Stiffness

HTN

Arterial Stiffness

HTN

Cause or Consequence?

Who is First ?

Stiffness

HTN

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PLOS | COMPUTATIONAL BIOLOGY

Arterial Stiffening Provides Sufficient Explanation for Primary Hypertension

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Abstract

Hypertension is one of the most common age-related chronic disorders, and by predisposing individuals for heart failure, stroke, and kidney disease, it is a major source of morbidity and mortality. Its etiology remains enigmatic despite intense research efforts over many decades. By use of empirically well-constrained computer models describing the coupled function of the baroreceptor reflex and mechanics of the circulatory system, we demonstrate quantitatively that arterial stiffening seems sufficient to explain age-related emergence of hypertension. Specifically, the empirically observed chronic changes in pulse pressure with age and the impaired capacity of hypertensive individuals to regulate short-term changes in blood pressure arise as emergent properties of the integrated system. The results are consistent with available experimental data from chemical and surgical manipulation of the cardio-vascular system. In contrast to widely held opinions, the results suggest that primary hypertension can be attributed to a mechanogenic etiology without challenging current conceptions of renal and sympathetic nervous system function.

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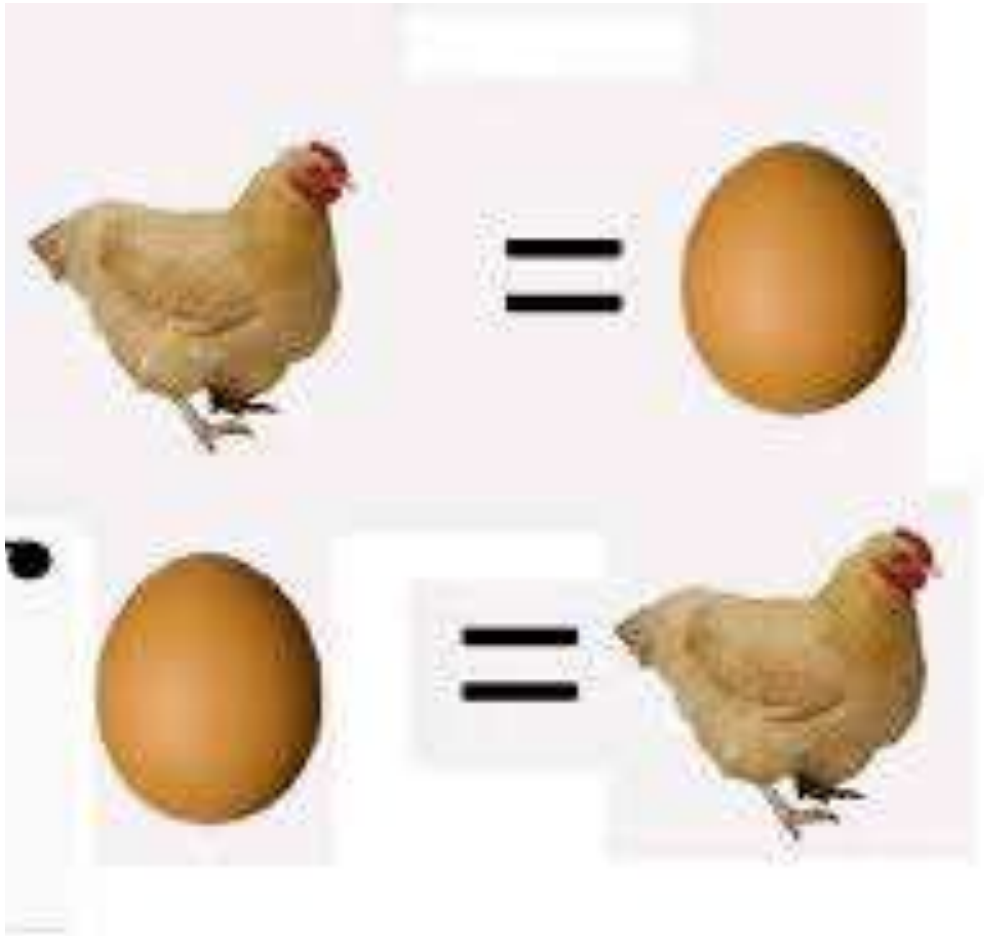

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Input Impedance of the Systemic Circulation

By Michael F. O'Rourke, M.B., B.S., and Michael G. Taylor, M.D., Ph.D.

ABSTRACT

The hydraulic load presented to the left ventricle by the systemic circulation was characterized by expressing pressure-flow relationships in the ascending aorta as input impedance. This was determined by spectral or Fourier analysis of simultaneously recorded pressure and flow waves in 1 unanesthetized and 27 anesthetized dogs. Impedance modulus fell steeply from its value at zero frequency (the peripheral resistance) and its value was lowest (less than 1/20th of the peripheral resistance) over that band of frequencies (usually between 1.5 and 10 cycle/sec) which contained most of the energy of the left ventricular ejection (flow) wave. The patterns of modulus and phase of ascending aortic impedance were found to result from the presence of two functionally discrete reflecting sites in the systemic circulation, one in the upper part of the body and the other in the lower. The presence of these two sites appears to be an important factor in maintaining a low impedance modulus between 1.5 and 10 cycle/sec, and so in providing a favorable impedance to pulsatile flow from the heart. Both modulus and phase of impedance in the ascending aorta showed changes similar to those seen in other arteries when blood pressure was altered and when vasodilation occurred in the vascular bed.

