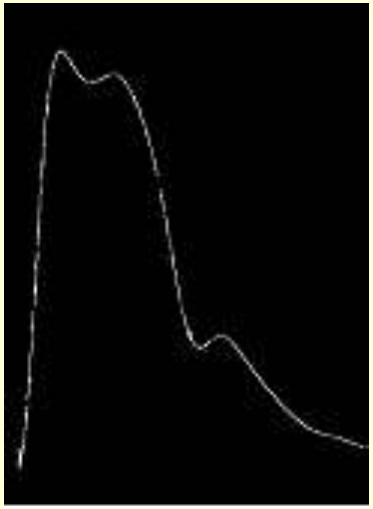


Endothel funkció

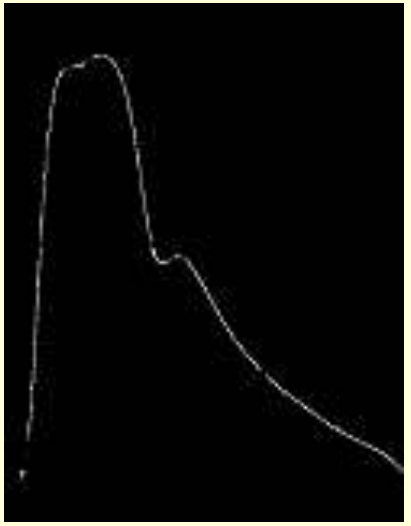


Vascularis funkció

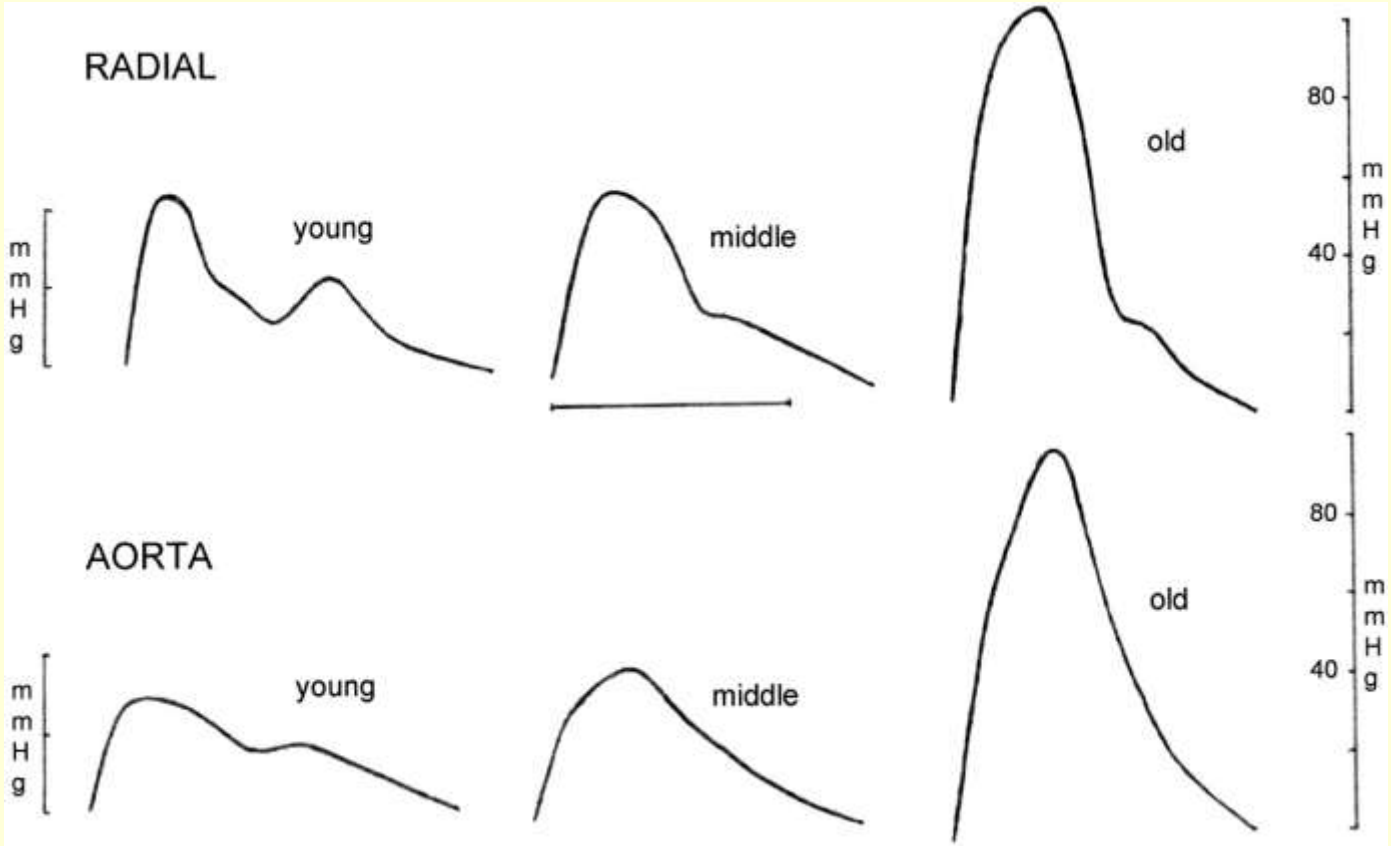
Emelkedett vérnyomás



Célszerv-károsodás

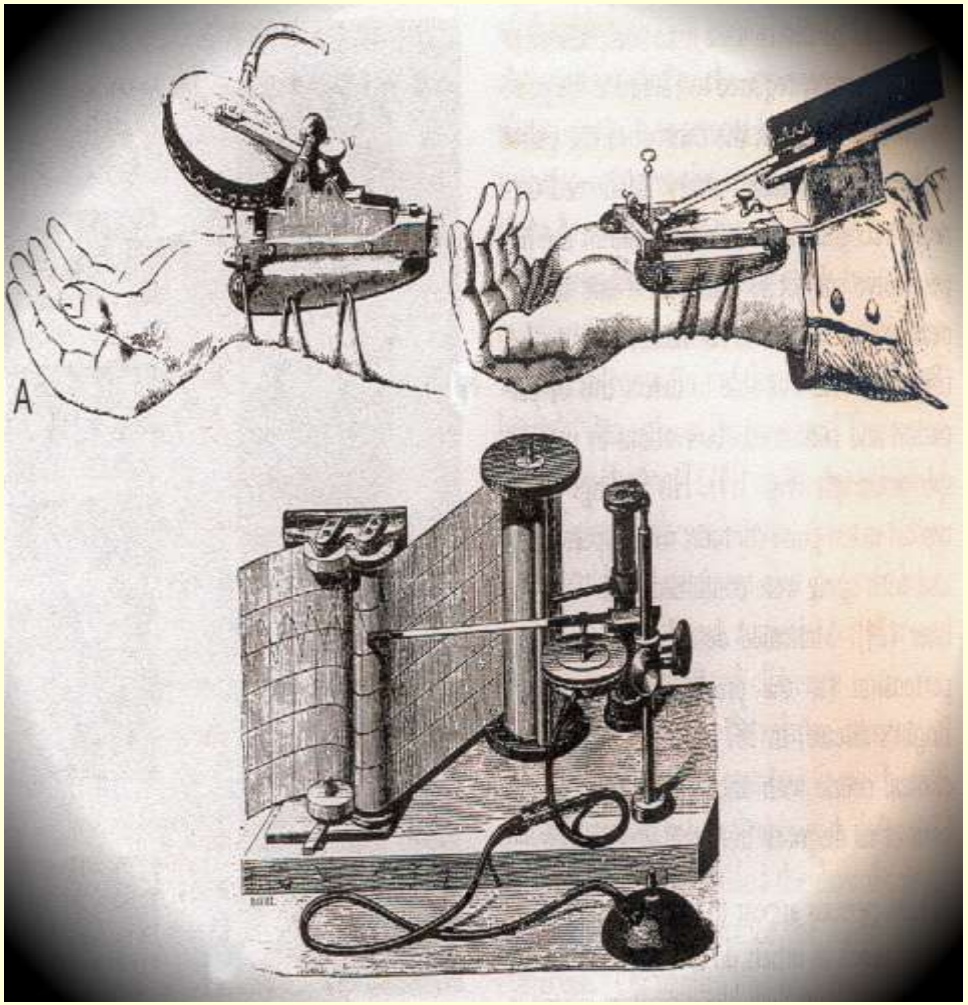


Pulzushullám görbe fiatal és idős embereken



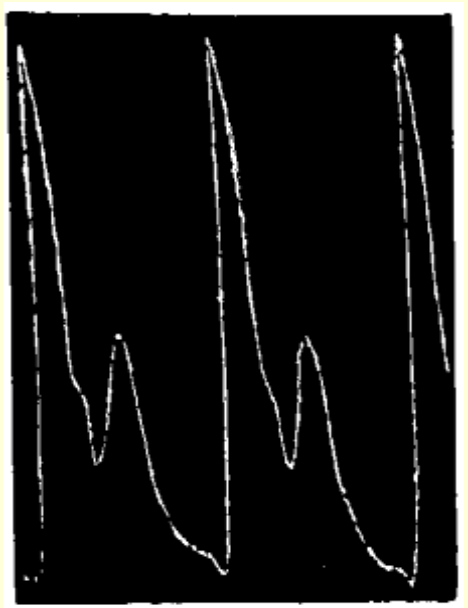
O'Rourke, M. F. et al. J Am Coll Cardiol 2007;50:1-13

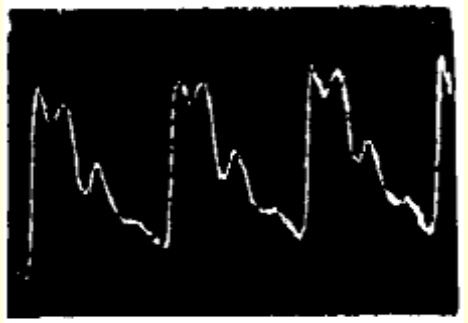
Hogyan mérjük az artériás funkciót?



