NEW TOOLS FOR VASCULAR EXAMINATION AVAILABLE TO THE PHYSICIAN

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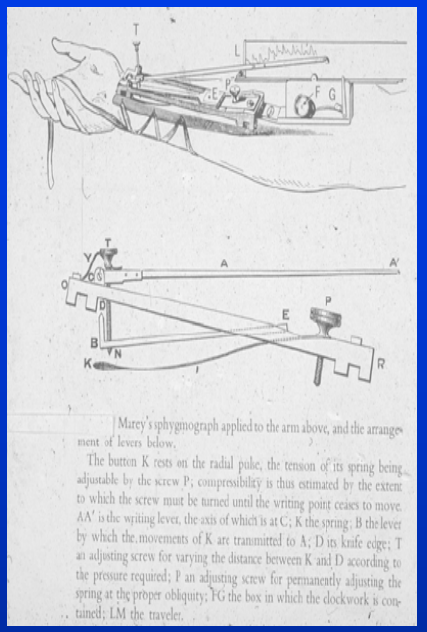
1733

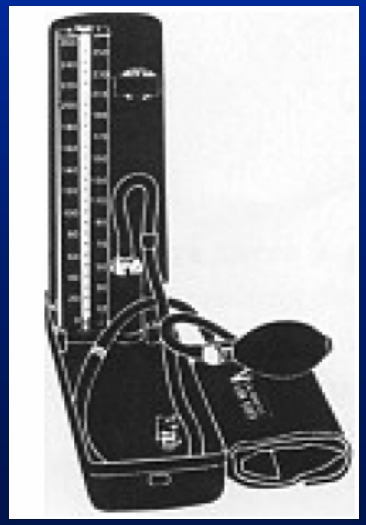
Sphygmograph: 1870

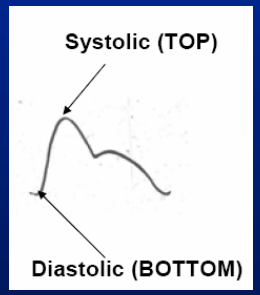


Marey's sphygmograph applied to the arm above, and the arrangement of levers below.

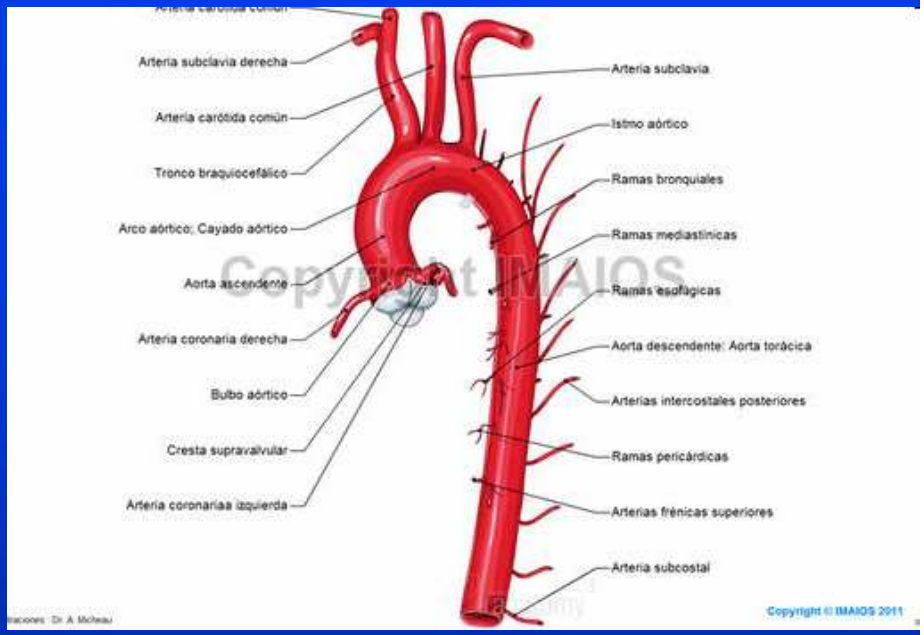
The button K rests on the radial pulse, the tension of its spring being adjustable by the screw P; compressibility is thus estimated by the extent to which the screw must be turned until the writing point ceases to move. AA' is the writing lever, the axis of which is at C; K the spring; B the lever by which the movements of K are transmitted to A; D its knife edge; T an adjusting screw for varying the distance between K and D according to the pressure required; P an adjusting screw for permanently adjusting the spring at the proper obliquity; FG the box in which the clockwork is contained; LM the traveler.