ADDITIONAL KEY WORDS

Fourier and spectral analysis
wave reflection
pulse wave velocity
ascending aorta
vasodilation
blood pressure
design of vascular system
external left ventricular work
pressure and flow waves
anesthetized dogs


1

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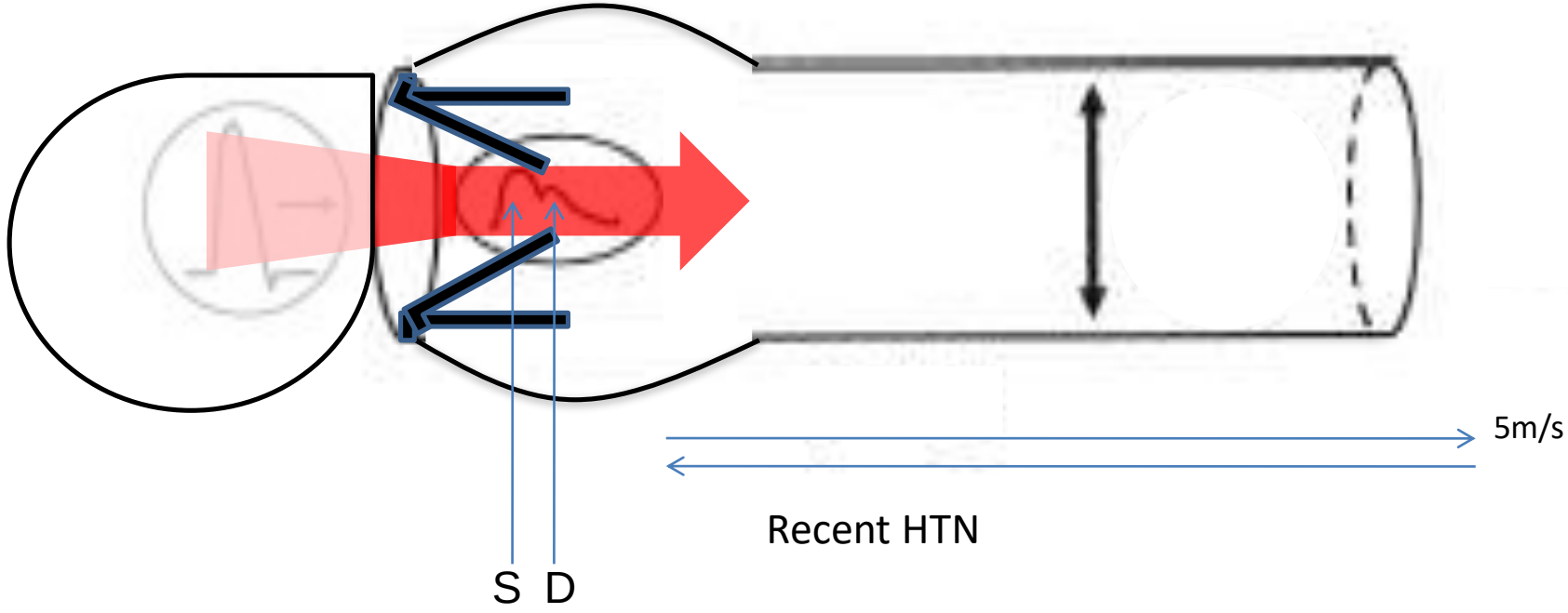

Stiffness	Systole	**SBP increase**
Arterial Dilation	Diastole	**DBP decrease**

HVG

Ischémie

Insuff. Card

Thrombose

OEdeme

Hémorragie


2

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Arterial Stiffness and Hypertension: Chicken or Egg?

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Cardiovascular Engineering, Inc., Norwood, MA

A common interpretation of known relations between arterial stiffness and hypertension is that elevated blood pressure, particularly PP, increases pulsatile aortic wall stress, which accelerates elastin degradation.[9–13] Thus, hypertension is viewed as an accelerated form of vascular aging that leads to aortic stiffening.