Sphygmograph

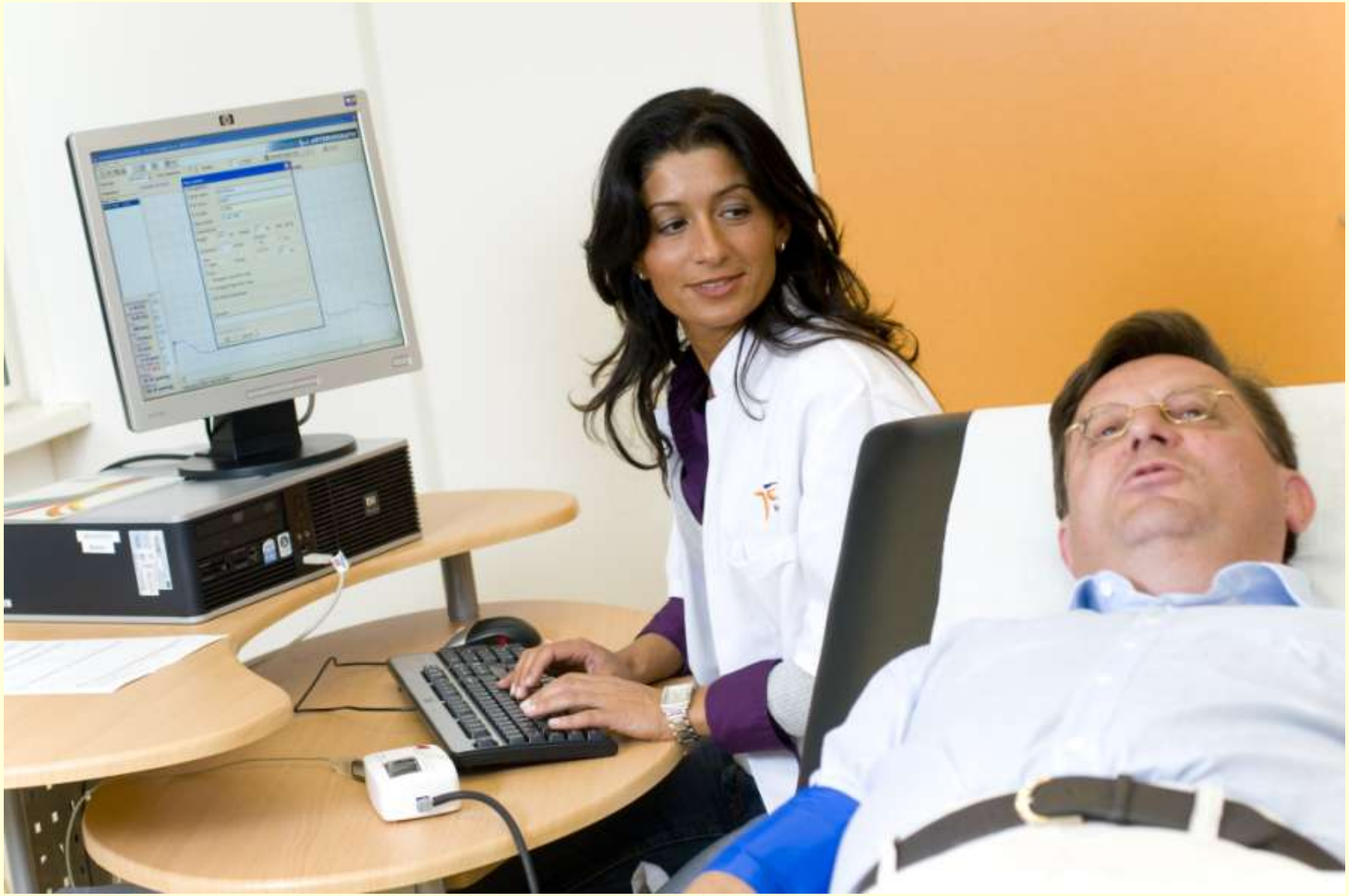
Mahomed 1874



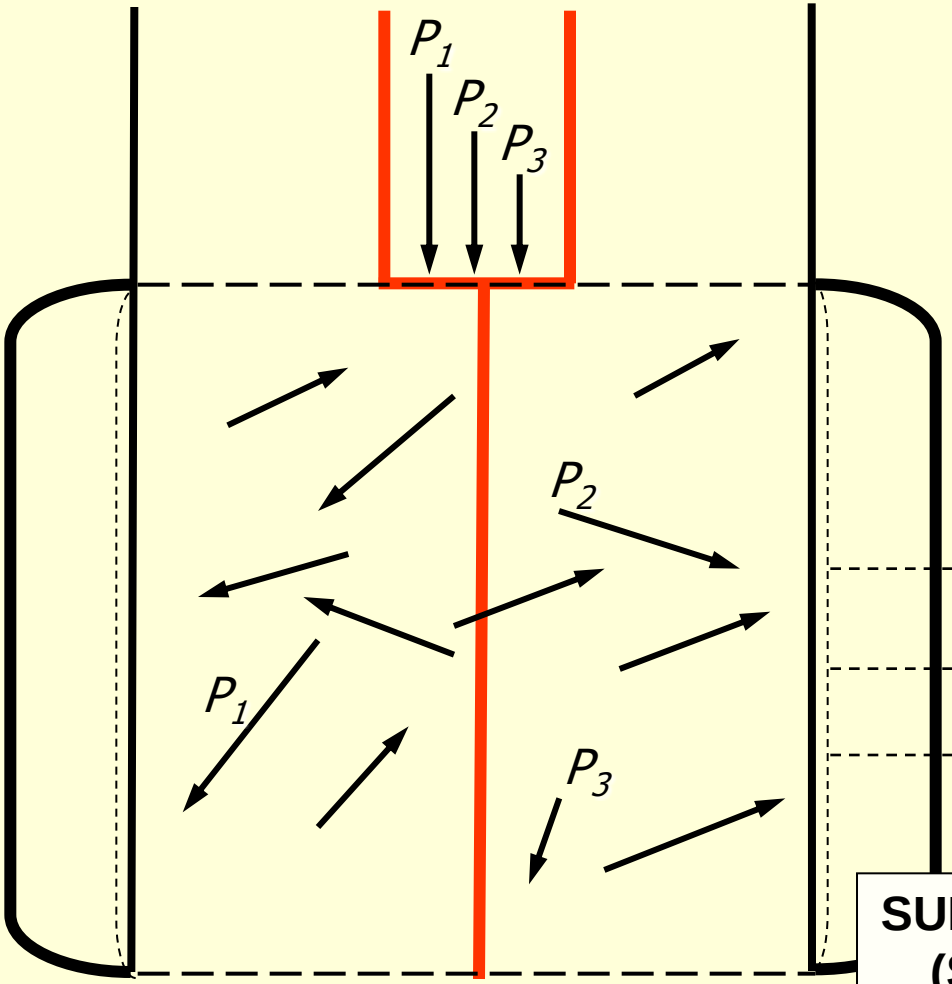



QUALITY CERTIFICATE
IEC 601-1:1988+A1:1991+A2:1995
EN 60601-1:1990+A1:1993+A2:1995
EN 60601-1-2:2002

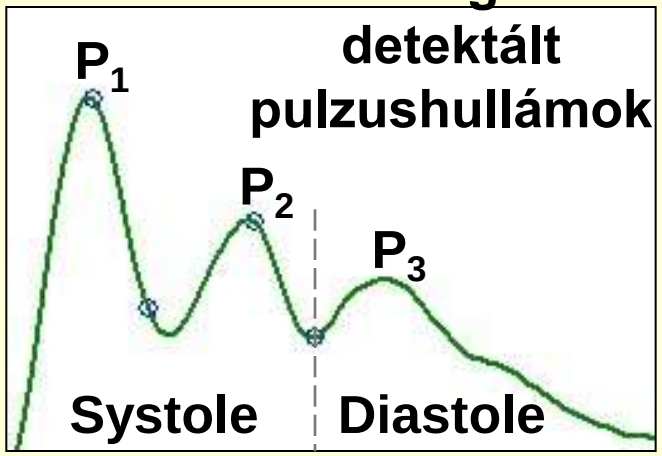

Arteriograph for
Vascular Age



A módszer elve



Az Arteriográf által detektált pulzushullámok



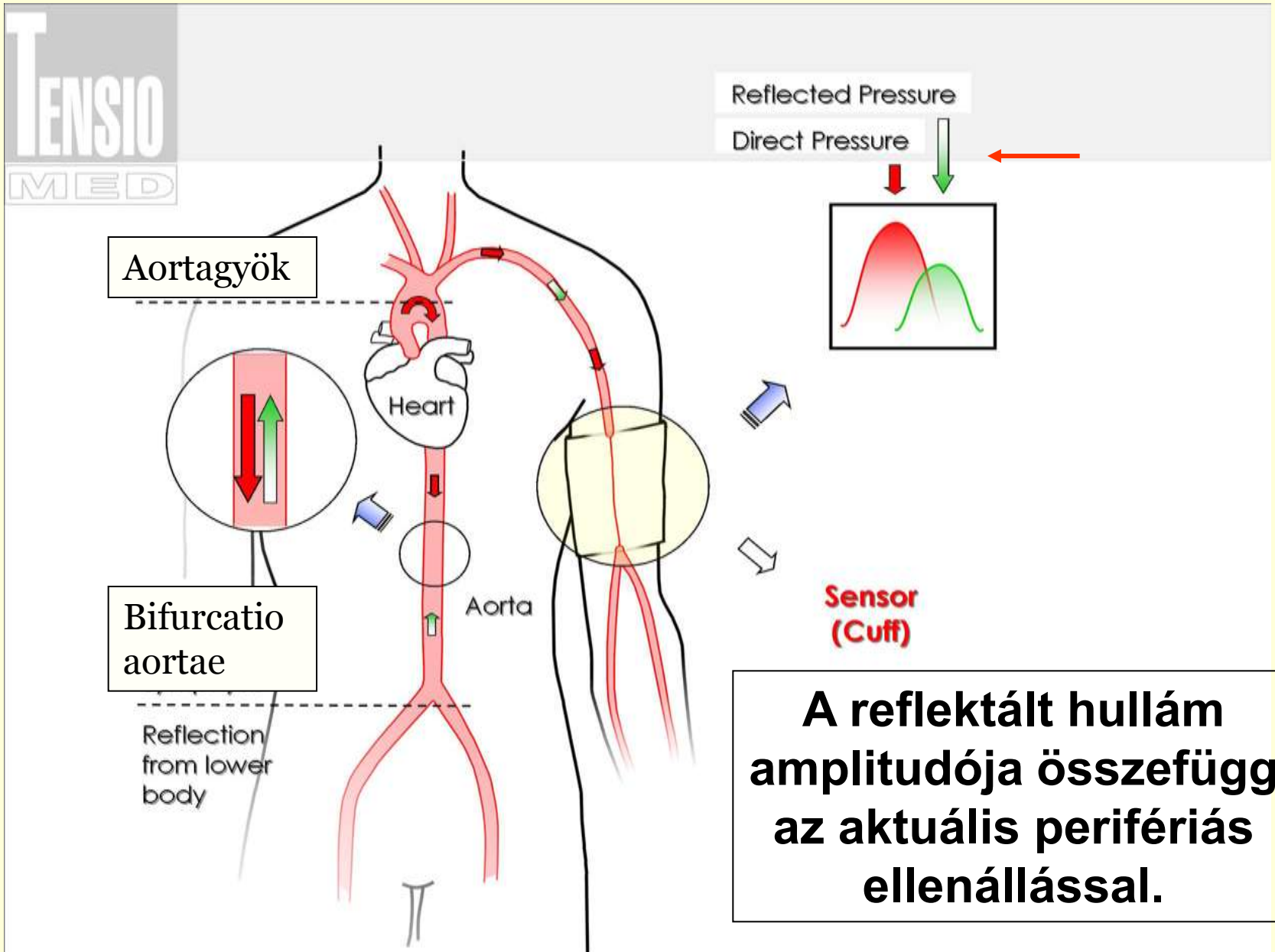
$\Delta V_1 \rightarrow \Delta P_1$

$\Delta V_2 \rightarrow \Delta P_2$

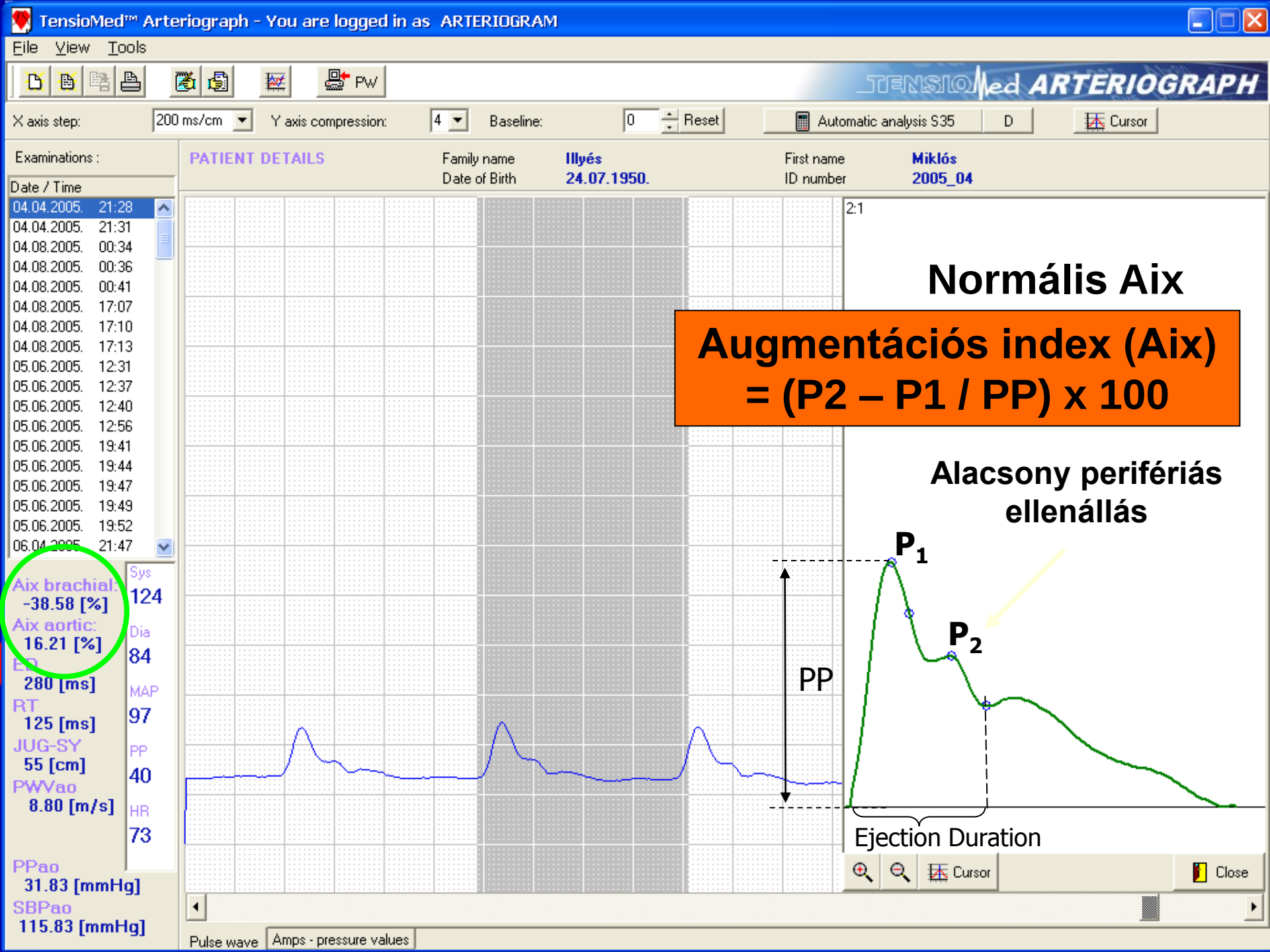
$\Delta V_3 \rightarrow \Delta P_3$

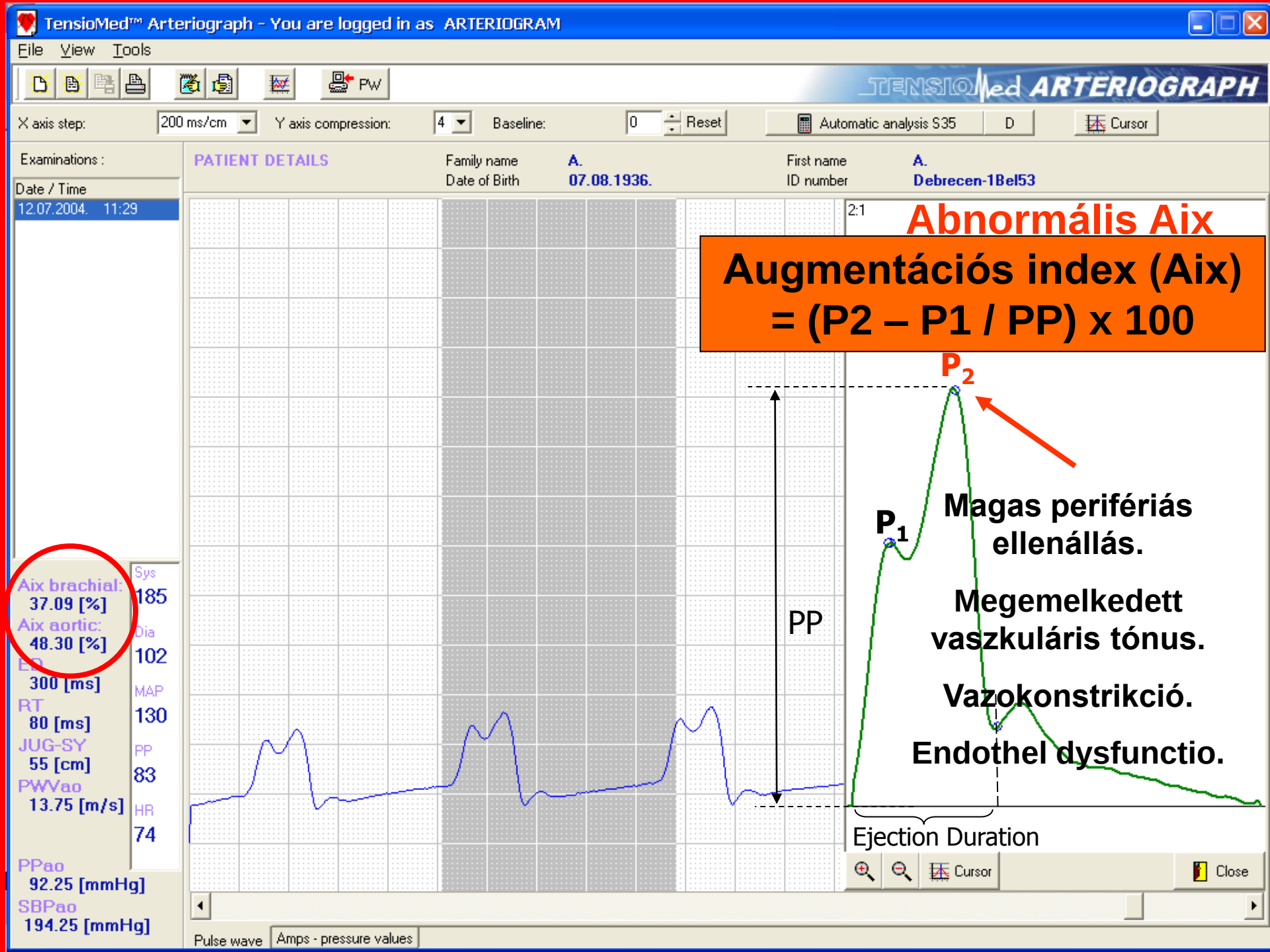
SUPRASYSTOLIC (S+35 mmHg) CUFF PRESSURE

Augmentációs index



A reflektált hullám amplitudója összefügg az aktuális perifériás ellenállással.


TensioMed™ Arteriograph - You are logged in as ARTERIOGRAM
File View Tools
TENSIOMed ARTERIOGRAPH
X axis step: 200 ms/cm
Y axis compression: 4
Baseline: 0
Reset
Automatic analysis S35
D
Cursor
Examinations :
Date / Time
04.04.2005. 21:28
04.04.2005. 21:31
04.08.2005. 00:34
04.08.2005. 00:36
04.08.2005. 00:41
04.08.2005. 17:07
04.08.2005. 17:10
04.08.2005. 17:13
05.06.2005. 12:31
05.06.2005. 12:37
05.06.2005. 12:40
05.06.2005. 12:56
05.06.2005. 19:41
05.06.2005. 19:44
05.06.2005. 19:47
05.06.2005. 19:49
05.06.2005. 19:52
06.04.2005. 21:47
PATIENT DETAILS
Family name Illyés
Date of Birth 24.07.1950.
First name Miklós
ID number 2005_04
Aix brachial: -38.58 [%]
Aix aortic: 16.21 [%]
ED 280 [ms]
RT 125 [ms]
JUG-SY 55 [cm]
PWVao 8.80 [m/s]
PPao 31.83 [mmHg]
SBPao 115.83 [mmHg]
Sys 124
Dia 84
MAP 97
PP 40
HR 73
2:1
Normális Aix
Augmentációs index (Aix)
= (P2 – P1 / PP) x 100
Alacsony perifériás ellenállás
P1
P2
PP
Ejection Duration
Cursor
Close
Pulse wave
Amps - pressure values


TensioMed™ Arteriograph - You are logged in as ARTERIOGRAM
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TENSIOMed ARTERIOGRAPH
X axis step: 200 ms/cm
Y axis compression: 4
Baseline: 0
Reset
Automatic analysis S35
D
Cursor
Examinations :
Date / Time
12.07.2004. 11:29
PATIENT DETAILS
Family name A.
Date of Birth 07.08.1936.
First name A.
ID number Debrecen-1Bel53
Aix brachial: 37.09 [%]
Aix aortic: 48.30 [%]
300 [ms]
RT 80 [ms]
JUG-SY 55 [cm]
PWVao 13.75 [m/s]
PPao 92.25 [mmHg]
SBPao 194.25 [mmHg]
Sys 185
Dia 102
MAP 130
PP 83
HR 74
2:1
Abnormális Aix
Augmentációs index (Aix)
= (P2 – P1 / PP) x 100
P2
P1
PP
Magas perifériás ellenállás.
Megemelkedett vaszkuláris tónus.
Vazokonstrikció.
Endothel dysfunctio.
Ejection Duration
Cursor
Close
Pulse wave
Amps - pressure values

Arterial Stiffness, Wave Reflections, and the Risk of Coronary Artery Disease

Thomas Weber, MD; Johann Auer, MD; Michael F. O'Rourke, MD; Erich Kvas, ScD; Elisabeth Lassnig, MD; Robert Berent, MD; Bernd Eber, MD

Background—Increased arterial stiffness, determined invasively, has been shown to predict a higher risk of coronary atherosclerosis. However, invasive techniques are of limited value for screening and risk stratification in larger patient groups.