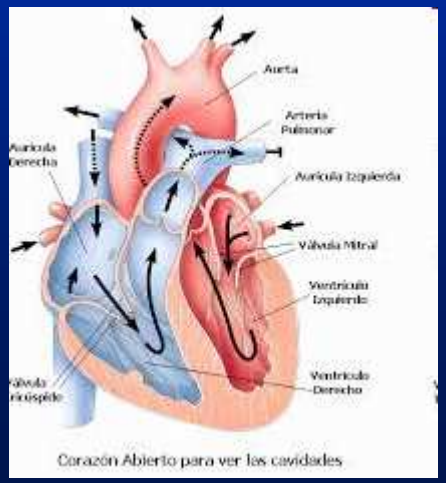
1896-1905





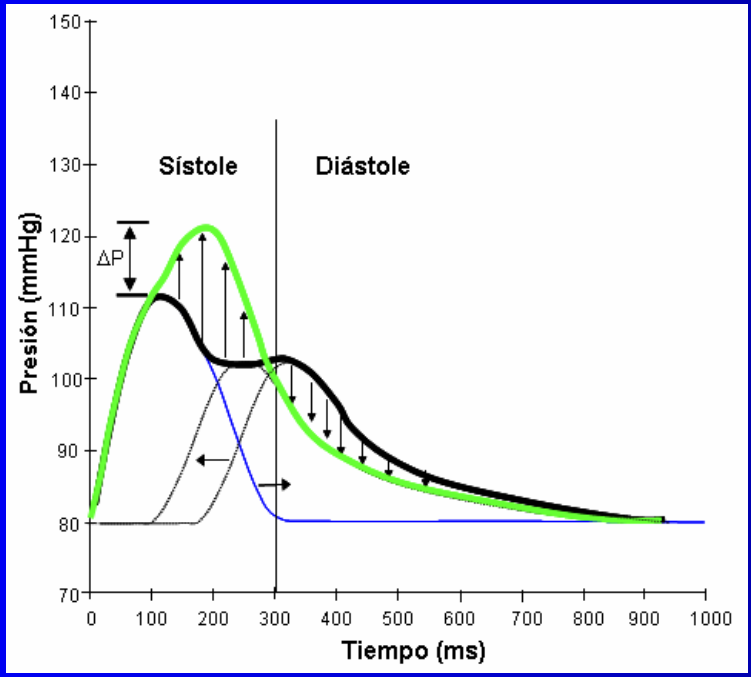
2016



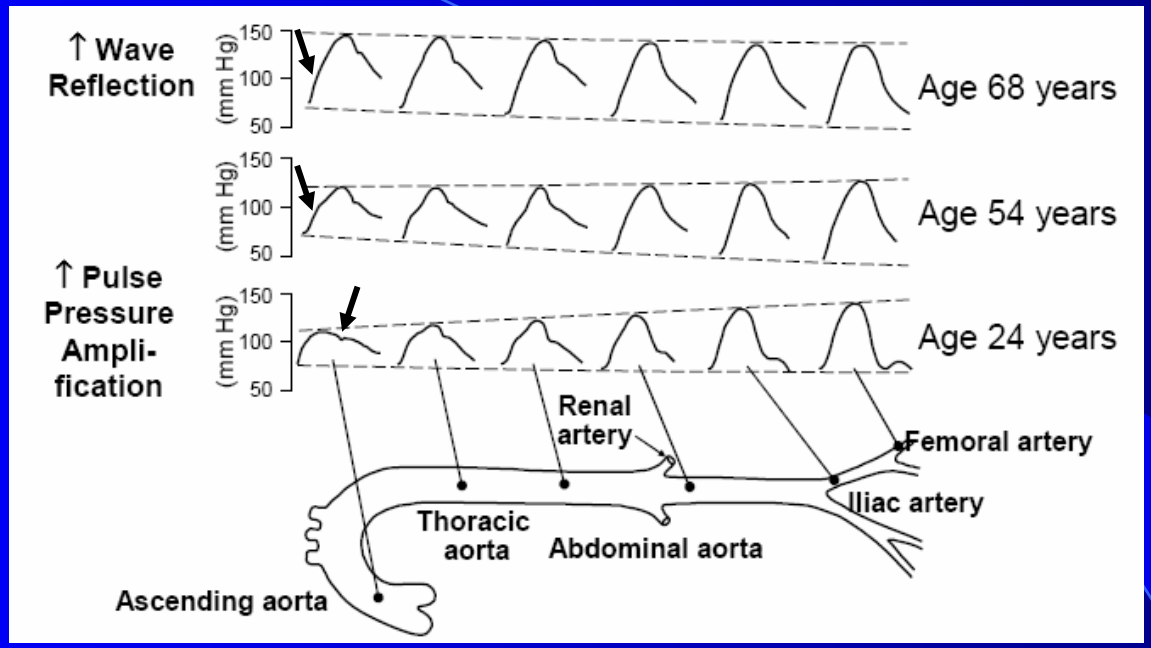


Corazón Abierto para ver las cavidades

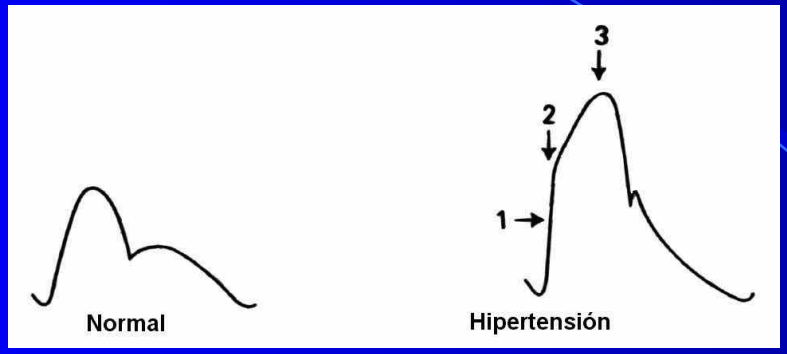
Physiopathology (Arteriosclerosis)



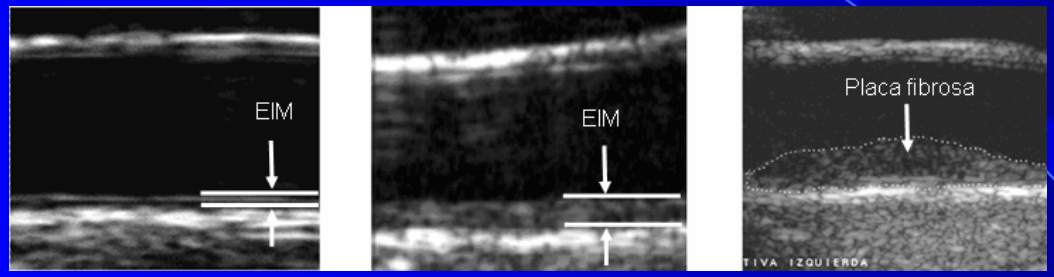
Age


↑ Wave Reflection
↑ Pulse Pressure Ampli-fication
(mm Hg)
150
100
50
Age 68 years
Age 54 years
Age 24 years
Renal artery
Femoral artery
Iliac artery
Thoracic aorta
Abdominal aorta
Ascending aorta

Arterial Hypertension



Atherosclerosis



↑ Intima: lipids, connective tissue, calcium

↑ **IMT**

NO INVASIVES TOOLS

ARTERIAL FUNCTION

ARTERIAL STRUCTURE

I- ARTERIAL STIFFNESS

II- CENTRAL PRESSURE

III- ENDOTELIAL FUNCTION

IV - INTIMA MEDIA THICKNESS

V- PLAQUES

VI- CAC

Table 5 Methods for measuring arterial stiffness in clinical investigation

Parameter	Main features and definition	Limitations	Predictive value	Degree of for CV events technical expertise
Carotid-femoral PWV	Gold standard for arterial stiffness Speed of travel of the pulse along an arterial segment ($L/\Delta t$ in m/s)	Pressure-dependent No data on arterial geometry Inaccuracy of distance measurement	+++	+
Central pulse-wave analysis (carotid and aortic pressure waves)	Central pulse pressure (PP) Central SBP Central augmentation pressure (AP) Central AIx with AIx = AP/PP	Indirect information on arterial stiffness	++	+
Local arterial stiffness	Carotid distensibility Carotid compliance Carotid Young's modulus Takes into account BP level	Requires echotracking systems Requires local PP	+	+++