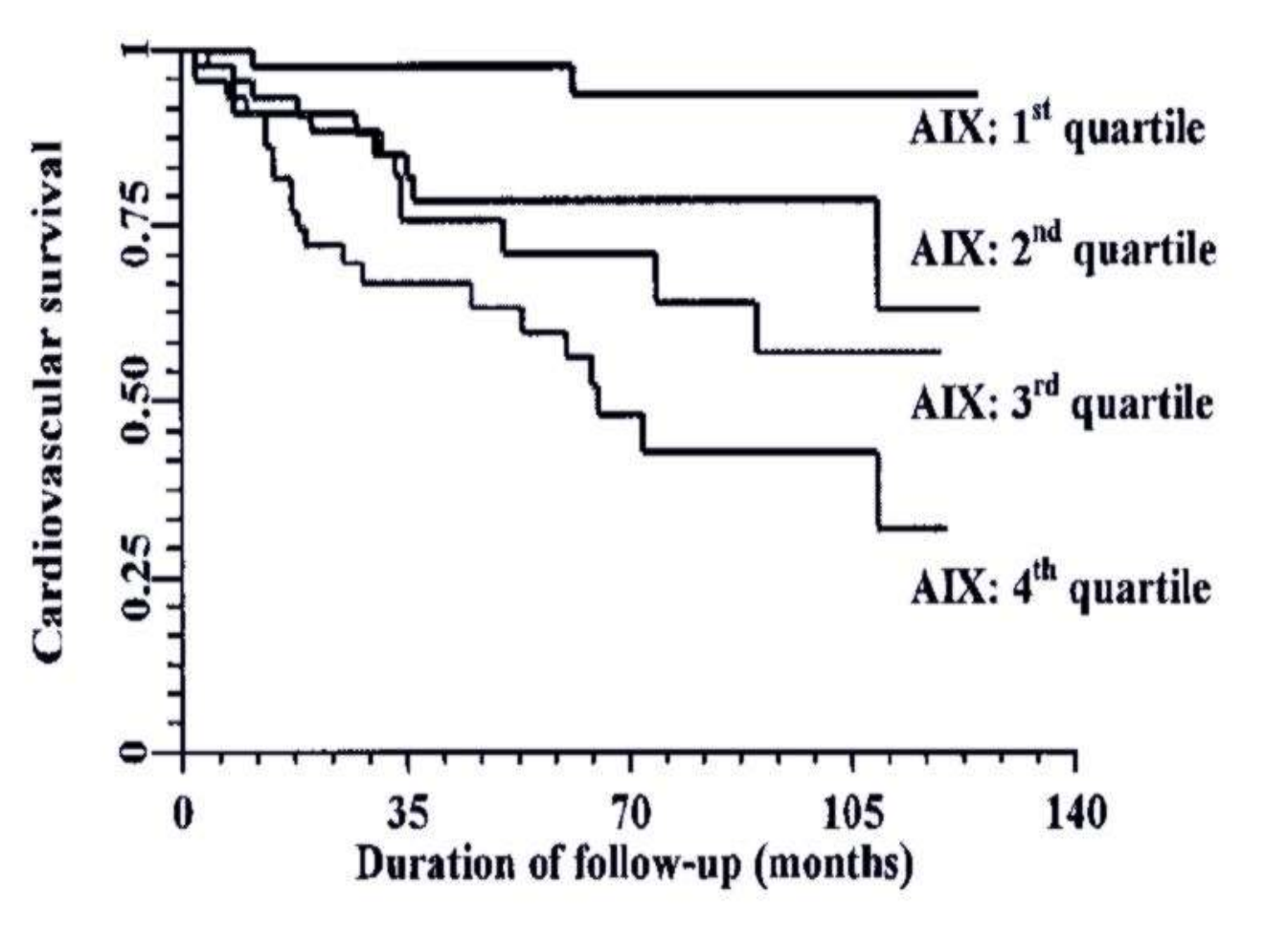
Methods an ngiography for the a quantified noninvasi enerate the corrispor etween the second ar e pressure. In univariate analysis, a higher AIx was associated with an increased risk for coronary artery disease (OR, 4.06 for the difference between the first and the fourth quartile [1.72 to 9.57; $P<0.01$]). In multivariate analysis, after controlling for age, height, presence of hypertension, HDL cholesterol, and medications, the association with coronary artery disease risk remained significant (OR, 6.91; $P<0.05$). The results were exclusively driven by an increase in risk with premature vessel stiffening in the younger patient group (up to 60 years of age), with an unadjusted OR between AIx quartiles I and IV of 8.25 ($P<0.01$) and a multiple-adjusted OR between these quartiles of 16.81 ($P<0.05$).

Conclusions—AIx and AP, noninvasively determined manifestations of arterial stiffening and increased wave reflections, are strong, independent risk markers for premature coronary artery disease. (***Circulation*. 2004;109:184-189.**)

Az Aix a koronáriabetegség erős és független prediktora

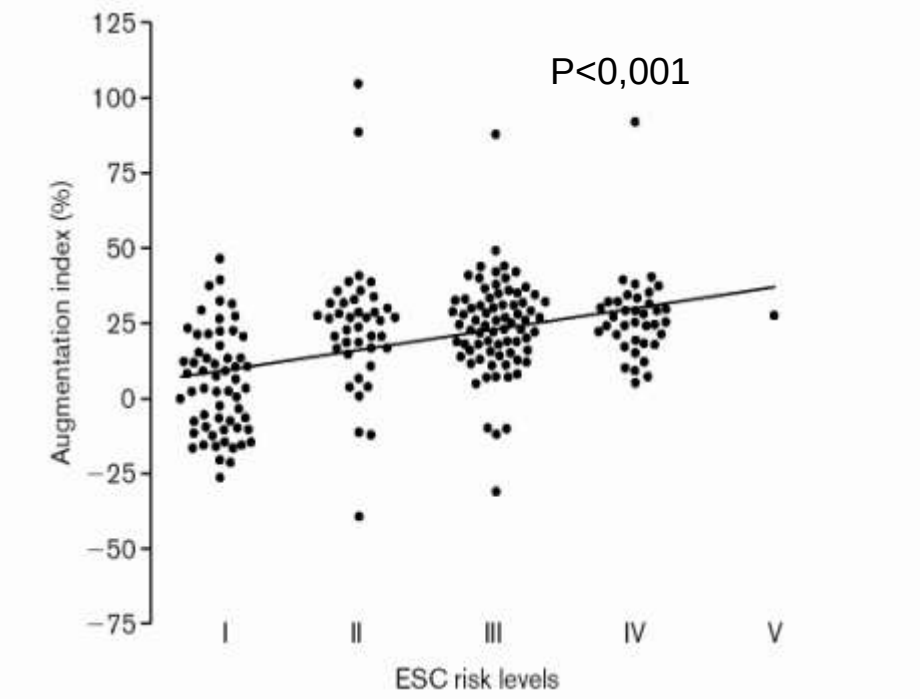
Key Words: coronary disease ■ waves ■ arteries ■ arteriosclerosis

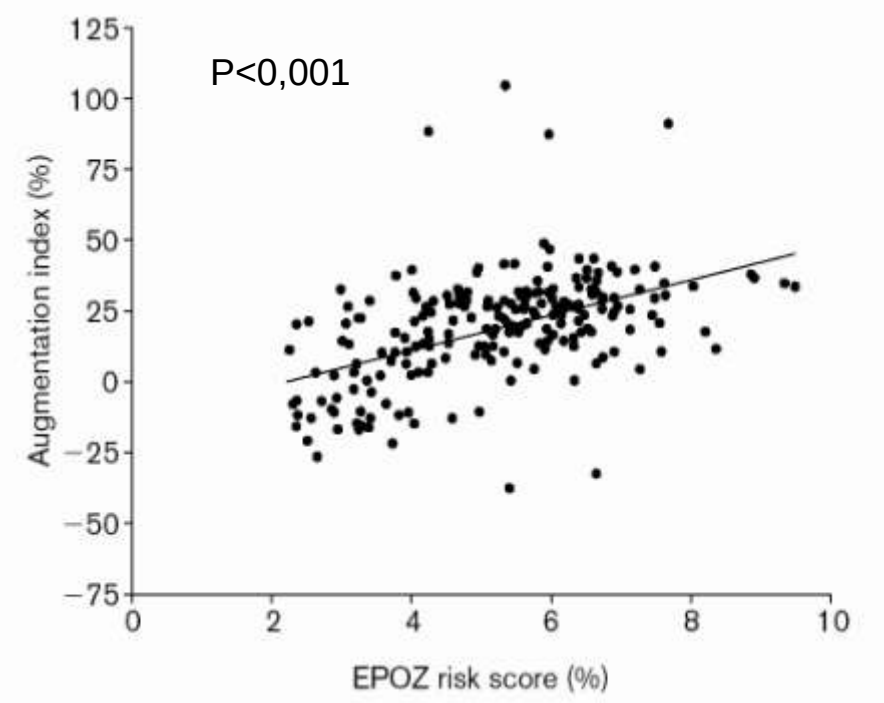
Aix és mortalitás



Hypertension 2001;38:434

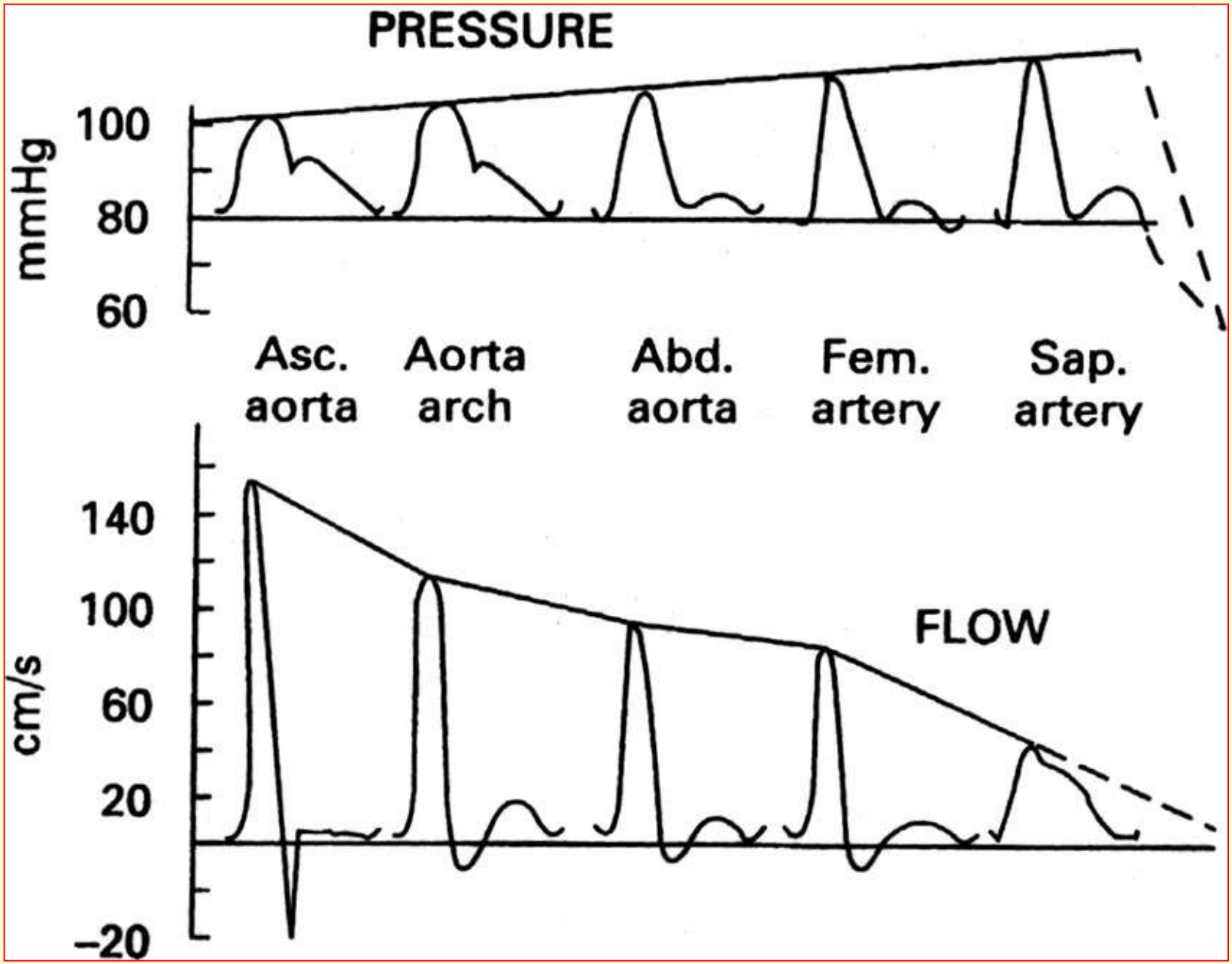
Augmentációs index és klasszikus rizikófaktorok közti összefüggés





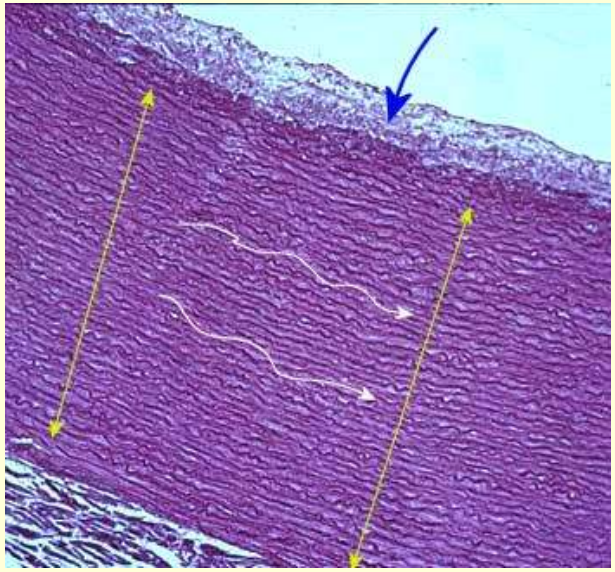
J Hypertens 2002;20:2407

Pulzushullám-amplifikáció

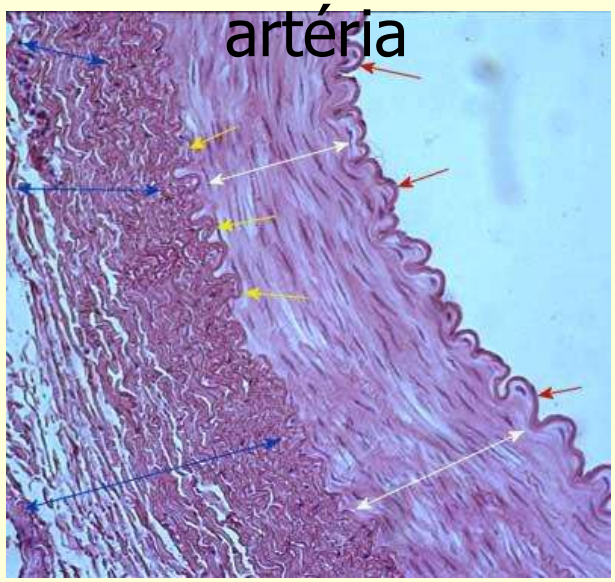


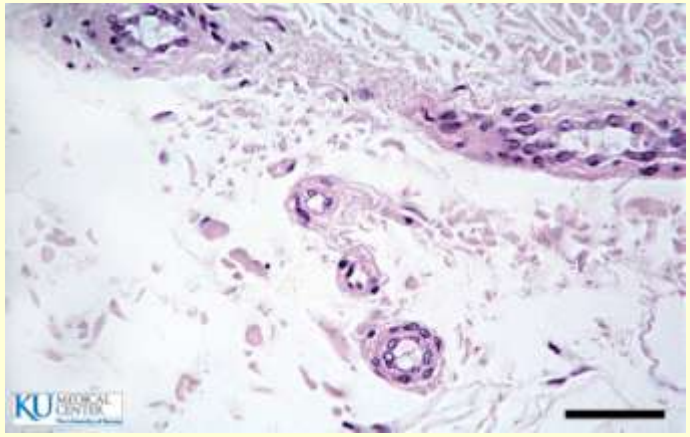
Különböző típusú artériák

Aorta



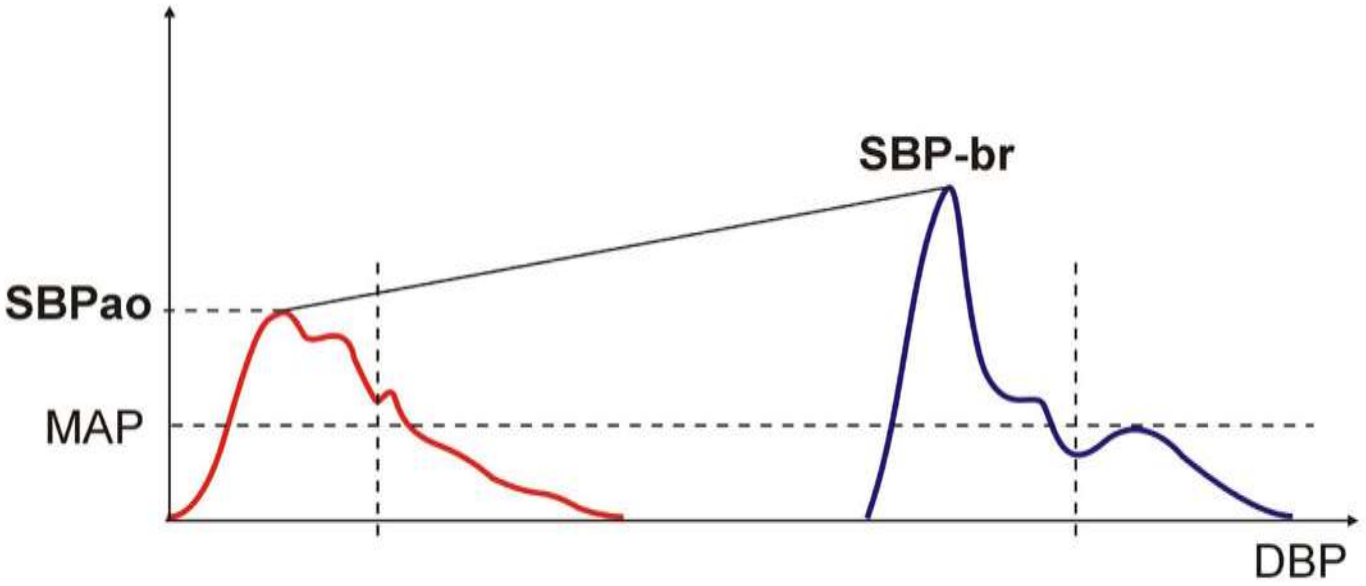
Muszkuláris típusú artéria



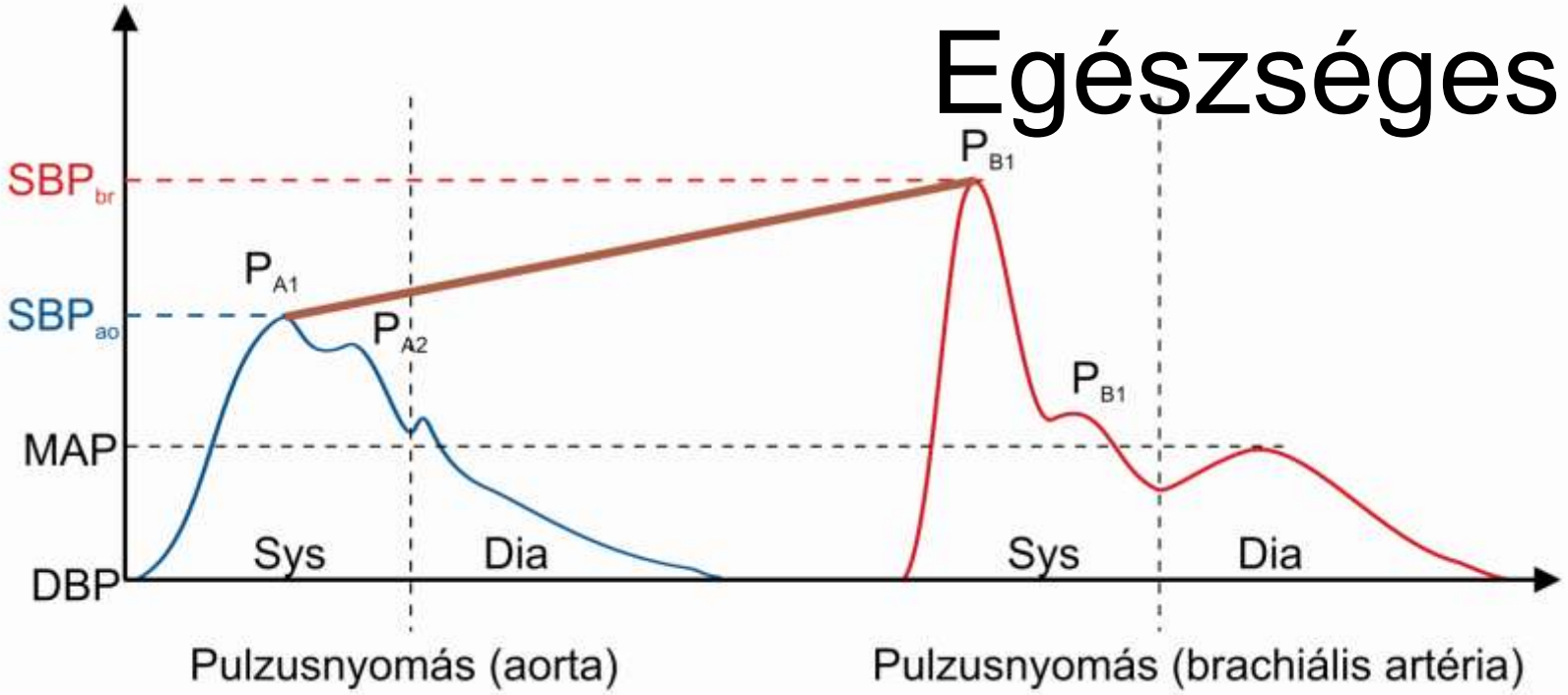


Arteriolák

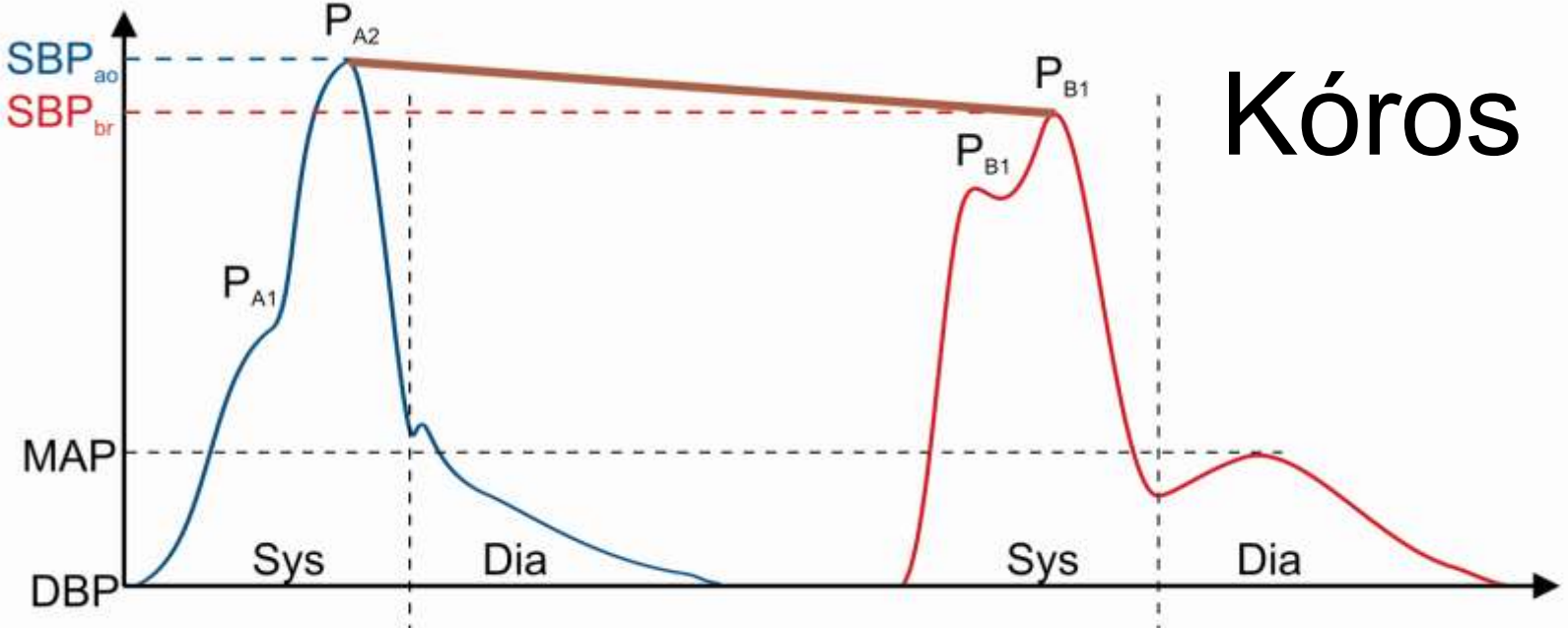
Pulzushullám amplifikáció



Egészséges



Kóros



A centrális systolés és pulzusnyomás jobban reprezentálja a BK-ra, a coronaria- és a cerebrális keringésre nehezedő terhelést

- A centrális systolés nyomás és pulzusnyomás megnövekszik.
- Az emelkedett centrális pulzusnyomás áttevődik a cerebrális keringésre, amely fokozza a stroke rizikóját.
- A centrális systolés nyomás növekedése anélkül jön létre, hogy a perifériás systolés nyomás változna !!

A centrális vérnyomás (SBPao)

Central Pressure More Strongly Relates to Vascular Disease and Outcome Than Does Brachial Pressure

The Strong Heart Study

Mary J. Roman, Richard B. Devereux, Jorge R. Kizer, Elisa T. Lee, James M. Galloway, Tauqeer Ali, Jason G. Umans, Barbara V. Howard

A centrális vérnyomás erősebb összefüggést mutat a szív- és érendszeri eseményekkel, mint a brachiális vérnyomás.

during mean follow-up of 4.8±1.3 years. After adjustment for age, gender, current s cholesterol:HDL ratio, creatinine, fibrinogen, diabetes, and heart rate, central pulse pressu events more strongly than brachial pulse pressure (hazards ratio=1.15 per 10 mm Hg, hazards ratio=1.10, χ^2=6.9, P=0.008). In conclusion, noninvasively-determined cent strongly related to vascular hypertrophy, extent of atherosclerosis, and cardiovascular ev pressure. These findings support prospective examination of use of central blood pressu future trials. (*Hypertension*. 2007;50:197-203.)

TensioMed™ Arteriograph

Arterial Stiffness Report

Patient details

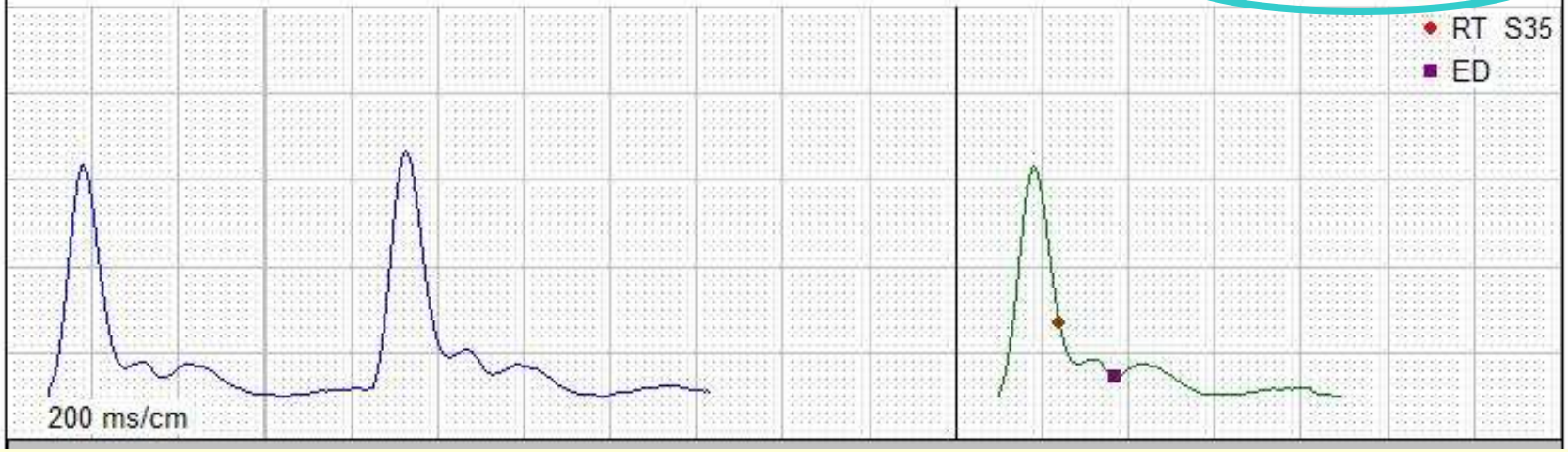
Name:	G H						
Date of Birth:	1970.10.15.	**Height:**	178 cm	**BMI:**	26.51	**Cholesterol:**	
Sex:	Male	**Weight:**	84 kg	**Smoker:**	No		
Comment:							

Study data

Examination date and time:	2007.04.24. 12:54					**JUG-SY:**	53 cm
Operator's name:	ARTERIOGRAM						
Sys:	160 mmHg	**Dia:**	88 mmHg	**HR:**	83 /min	**MAP:**	112 mmHg	**PP:**	72 mmHg

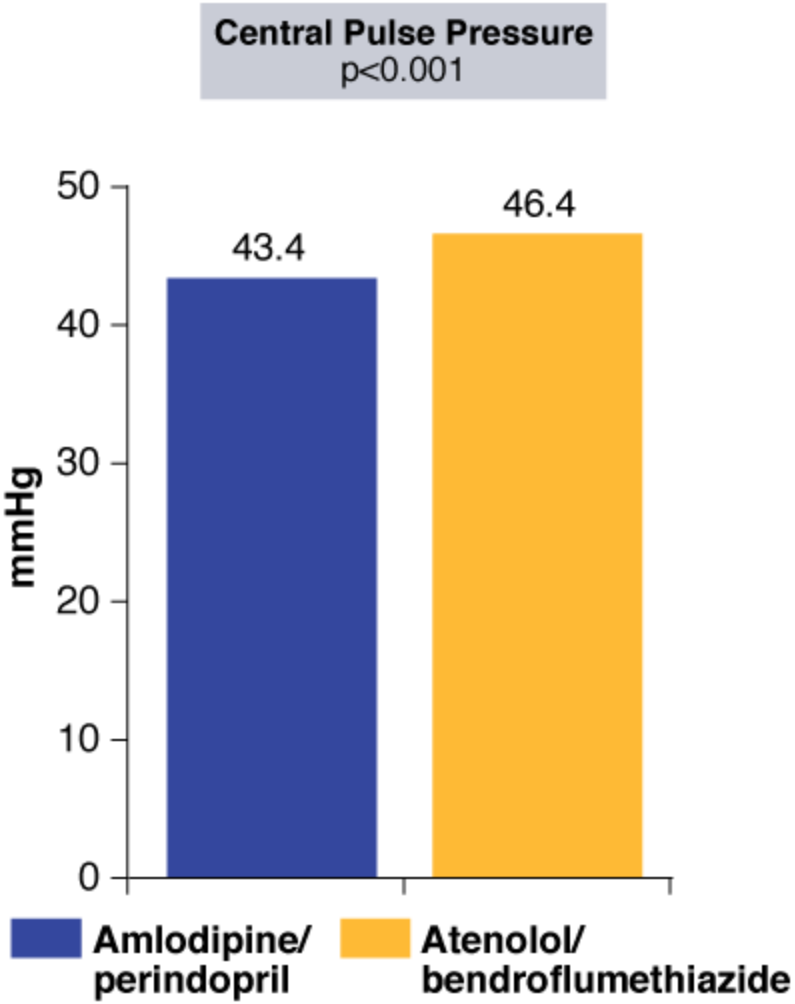
Results S 35

Aix brachial:	-65.1 %	**ED:**	270 ms	**PWVao:**	7.7 m/s	**SBPao:**	138.4 mmHg
Aix aortic:	4.7 %	**RT :**	138 ms	**SD_{PWVao}:**	0.3 m/s	**PPao:**	50.4 mmHg



CAFE

Trial Design: CAFE was a substudy (n=2073) of the ASCOT trial, a randomized trial of treatment with a calcium channel blocker (amlodipine 5 mg) with or without an ACE-I (perindopril 4 mg) compared with a beta-blocker (atenolol 50 mg) with or without a diuretic (bendroflumethiazide 1.25 mg) in hypertensive patients. In CAFE, central aortic blood pressure was assessed.