Table 1. Features of Central Blood Pressure Estimation Devices/Methods

Device	Site of Measurement	Measurement Principle	Sensor Structure (Operation)	Calibration (NIBP Measurement)	CBP Estimation Method	Estimated CBP Parameters (CBP Related Indexes)*
Any tonometric devices	common carotid artery	applanation tonometry	single (manual)	BrBP: MBP/DBP (manual input of separately measured BrBP)	simple substitution	caSBP, caPP (caAI, PPA)
SphygmoCor®	radial artery	applanation tonometry	single (manual)	BrBP: SBP/DBP (manual input of separately measured BrBP)	GTF	P_{Ao}, cSBP, cDBP, cPP (cAI, AP, PPA)
HEM-9000AI®	radial artery	applanation tonometry	arrayed (automated)	BrBP: SBP/DBP (automatically measured BrBP with an inbuilt oscillometric sphygmomanometer)	SBP2	cSBP, rSBP, rPP2 (rAI ≈ PPA^{-1}%)
BPro® + A-PULSE CASP®	radial artery	modified applanation tonometry	Single (fixed)	BrBP: SBP/DBP (acquired from a dedicated oscillometric sphygmomanometer temporarily connected before use)	NPMA	cSBP, (rAI ≈ PPA^{-1}%)
Dedicated oscillometric devices**	brachial artery	modified oscillometry	brachial cuff (fixed)	BrBP: SBP/DBP (a same brachial cuff is used for BrBP as well as oscillometric pulse wave measurements)	dedicated software**	cSBP, cDBP, cPP (brAI, cAI, AP, PPA)

AI = augmentation index; BrBP = brachial cuff blood pressure; DBP = diastolic blood pressure; MBP = mean blood pressure; NIBP = noninvasive blood pressure; NPMA = N-point moving average; P_{Ao} = aortic pressure waveform; PP = pulse pressure; PPA = PP amplification; rPP2 = pressure amplitude at the second systolic peak or shoulder of radial pressure wave; SBP = systolic blood pressure; SBP2 = late or second systolic pressure of peripheral pressure wave; br- = brachial; c- = central aortic; ca- = carotid; r- = radial.

* Refer to Fig. (4) for the relationship between each parameter and blood pressure waveforms.

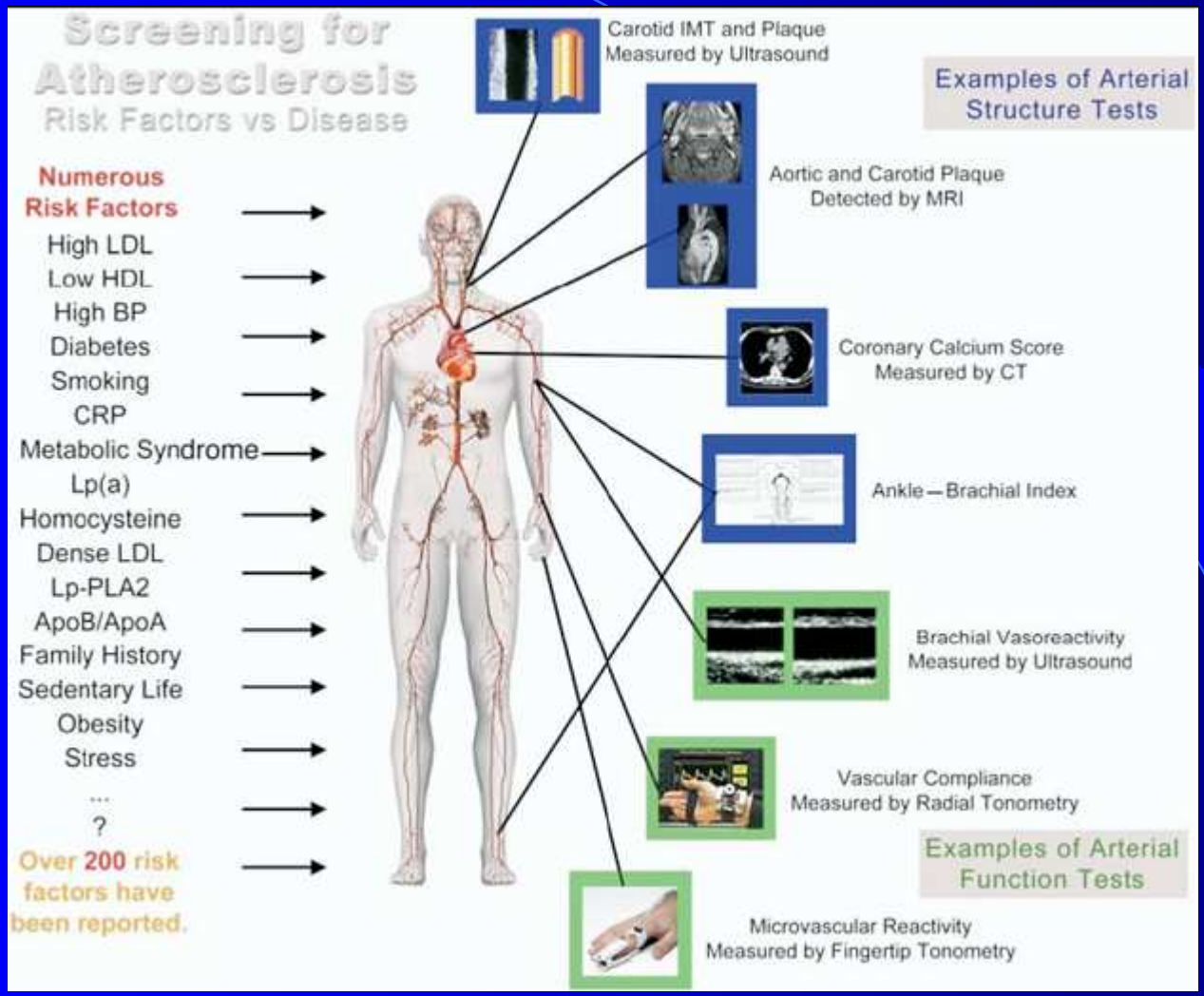
** They include, e.g. Arteriograph®, BPPlus®+VasomonR®, BPLab®+Vasotens®, and Mobil-O-Graph® etc.

Table 1 Indirect, non-invasive methods for estimating central pressure

Method of waveform recording	Device	Company	Method of calibration	Method of estimation	Clinical applicability†
Radial tonometry	BPro[86,87]	HealthSTATS	Brachial–radial cuff BP	GTF (radial-aortic)	++
	SphygmoCor[12,88]	AtCor Medical	Brachial–radial cuff BP	(i) GTF (radial-aortic)	+
				(ii) Late systolic shoulder	+
	HEM9000AI[39,77]	Omron	Brachial cuff BP	(i) Algorithm	++
				(ii) Late systolic shoulder	++
Brachial cuff PVP	*ARCsolver[89,90]		Brachial cuff BP	GTF (brachial-aortic)	+++
	Centron cBP301[35,91]	Centron Diagnostics	Brachial cuff BP	GTF (brachial-aortic)	++++
	Vicorder[92]	Skidmore Medical	Brachial cuff BP	GTF (brachial-aortic)	+++
	XCEL	AtCor Medical	Brachial cuff BP	GTF (brachial-aortic)	+++
	Method of Sung *et al.*[42]		Brachial cuff BP	Algorithm	++
Suprasystolic brachial cuff PVP	Arteriograph[37,93]	TensioMed	Brachial cuff BP	Late systolic wave amplitude	+++
	Cardioscope II[36,94]	Pulsecor	Brachial cuff BP	Algorithm	++++