Results

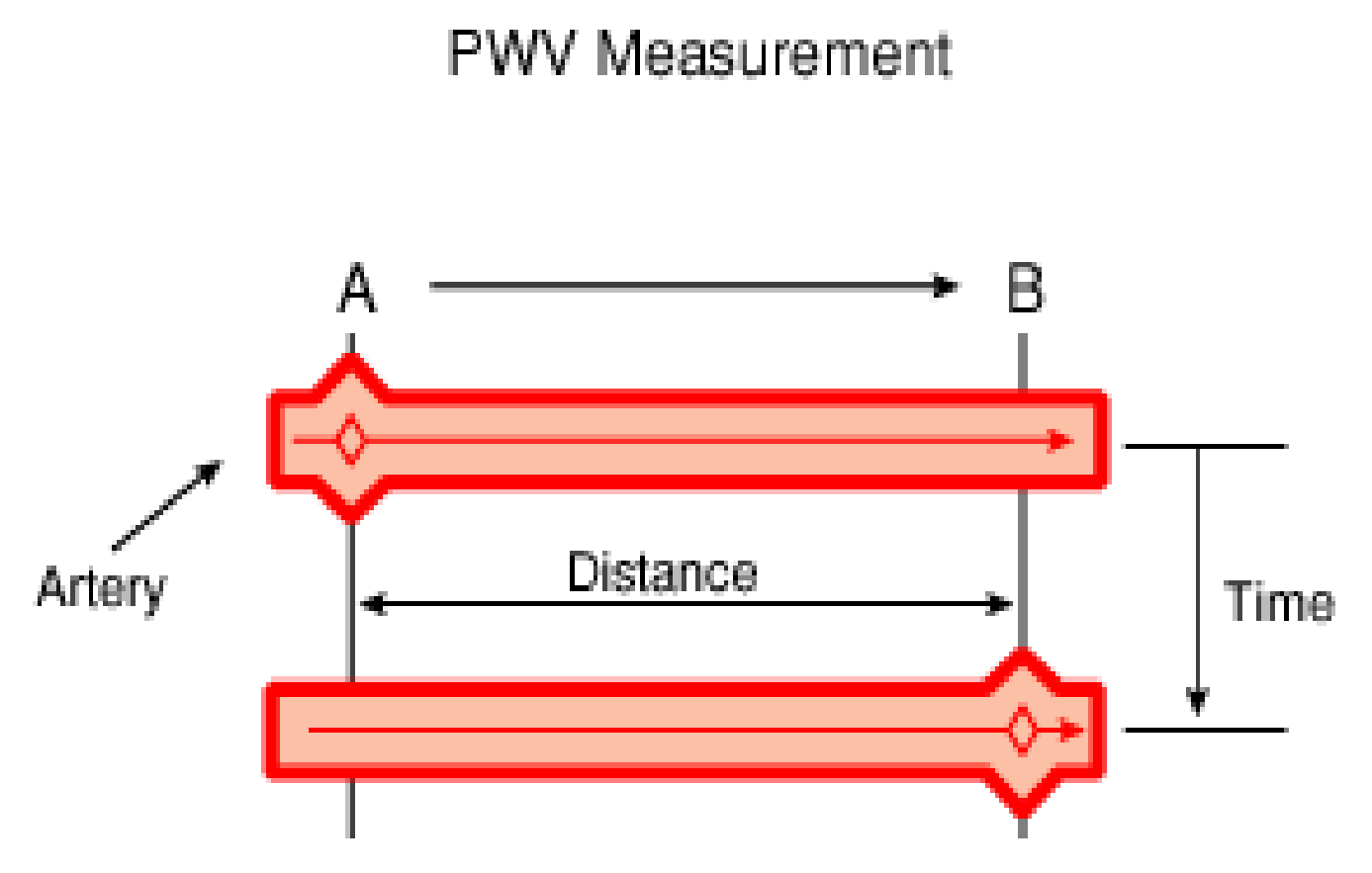
- No difference in brachial SBP by treatment group (133.2 mmHg for amlodipine vs 133.9 mmHg for atenolol group, p=NS), but DBP slightly ↓ in amlodipine group (76.9 vs 78.6 mmHg, p<0.001)
- Area under curve for central SBP ↓ in amlodipine group (121.2 vs 125.5 mmHg, p<0.001)
- Central pulse pressure ↓ with amlodipine (Figure), while brachial pulse pressure did not differ (55.3 vs 56.2 mmHg, p=0.06)

Conclusions

- Among hypertensive patients, treatment with regimen of calcium channel blocker with or without ACE inhibitors was associated with reductions in central systolic blood pressure and pulse pressure compared with regimen of beta-blocker with or without diuretic, despite no difference in brachial blood pressure
- Small reductions in brachial SBP in overall trial with amlodipine/perindopril strategy not large enough to account for entire clinical benefit
- Present substudy suggests that reductions in blood pressure may have been greater than originally estimated when assessed using brachial artery evaluation

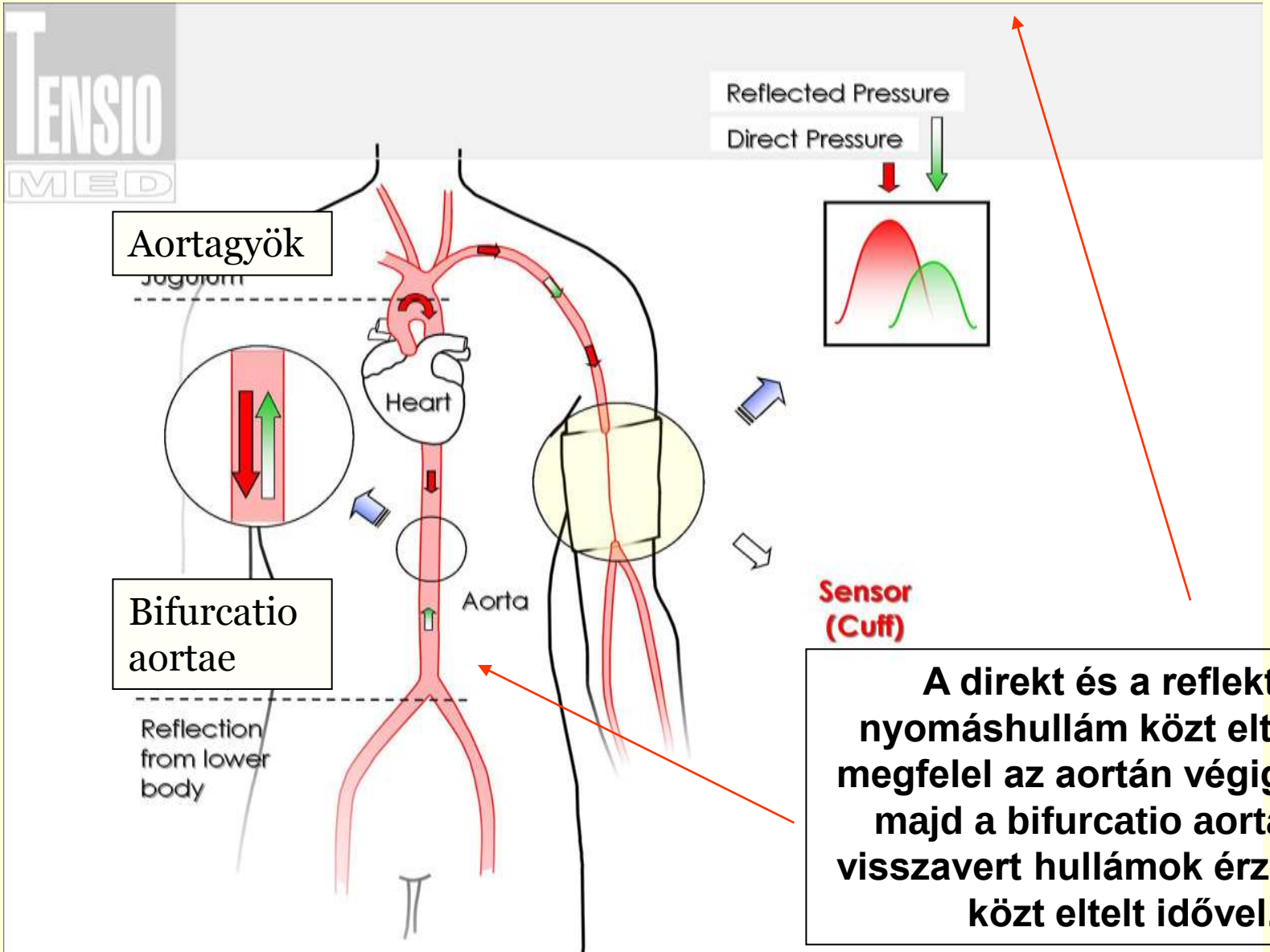
Presented at AHA 2005

A pulzushullám-terjedési sebesség (Pulse Wave Velocity, PWV)



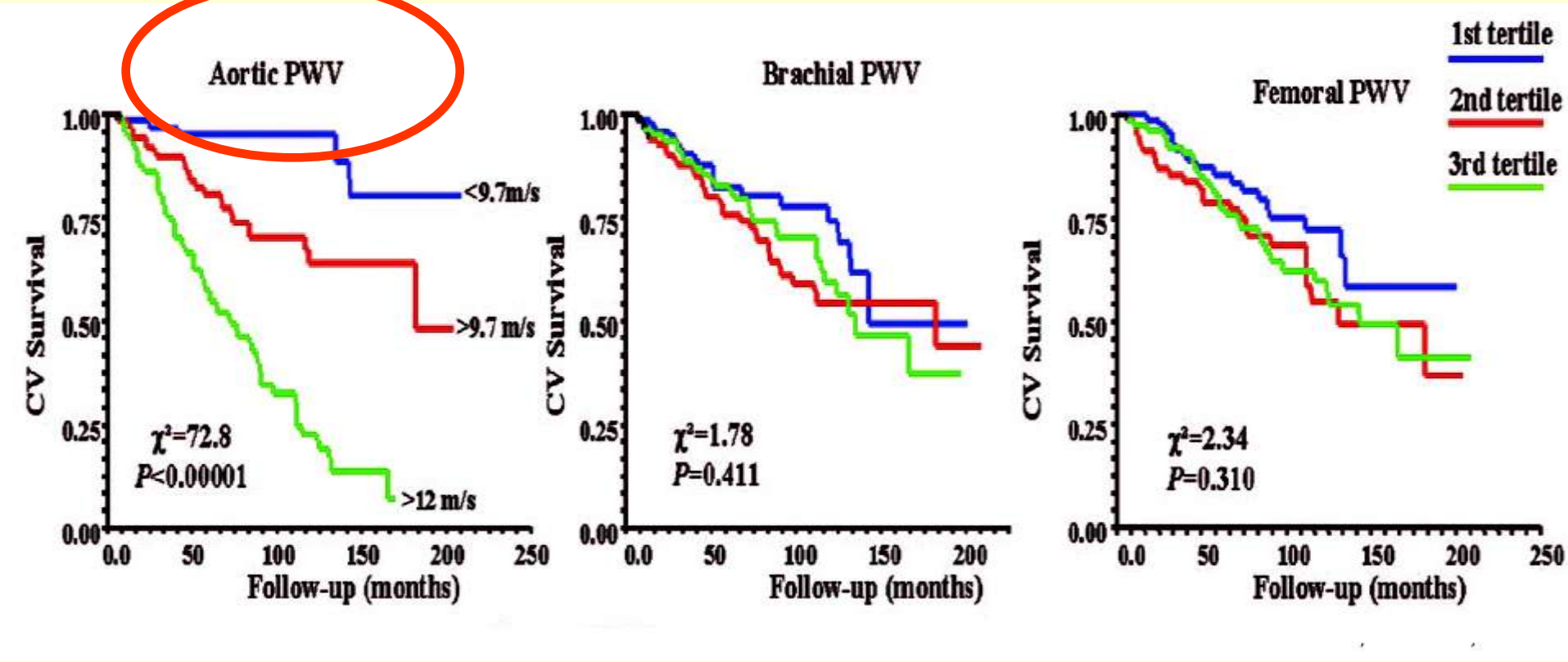
Az aorta stiffness vizsgálata az aortafal elasztikus sajátosságairól ad információt.

Pulzushullám terjedési sebesség



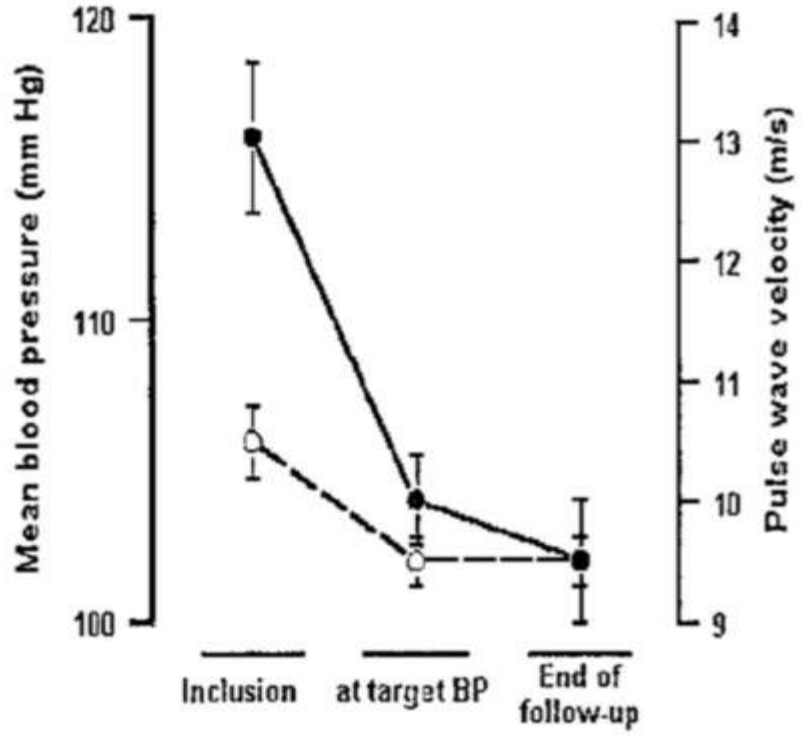
A direkt és a reflektált nyomáshullám közt eltelt idő megfelel az aortán végighaladó majd a bifurcatio aortae-ről visszavert hullámok érzékelése közt eltelt idővel.

Az emelkedett PWV és a kardiovaszkuláris mortalitás

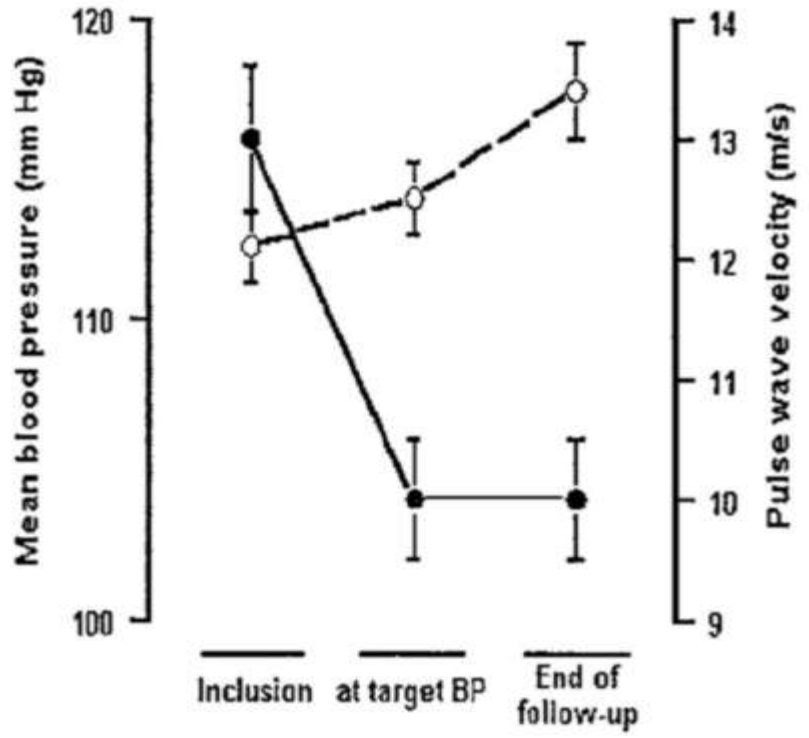


ESRD patients, N = 305, 70 months follow up, Hypertension 2005;45:596

Impact of Aortic Stiffness Attenuation on Survival of Patients in End-Stage Renal Failure



n=100



n=50

Circulation 2001;103:987

Aortic Pulse Wave Velocity Is Associated With the Presence and Quantity of Coronary Artery Calcium

A Community-Based Study

Iftikhar J. Kullo, Lawrence F. Bielak, Stephen T. Turner, Patrick F. Sheedy II, Patricia A. Peyser

Abstract—We investigated the relationship of aortic pulse wave velocity (aPWV), a measure of central arterial stiffness, with the presence and quantity of coronary artery calcium (CAC) in a community-based sample of adults without prior history of heart attack or stroke (n=401, mean age 59.8 years, 53% men). ECG-gated waveforms of the right carotid and right femoral artery were obtained by applanation tonometry, and aPWV was calculated using established methods. CA WV was sign variable logi of CAC, resp =0.011) afte moking, syst e linear regr variates enumerated above ($P<0.0001$). aPWV remained significantly associated with both the presence and quantity of CAC even after the additional adjustment for diastolic blood pressure. We conclude that aPWV is related to subclinical coronary atherosclerosis independent of conventional risk factors (including indices of blood pressure) and may be a biomarker of cardiovascular risk in asymptomatic individuals. (*Hypertension*. 2006;47:174-179.)

Az Aorta PWV értéke összefüggést mutat a szubklinikus koszorúér-atherosclerosissal.

Prognostic Value of Aortic Pulse Wave Velocity as Index of Arterial Stiffness in the General Population

Tine Willum Hansen, MD, PhD; Jan A. Staessen, MD, PhD; Christian Torp-Pedersen, MD, DMSc; Susanne Rasmussen, MD, PhD; Lutgarde Thijs, MSc; Hans Ibsen, MD, DMSc; Jørgen Jeppesen, MD, DMSc

Az Aorta PWV
a tünetmentes átlagpopulációban
a hagyományos rizikófaktoroknál,
és a 24 órás vérnyomás-monitorozásnál
hatékonyabb előjelzője a
kardiovaszkuláris eseményeknek.

Circulation. **2006;113:664-670**

Arterial Stiffness and Risk of Coronary Heart Disease and Stroke

The Rotterdam Study

Francesco U.S. Mattace-Raso, MD, PhD; Tischa J.M. van der Cammen, MD, PhD;
Albert Hofman, MD, PhD; Nicole M. van Popele, MD, PhD; Michiel L. Bos, MSc;

Conclusions—Aortic pulse wave velocity is an independent predictor of coronary heart disease and stroke in apparently healthy subjects. **(*Circulation*. 2006;113:657-663.)**

Az Aorta PWV független előjelzője a kardiovaszkuláris eseményeknek (CHD, stroke) **az időskorú populációban is.**

and pulse pressure. Carotid distensibility as measured in this study was not independently associated with cardiovascular disease.

Conclusions—Aortic pulse wave velocity is an independent predictor of coronary heart disease and stroke in apparently healthy subjects. (***Circulation*. 2006;113:657-663.)**

2007 Guidelines for the Management of Arterial Hypertension

The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC)

Authors/Task Force Members: Giuseppe Mancia, Co-Chairperson (Italy), Guy de Backer, Co-Chairperson (Belgium), Anna Dominiczak (UK), Renata Cifkova (Czech Republic), Robert Fagard (Belgium), Giuseppe Germano (Italy), Guido Grassi (Italy), Anthony M. Heagerty (UK), Sverre E. Kjeldsen (Norway), Stephane Laurent (France), Krzysztof Narkiewicz (Poland), Luis Ruilope (Spain), Andrzej Rynkiewicz (Poland), Roland E. Schmieder (Germany), Harry A.J. Struijker Boudier (Netherlands), Alberto Zanchetti (Italy)

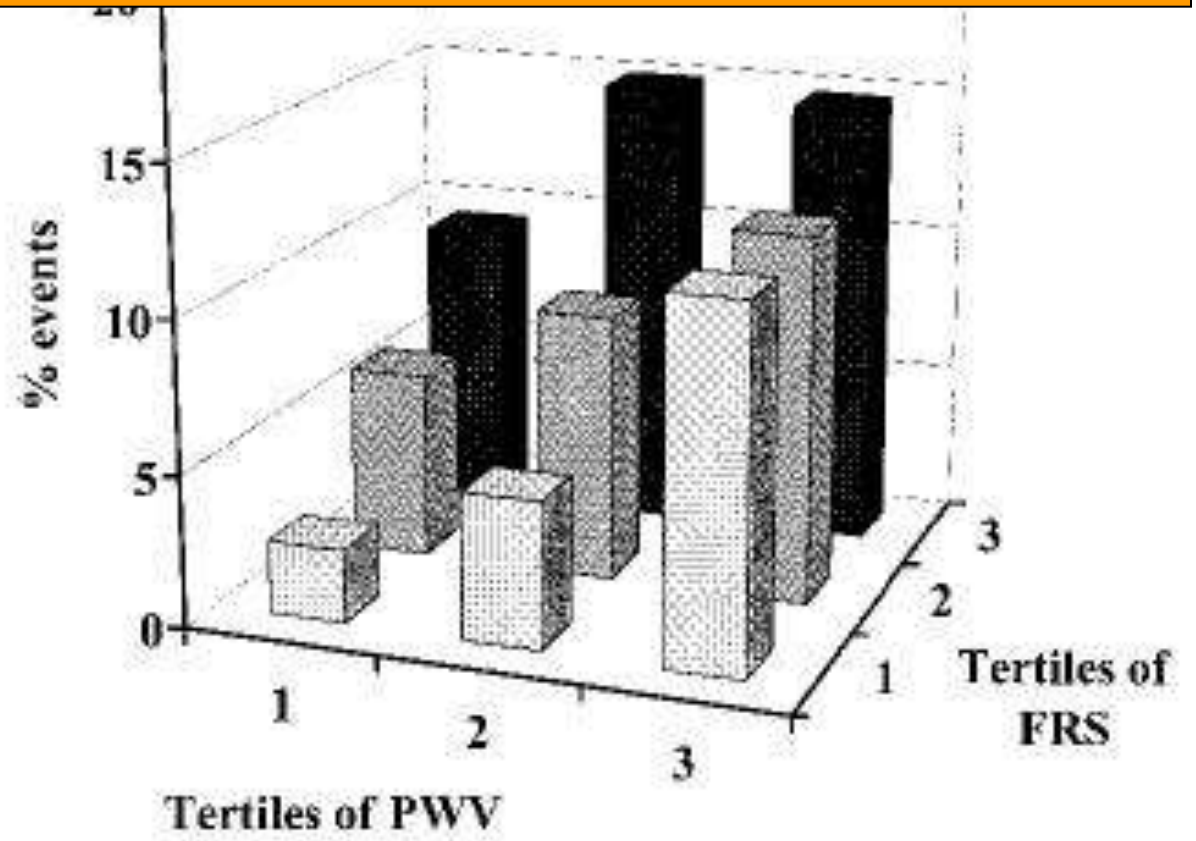
Journal of Hypertension 2007, **25**:1105–1187

Table 3 High/Very high risk subjects

- BP ≥ 180 mmHg systolic and/or ≥ 110 mmHg diastolic
- Systolic BP > 160 mmHg with low diastolic BP (< 70 mmHg)
- Diabetes mellitus
- Metabolic syndrome
- ≥ 3 cardiovascular risk factors
- One or more of the following subclinical organ damages:
  - Electrocardiographic (particularly with strain) or echocardiographic (particularly concentric) left ventricular hypertrophy
  - Ultrasound evidence of carotid artery wall thickening or plaque
  - Increased arterial stiffness
  - Moderate increase in serum creatinine
  - Reduced estimated glomerular filtration rate or creatinine clearance
  - Microalbuminuria or proteinuria
- Established cardiovascular or renal disease

Az arterial stiffness additív prediktív értéke

A Framingham-rizikóstátusz független a PWV-től.



Boutouyrie et al: „Aortic Stiffness and Coronary Heart Disease” *Hypertension*. 2002;39:10-15.

Az arterial stiffness additív prediktív értéke

A PWV ismerete pontosabbá teszi a kardiovaszkuláris rizikóbecslést.

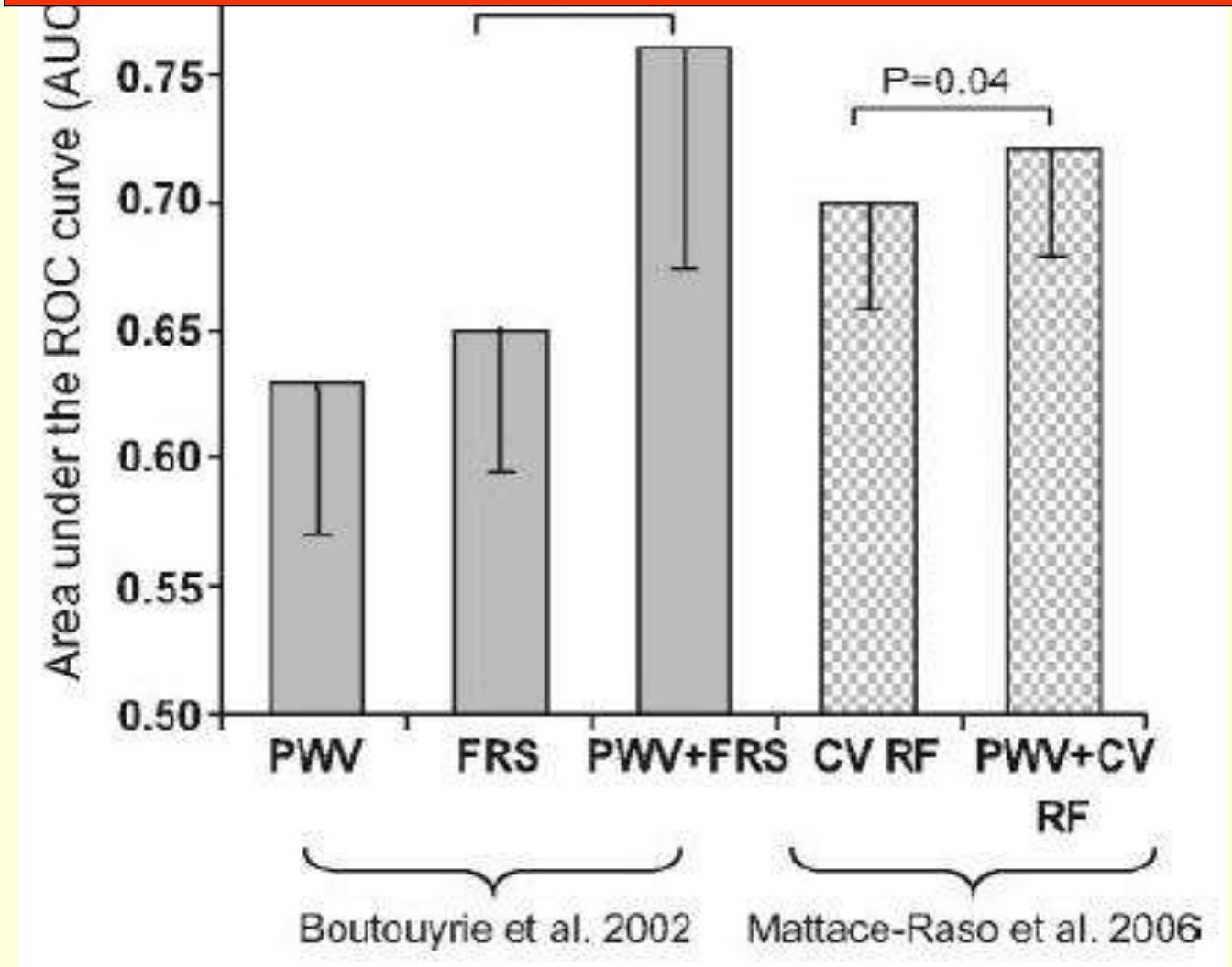


Table 1 Summary of main advantages and limitations of three different techniques for arterial stiffness evaluation

Device	Advantages	Limitations
Complior	• The delay in pulse transit time between two arteries sites is taken simultaneously using a 'foot to foot' waveform method • Numerous data on the prognostic value of cf-PWV so obtained are available	• Operator's skill dependency • Carotid tonometry is difficult • Necessity to undress and expose the groin • Possibility of technical errors in obese patients • Uncertainty and approximation in measurement of distance between the two arterial sites • Theoretical risk of carotid plaque rupture by probe (never reported) • Patients with atrial fibrillation cannot be evaluated • Unable to allow PWA • Underestimation of elevated PWV by built-in algorithm
SphygmoCor	• PWA is available allowing assessment of augmentation index and central BP through a transfer function application • Numerous data on the prognostic value of the parameters so obtained are available	• Operator's skill dependency • Carotid tonometry is difficult • Necessity to undress and expose the groin • Possibility of technical errors in obese patients • Uncertainty and approximation in measurement of distance between the two arterial sites • Theoretical risk of carotid plaque rupture by probe (never reported) • Patients with atrial fibrillation cannot be evaluated • Debate regarding the validity of the generic transfer function used • Need of a precise BP calibration for PWA, currently not available • The PWV transit time delay is calculated using reference ECG signals obtained at different times, respectively, for carotid and femoral pulse waveforms sequentially recorded
Arteriograph	• The technique only needs access to the patient's upper arm (no need to undress) • It is based on an easy methodology (largely operator-independent method) • It is a time-saving method. This fast assessment of arterial stiffness parameters is particularly suitable to population studies • Higher reproducibility of parameters, as compared with the other two methods • Potentially adaptable to ambulatory arterial stiffness assessment	• Scarce data on its validation and on the prognostic value of parameters so obtained are available • Patients with atrial fibrillation or marked bradycardia cannot be evaluated

EDITORIAL COMMENT
Boutouyrie, P., Revera, M., Parati, G.
Journal of Hypertension
2009, 27:2159–2161

Mi mindent mérünk?

- Ez az egyetlen módszer, amely egyetlen lépésben mér artériás funkciót és érfali (aorta) merevséget.
- Perifériás vérnyomásmérés
  - Sys, Dia, PP, HR, MAP
- Érfali merevség vizsgálata
  - Pulzushullám terjedési sebesség
- Pulzushullám analízis:
  - Brachialis Augmentációs Index
  - Aorta Augmentációs Index
  - Centrális vérnyomás
  - Centrális pulzusnyomás
  - Ejectós idő (systolé hossza)
  - Diasztolés Reflexiós Area
  - Systolés/Diastolés Area index

TensioMed™ Arteriograph

Arterial Stiffness Report

Patient details

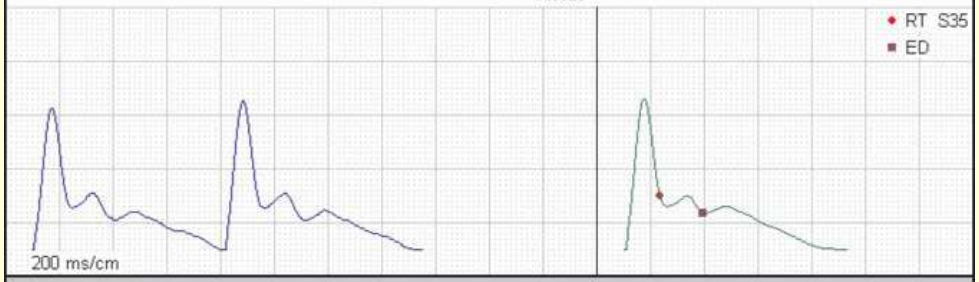
Name: FM
Date of Birth: 1981.02.22. **Height:** 170 cm **BMI:** 19.03 **Cholesterol:** 4.00 mmol/l
Sex: Female **Weight:** 55 kg **Smoker:** No
Comment:
10 year risk of fatal CVD (EHRC score): 0% (low risk)

Study data

Examination date and time: 2006.05.26. 13:08 **JUG-SY:** 50 cm
Operator's name: ARTERIOGRAM
Sys: 140 mmHg **Dia:** 71 mmHg **HR:** 78 /min **MAP:** 94 mmHg **PP:** 69 mmHg

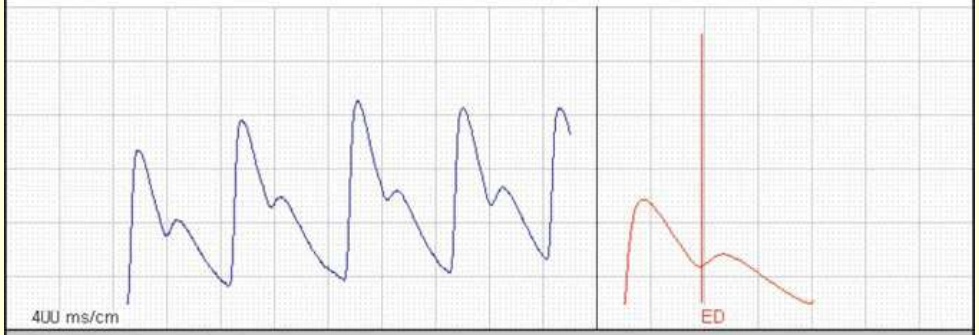
Results S 35

Aix brachial: -64.17 % **ED:** 295 ms **PWVao:** 7.46 m/s **SBPao:** 119.60 mmHg
Aix aortic: 5.36 % **RT:** 134 ms **SD_{PWVao}:** 0.19 m/s



Results D

DRA: 57 **SAI:** 51.32 % **DAI:** 48.68 %



Automatic analysis

Aix brachial: -64.17 % **PWVao:** 7.46 m/s

Az artériás funkció mérésének indikációi

Szűrővizsgálat – szubklinikus érelmeszesedés diagnosztizálása tünet- és panaszmentes, „egészséges” páciensenkél
és
az alkalmazott antihipertenzív terápia optimalizálása.

A módszer nem alkalmas az artérián belüli stenosis lokalizációjának megállapítására!

Esettanulmányok

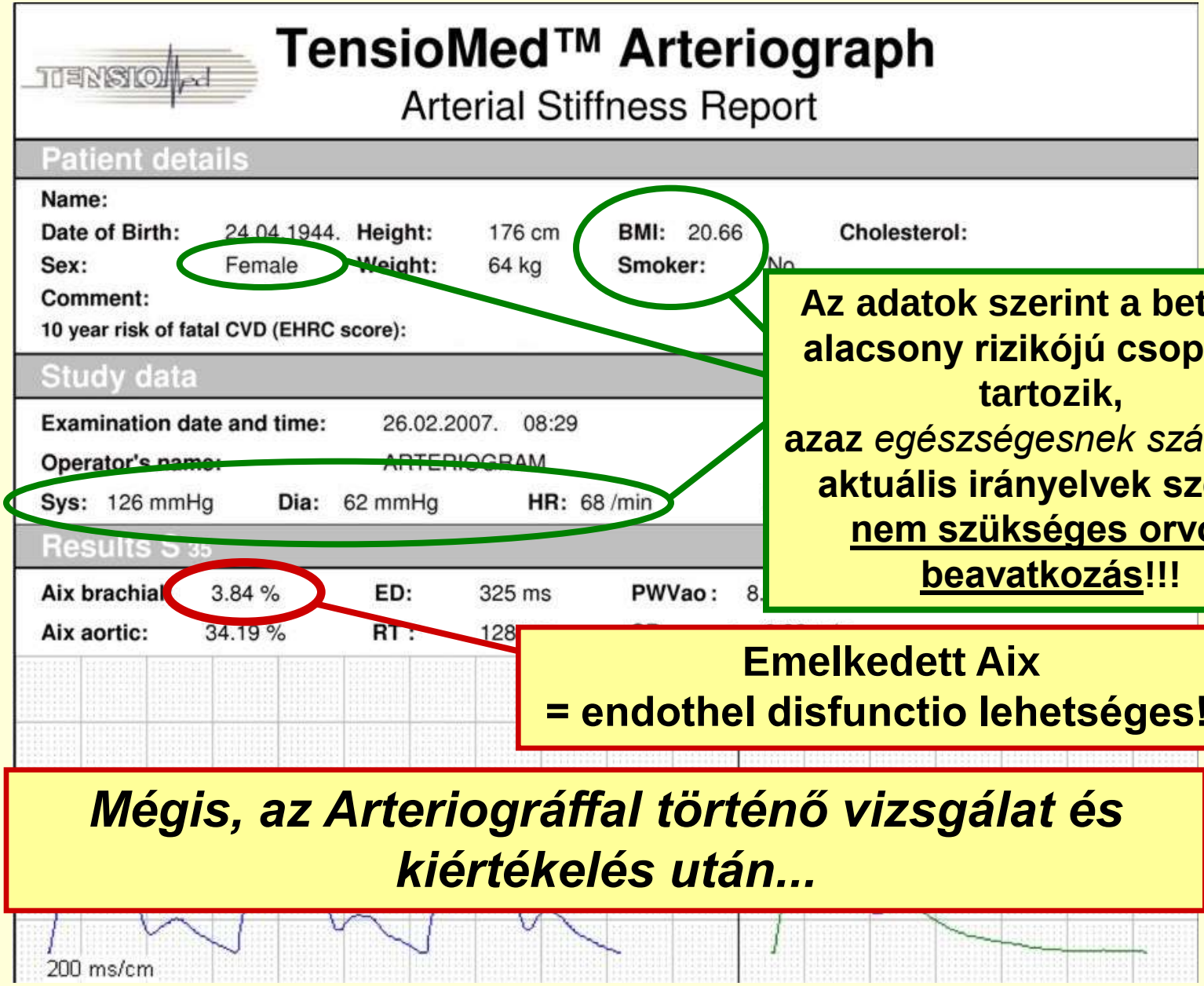
Betegkövetés Arteriográffal

- **Az Arteriográf alkalmazási területei:**

1. **Tünetmentes, látszólag egészséges páciensek szűrővizsgálata**
   - **Az érelmeszedés korai stádiumának megállapítása**

2. **Az alkalmazott terápia hatékonyságának ellenőrzése**
   - **Betegkövetés**
   - **Összevetés**

1. Tünetmentes, látszólag egészséges páciensek szűrővizsgálata



Az adatok szerint a beteg az alacsony rizikójú csoportba tartozik,
azaz *egészségesnek számít*, az aktuális irányelvek szerint <u>nem szükséges orvosi beavatkozás</u>!!!