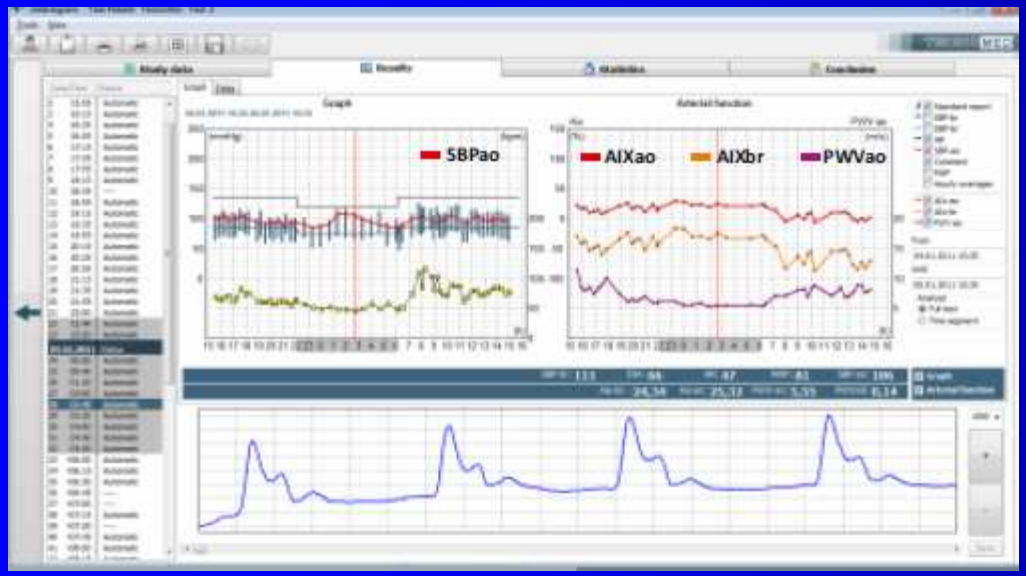
PVP, pulse volume plethysmography; GTF, generalized transfer function.
*Incorporated in Mobil-O-Graph PWA device (IEM GmbH).
†Personal view based on experience, operator-dependency, need for computer/software interface, with + indicating limited applicability to routine clinical practice and ++++ indicating high applicability.

Present:

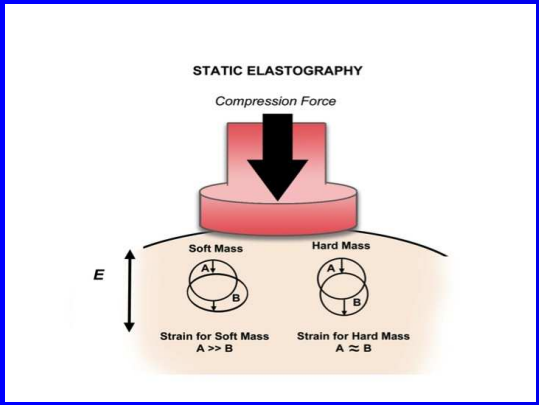

Screening for Atherosclerosis
Risk Factors vs Disease
Numerous Risk Factors
High LDL
Low HDL
High BP
Diabetes
Smoking
CRP
Metabolic Syndrome
Lp(a)
Homocysteine
Dense LDL
Lp-PLA2
ApoB/ApoA
Family History
Sedentary Life
Obesity
Stress
...
?
Over 200 risk factors have been reported.
Carotid IMT and Plaque Measured by Ultrasound
Examples of Arterial Structure Tests
Aortic and Carotid Plaque Detected by MRI
Coronary Calcium Score Measured by CT
Ankle—Brachial Index
Brachial Vasoreactivity Measured by Ultrasound
Vascular Compliance Measured by Radial Tonometry
Examples of Arterial Function Tests
Microvascular Reactivity Measured by Fingertip Tonometry

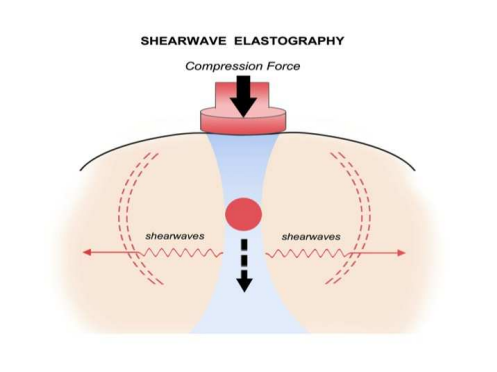
Future?:

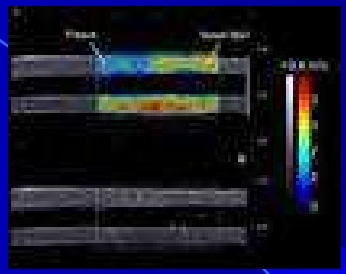
- PWV 24hs
-Central Pressure 24 hs



- Elastography x shearwave







- 3D ultrasound imaging of the carotid arteries (IMT 3D Y PLAQUE 3D)