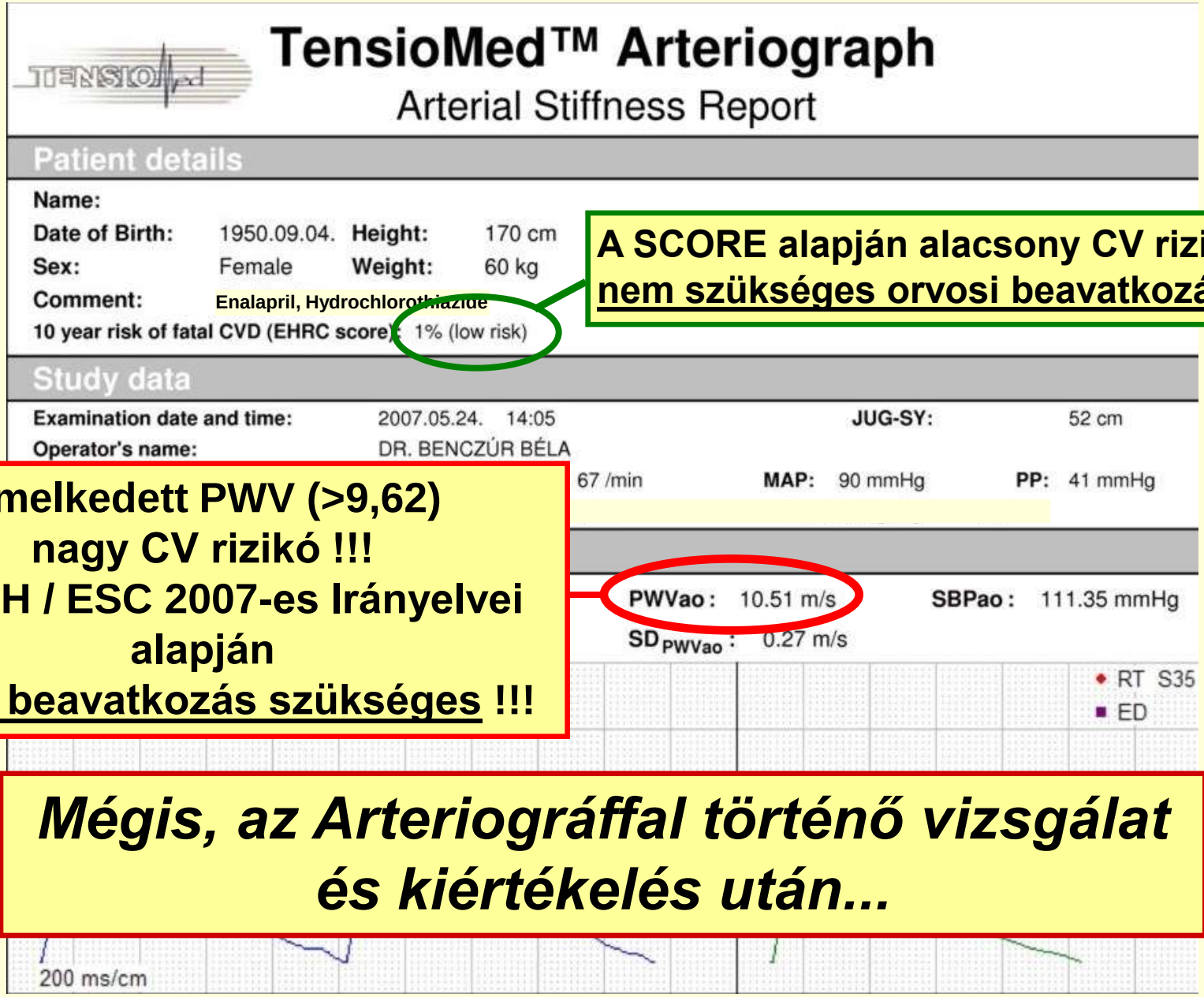
Emelkedett Aix
= endothel disfunctio lehetséges!!!

Mégis, az Arteriográffal történő vizsgálat és kiértékelés után...

- **Vizsgálat:**
  - **Magas koleszterinszint (7,30 mmol/l)**

- **Következtetés:**
  - **Alacsony rizikócsoportba tartozó, látszólag egészséges páciens esetében az Arteriográffal történő vizsgálat során felmerül az endothel disfunctio fennállásának lehetősége.**

  - **Tehát a tünetmentes betegcsoport szűrése szükséges!**



A SCORE alapján alacsony CV rizikó, nem szükséges orvosi beavatkozás

Emelkedett PWV (>9,62)
nagy CV rizikó !!!
Az ESH / ESC 2007-es Irányelvei alapján
orvosi beavatkozás szükséges !!!

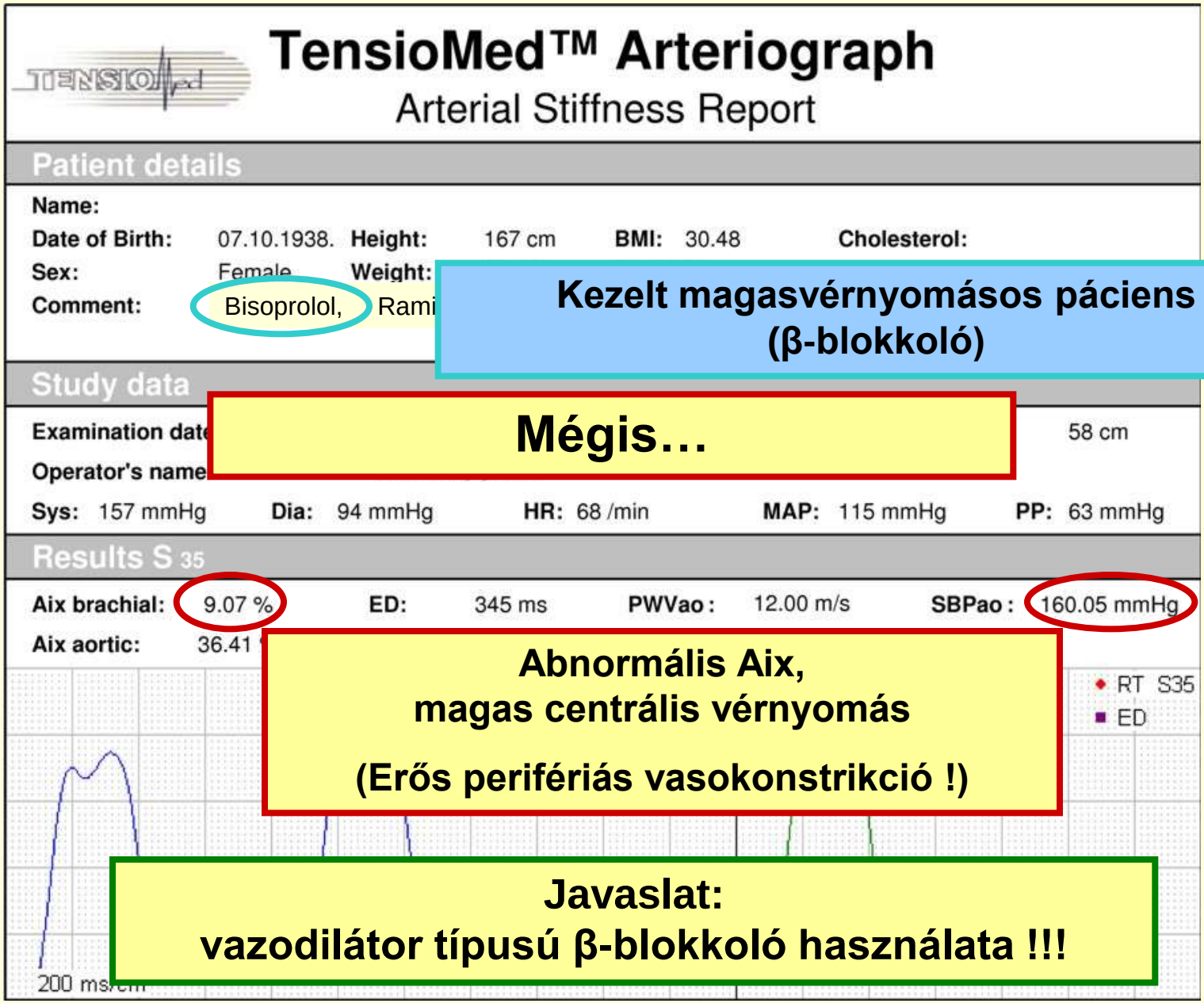
Mégis, az Arteriográffal történő vizsgálat és kiértékelés után...

- **Vizsgálat:**
  - **Ultrahangos carotis vizsgálat (plaque)**

- **Következtetés:**
  - **A látszólag egészséges páciens Arteriográffal történő szűrése során a magas CV rizikóstátusz kimutathatóvá válik.**
  - **További megerősítő vizsgálatok (CUS) a döntőek, és megerősítik a szűrés megalapozottságát.**

2. Az alkalmazott terápia hatékonyságának ellenőrzése

Első példa


TensioMed™ Arteriograph
Arterial Stiffness Report
Patient details
Name:
Date of Birth: 07.10.1938. Height: 167 cm BMI: 30.48 Cholesterol:
Sex: Female Weight:
Comment: Bisoprolol, Rami
Kezelt magasvérnyomásos páciens
(β-blokkoló)
Study data
Mégis…
Examination date
Operator's name
58 cm
Sys: 157 mmHg Dia: 94 mmHg HR: 68 /min MAP: 115 mmHg PP: 63 mmHg
Results S 35
Aix brachial: 9.07 % ED: 345 ms PWVao : 12.00 m/s SBPao : 160.05 mmHg
Aix aortic: 36.41
Abnormális Aix,
magas centrális vérnyomás
(Erős perifériás vasokonstrikció !)
RT S35
ED
200 ms/cm
Javaslat:
vazodilátor típusú β-blokkoló használata !!!

Első példa

TensioMed™ Arteriograph

Arterial Stiffness Report

Ugyanaz a beteg, módosított terápia után

Patient details

Name:

Date of Birth: 07.10.1938. **Height:** 167 cm **BMI:** 29.40 **Cholesterol:** 3.90 mmol/l

Sex: Female **Weight:** 82 kg

Comment: Quinapril, Nebivolol, Atorvas

Vazodilátor β-blokkoló

10 year risk of fatal CVD (EHRC score): 3% (medium risk)

Study data

Examination date and time: 29.11.2006. 13:45 **JUG-SY:** 54 cm

Operator's name: ARTERIOGRAM

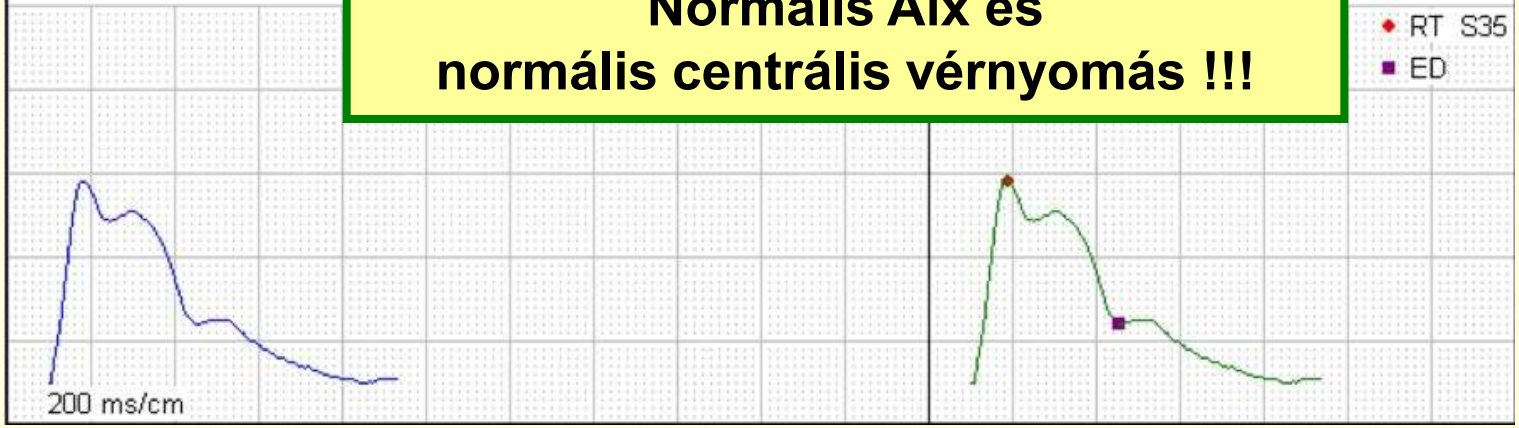
Sys: 141 mmHg **Dia:** 77 mmHg **HR:** 70 /min **MAP:** 98 mmHg **PP:** 64 mmHg

Results S 35

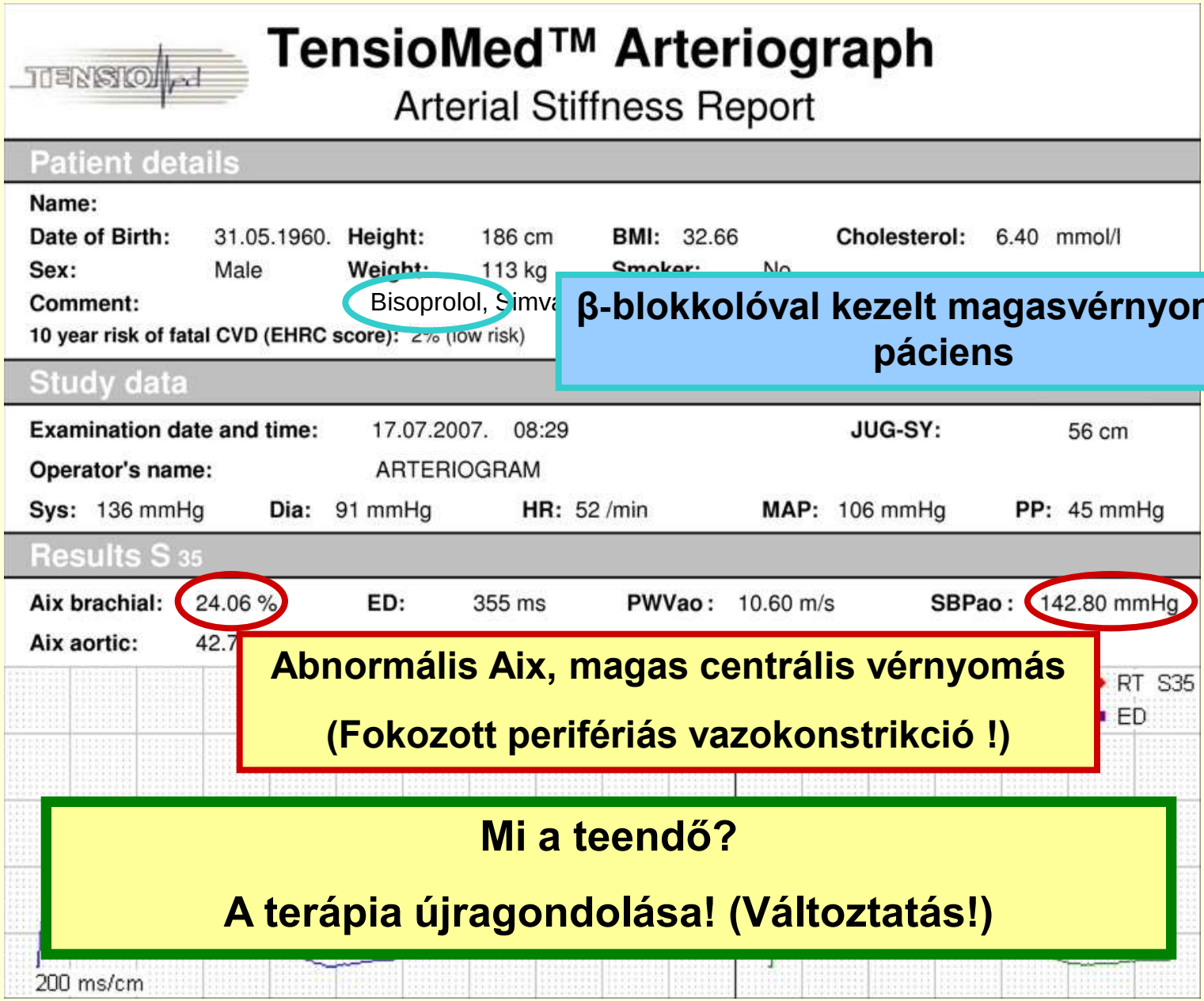
Aix brachial: -15.03 % **ED:** 355 ms **PWVao:** 9.80 m/s **SBPao:** 134.81 mmHg

Aix aortic: 26.20 %

Normális Aix és normális centrális vérnyomás !!!



Második példa



TensioMed™ Arteriograph

Arterial Stiffness Report

Patient details

Name:

Date of Birth: 31.05.1960. Height: 186 cm BMI: 32.66 Cholesterol: 6.40 mmol/l

Sex: Male Weight: 113 kg Smoker: No

Comment: Bisoprolol, Simva

10 year risk of fatal CVD (EHRC score): 2% (low risk)

β-blokkolóval kezelt magasvérnyomásos páciens

Study data

Examination date and time: 17.07.2007. 08:29 JUG-SY: 56 cm

Operator's name: ARTERIOGRAM

Sys: 136 mmHg Dia: 91 mmHg HR: 52 /min MAP: 106 mmHg PP: 45 mmHg

Results S 35

Aix brachial: 24.06 % ED: 355 ms PWVao: 10.60 m/s SBPao: 142.80 mmHg

Aix aortic: 42.7

Abnormális Aix, magas centrális vérnyomás

(Fokozott perifériás vazokonstrikció !)

RT S35

ED

200 ms/cm

Mi a teendő?

A terápia újragondolása! (Változtatás!)

Második példa

TensioMed™ Arteriograph

Arterial Stiffness Report

Patient details

Name:

Date of Birth: 31.05.1960. **Height:** 186 cm **BMI:** 32.66 **Cholesterol:** 6.40 mmol/l

Sex: Male **Weight:** 113 kg **Smoker:** No

Comment: Amlodipine, Simvas

10 year risk of fatal CVD (EHRC score): 2%

Az újonnan javasolt gyógyszer: CCB

Study data

Examination date and time: 30.07.2007. 11:28 **JUG-SY:** 56 cm

Operator's name: ARTERIOGRAM

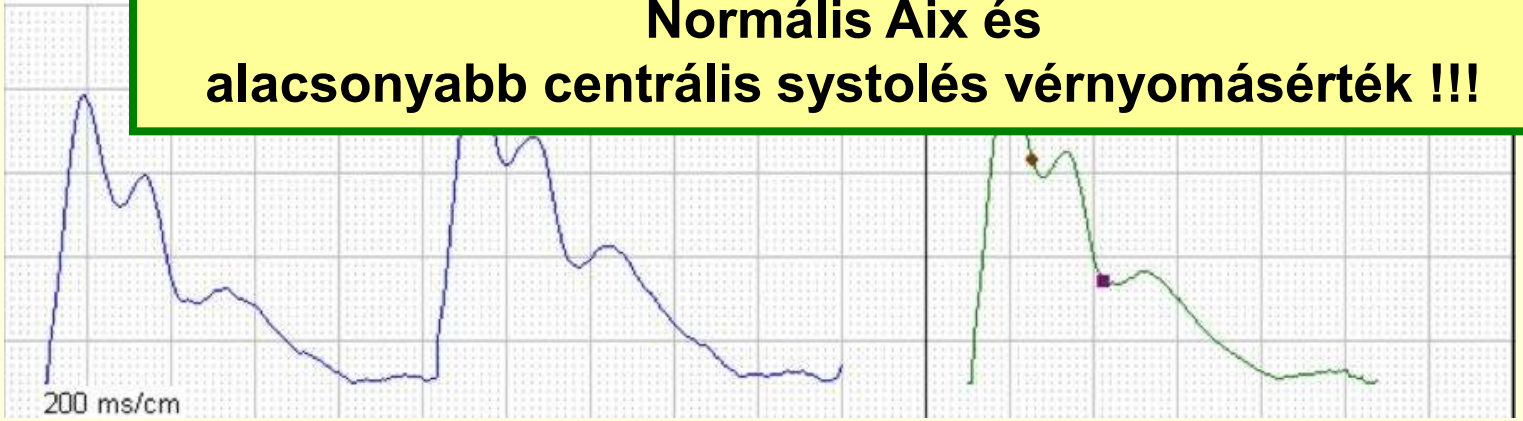
Sys: 128 mmHg **Dia:** 86 mmHg **HR:** 63 /min **MAP:** 100 mmHg **PP:** 42 mmHg

Results S 35

Aix brachial: -27.71 % **ED:** 325 ms **PWVao:** 7.23 m/s **SBPao:** 121.36 mmHg

Aix aortic: 20.83 % **PT:** 155 ms **SD:** 0.62 m/s

Normális Aix és
alacsonyabb centrális systolés vérnyomásérték !!!



- **Következtetés:**
  - **Magasvérnyomásos beteg kezelése esetén a perifériás (brachialison mért) vérnyomás csökkentése mellett a centrális vérnyomás csökkentése is nagyon fontos !!!**
  - **Az Arteriográf fontos hemodinamikai paraméterekről ad információt, amelyekkel a vérnyomáscsökkentő gyógyszer hatása pontosabban kiértékelhető.**

Validáció

Clin Rheumatol
DOI 10.1007/s10067-009-1118-y

ORIGINAL ARTICLE

A comparative study of arterial stiffness, flow-mediated vasodilation of the brachial artery, and the thickness of the carotid artery intima–media in patients with systemic autoimmune diseases

Pál Soltész · Henriett Dér · György Kerekes · Péter Szodoray · Gabriella Szücs · Katalin Dankó · Yehuda Shoenfeld · Gyula Szegedi · Zoltán Szekanecz

Received: 26 June 2008 / Revised: 30 January 2009 / Accepted: 30 January 2009

A new oscillometric method for assessment of arterial stiffness: comparison with tonometric and piezo-electronic methods

Johannes Baulmann[a], Ulrich Schillings[a], Susanna Rickert[a], Sakir Uen[a], Rainer Düsing[a], Miklos Illyes[b], Attila Cziraki[b], Georg Nickering[a] and Thomas Mengden[a]

Introduction Pulse wave velocity (PWV) and augmentation index (AIx) are parameters of arterial stiffness and wave reflection. PWV and AIx are strong indicators for cardiovascular risk and are used increasingly in clinical practice. Previous systems for assessment of PWV and AIx are investigator dependent and time consuming. The aim of this study was to validate the new oscillometric method (Arteriograph) for determining PWV and AIx by comparing it to two clinically validated, broadly accepted tonometric and piezo-electronic systems (SphygmoCor and Complior).

Design and method PWV and AIx were measured up to five times in 51 patients with the SphygmoCor, Complior and Arteriograph. In 35 patients, the measurements were repeated after 1 week in a second session using the same protocol.

Results The correlations of the PWV as assessed with the Arteriograph with the values obtained using the SphygmoCor ($r = 0.67$, $P < 0.001$) and the Complior ($r = 0.69$, $P < 0.001$) were highly significant. Variability and reproducibility for PWV were best for the Arteriograph, followed by Complior and SphygmoCor. AIx (SphygmoCor versus Arteriograph) were very closely correlated ($r = 0.92$, $P < 0.001$).

Perspectives The Arteriograph is a new, easy-to-use and time-effective method for assessing arterial stiffness and wave reflection. *J Hypertens* 26:523–528 © 2008 Wolters Kluwer Health | Lippincott Williams & Wilkins.

Journal of Hypertension 2008, 26:523–528

Keywords: arterial stiffness, Arteriograph, augmentation index, Complior, oscillometry, pulse wave velocity, SphygmoCor, tonometry, validation

Abbreviations: PWV, Pulse Wave Velocity; AIx, Augmentation Index; NYHA, New York Heart Association; PP, Pulse Pressure; BHS, British Hypertension Society; AAMI, Association for the Advancement of Medical Instrumentation

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Obtaining arterial stiffness indices from simple arm cuff measurements: the holy grail?

Pierre Boutouyrie[a,b], Miriam Revera[c,d] and Gianfranco Parati[c,d]

determinants of PWV and AIx making use of any of these three devices. However, at least in the population of the study by Jatoi *et al.* [14], the limits of agreement when comparing the data provided by the three devices were quite wide. This indicates that these techniques for arterial stiffness assessment are not interchangeable. In Table 1, the main advantages and limitations of each of these three techniques are summarized. The results also indicate that the 'gold standard' in this field still needs to be identified, an issue that deserves to be addressed in a specific study.

Moreover, for a meaningful risk stratification, we need to have undisputable reference values for a patient to be classified as having elevated arterial stiffness. We also need to know which therapeutic interventions might be beneficial in patients with elevated arterial stiffness. Needless to say, the availability of a simple, affordable, and easy to apply technique will be of great help in this regard.

It has to be emphasized that this study raises a number of questions. First, it is still unknown what the minimal level of agreement between techniques, for them to be used interchangeably, might be. Second, it needs to be clarified whether we need data illustrating prediction of morbidity and mortality for each new technique, even when they are assessing a parameter, which has previously been shown to have an independent prognostic value. Finally, and most importantly, the biggest question is 'How and when should we use any measure of arterial stiffness in clinical decision-making?'. This question has yet to be addressed properly.

To our knowledge, the demonstration of a better risk stratification, leading to better care of patients by using arterial stiffness indices, has only been shown in a small group of patients with end-stage renal disease [17]. Similar studies are needed in more general populations.

Journal of Hypertension 2009, 27:2159–2161

Table 1 Summary of main advantages and limitations of three different techniques for arterial stiffness evaluation

Device	Advantages	Limitations
Complior	• The delay in pulse transit time between two arteries sites is taken simultaneously using a 'foot to foot' waveform method • Numerous data on the prognostic value of cf-PWV so obtained are available	• Operator's skill dependency • Carotid tonometry is difficult • Necessity to undress and expose the groin • Possibility of technical errors in obese patients • Uncertainty and approximation in measurement of distance between the two arterial sites • Theoretical risk of carotid plaque rupture by probe (never reported) • Patients with atrial fibrillation cannot be evaluated • Unable to allow PWA • Underestimation of elevated PWV by built-in algorithm
SphygmoCor	• PWA is available allowing assessment of augmentation index and central BP through a transfer function application • Numerous data on the prognostic value of the parameters so obtained are available	• Operator's skill dependency • Carotid tonometry is difficult • Necessity to undress and expose the groin • Possibility of technical errors in obese patients • Uncertainty and approximation in measurement of distance between the two arterial sites • Theoretical risk of carotid plaque rupture by probe (never reported) • Patients with atrial fibrillation cannot be evaluated • Debate regarding the validity of the generic transfer function used • Need of a precise BP calibration for PWA, currently not available • The PWV transit time delay is calculated using reference ECG signals obtained at different times, respectively, for carotid and femoral pulse waveforms sequentially recorded
Arteriograph	• The technique only needs access to the patient's upper arm (no need to undress) • It is based on an easy methodology (largely operator-independent method) • It is a time-saving method. This fast assessment of arterial stiffness parameters is particularly suitable to population studies • Higher reproducibility of parameters, as compared with the other two methods • Potentially adaptable to ambulatory arterial stiffness assessment	• Scarce data on its validation and on the prognostic value of parameters so obtained are available • Patients with atrial fibrillation or marked bradycardia cannot be evaluated

EDITORIAL COMMENT

Boutouyrie, P., Revera, M., Parati, G.

Journal of Hypertension

2009, 27:2159–2161

Invasive validation of a new oscillometric device (Arteriograph) for measuring augmentation index, central blood pressure and aortic pulse wave velocity

Iván G. Horváth[a], Ádám Németh[a], Zsófia Lenkey[a], Nicola Alessandri[b], Fabrizio Tufano[b], Pál Kis[a], Balázs Gaszner[a] and Attila Cziráki[a]

Background The importance of measuring aortic pulse wave velocity (PWVao), aortic augmentation index (Aix) and central systolic blood pressure (SBPao) has been shown under different clinical conditions; however, information on these parameters is hard to obtain. The aim of this study was to evaluate the accuracy of a new, easily applicable oscillometric device (Arteriograph), determining these parameters simultaneously, against invasive measurements.

Methods Aortic Aix, SBPao and PWVao were measured invasively during cardiac catheterization in 16, 55 and 22 cases, respectively, and compared with the values measured by the Arteriograph.

Results We found strong correlation between the invasively measured aortic Aix and the oscillometrically measured brachial Aix on either beat-to-beat or mean value per patient basis ($r = 0.9$, $P < 0.001$; $r = 0.94$, $P < 0.001$), which allowed the noninvasive calculation of the aortic Aix without using generalized transfer function. Similarly strong correlation ($r = 0.95$, $P < 0.001$) was found between the invasively measured and the noninvasively calculated central SBPao; furthermore, the BHS assessment of the paired differences fulfilled the 'B' grading. The PWVao values measured invasively and by Arteriograph were 9.41 ± 1.8 m/s and 9.46 ± 1.8 m/s, respectively (mean $\pm$ SD); furthermore, the Pearson's correlation was 0.91 ($P < 0.001$). The limits of agreement were 11.4% for aortic Aix and 1.59 m/s for PWVao.

Conclusion Aix, SBPao and PWVao, measured oscillometrically, showed strong correlation with the invasively obtained values. The observed limits of agreement are encouragingly low for accepting the method for clinical use. Our results suggest that the PWVao values, measured by Arteriograph, are close to the true aortic PWV, determined invasively. *J Hypertens* 28:000–000 © 2010 Wolters Kluwer Health | Lippincott Williams & Wilkins.

Journal of Hypertension 2010, 28:000–000

Keywords: arterial stiffness, Arteriograph, augmentation index, invasive measurement, oscillometric method, pulse wave velocity, validation

Abbreviations: Aix-ao, aortic augmentation index; Aix-br, brachial augmentation index; BP, blood pressure; CAS, coronary artery stenosis; c-f PWV, carotid–femoral pulse wave velocity; GTF, generalized transfer function; Jug-Sy, Jugulum-Symphisis; PWVao, aortic pulse wave velocity; RT, return time; SBPao, central systolic blood pressure

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The method is

- easy to use

and fast

- non-invasive

-patient-friendly, painless

- user friendly, 2 minutes.

The technology is COMPLETE,
includes the examination of the entire arterial tree.
It does

Blood pressure measurement

By examining the peripheral arteries, shows the **ARTERIAL FUNCTION** in the arterioles, the regulatory system of all pressure conditions. Related parameters: *Augmentation index, Central Blood Pressure* (by suprasystolic measurement, sys.bp+35mmHg) and *DRA* (by the cuff inflation at diastolic pressure).

Examines the Large Arteries (=Aorta+carotides), their **STIFFNESS** that refers to arterial STRUCTURE. Related parameter: *Pulse Wave Velocity*. If PWV is high, it shows target organ damage that is to be treated by the recommendations of the newest European Guidelines.

ABI (ankle-brachial index) is a well known test for the lower limb circulation

Összefoglalva

- The Arteriograph is for two reasons:
- SCREENING of asymptomatic patients (from age 30-65), in order to catch the earliest, reversible, treateable stage of the disease
- Therapy OPTIMIZATION (you can see the different effects of the different antihypertensive treatments)

Köszönöm a figyelmet!

Mit teszünk emelkedett értékek esetén?

Increased/abnormal Aix (during routine screening without knowing anything about the subject)

Lipidprofile (LDL, HDL cholesterol, trigliceride)

fasting and postprandial se-glucose, Hgb A_1C

routine liver function tests, renal function tests,

24 collected urine for microalbumin excretion and creatinine clearance

If BP>140/90 mmHg - ABPM

Increased/abnormal PWVao

If SBP<140 mmHg, HR<80/min

carotid ultrasound for echogenic plaque >1 mm

If SBP>140 mmHg, HR>80/min

repeat Arteriograph measurement when BP<140 mmHg and HR<80/min and if PWVao increased/abnormal perform carotid ultrasound

Increased/abnormal SBPao

See CAFE