Arteries

Arterial Rigidity

Endothelial Lesions

Atherosclerosis

TS

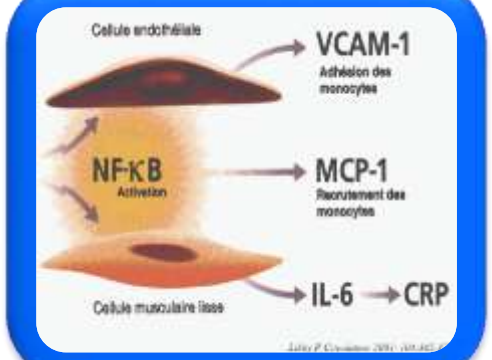
SS

NO

Mechanosensors

Integrins
Stretch-sensitive ion channels
Tyrosine kinase receptors
G-Proteins

Elastin



Genetics

Lifestyle Risk factors

Sympathetic Overdrive

Smoking

Hormonal factors

Sedentarity

Metabolic factors

Nutrition

HTN → Stiffness

Pulse Wave Reflection

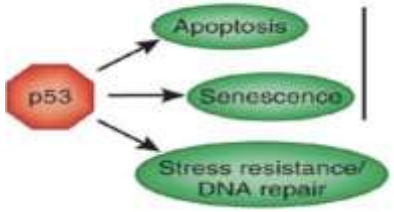
HTN

Stiffness

Elastin Degradation

NO consumption

p53 activation



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Am J Physiol Heart Circ Physiol 301: H221–H229, 2011.
First published May 2, 2011; doi:10.1152/ajpheart.00119.2011.

Decreased aortic diameter and compliance precedes blood pressure increases in postnatal development of elastin-insufficient mice

Victoria P. Le,[1] Russell H. Knutsen,[2] Robert P. Mecham,[2] and Jessica E. Wagenseil[1]

[1]*Department of Biomedical Engineering, Saint Louis University, and* [2]*Department of Cell Biology and Physiology, Washington University School of Medicine, St. Louis, Missouri*

Eln +/-

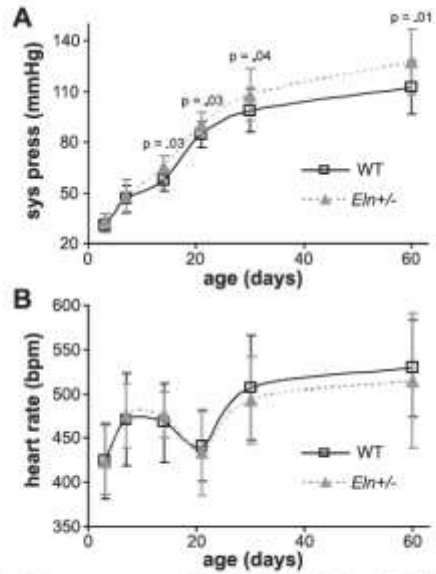

Fig. 4. Systolic pressure (sys press) is significantly higher in $Eln^{+/-}$ mice by P14 (*A*). There are no significant differences in heart rate between genotypes (*B*). bpm, Beats/min; n = 12–25/group.

SP↑

Arterial Stiffness

Arterial Stiffening Precedes Systolic Hypertension in Diet-Induced Obesity

1st month

Increased PWV Stiffness

6th month

Increased SBP

Diet induced Obesity

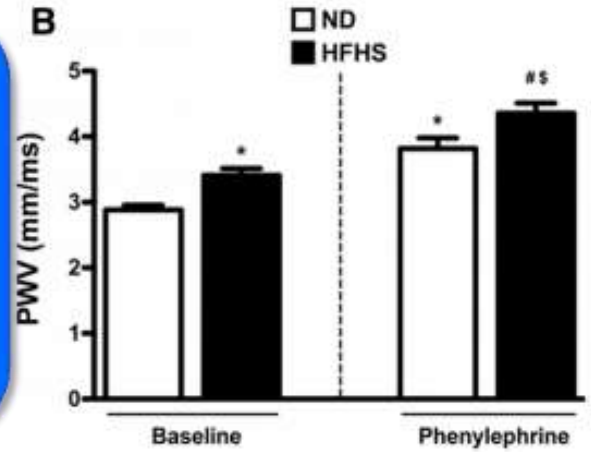

Figure 1. Arterial stiffness precedes hypertension in diet-induced obese mice. Pulse wave velocity (PWV, mm/ms), an index of arterial stiffness, measured by Doppler echocardiography, mean±SD, n=4 to 10 each group (**A**) and invasively with high-fidelity pressure catheters, mean±SEM, n=8 each group (**B**) is increased in high-fat/high-sucrose (HFHS)–fed mice within 2 months. Mean arterial pressure was modulated by intravenous infusion of phenylephrine (0.1 μg/g body weight). **P*<0.05 vs normal diet (ND) or ND baseline; #*P*<0.05 vs HFHS baseline; $*P*<0.05 vs ND-phenylephrine. Mice develop systolic hypertension after 6 months of HFHS (**C**) compared with ND (**D**). **P*<0.05 vs baseline (time 0) or ND. SBP indicates systolic blood pressure.


4

ESC European Society of Cardiology

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doi:10.1093/eurheartj/ehy165

CLINICAL RESEARCH
Prevention and epidemiology

Arterial stiffening is a heritable trait associated with arterial dilation but not wall thickening: a longitudinal study in the twins UK cohort

Marina Cecelja[1], Benyu Jiang[1], Louise Keehn[1], Tarique Hussain[2], Miguel Silva Vieira[3], Alkystis Phinikaridou[3], Gerald Greil[2], Tim D. Spector[4], and Phil Chowienczyk[1]*

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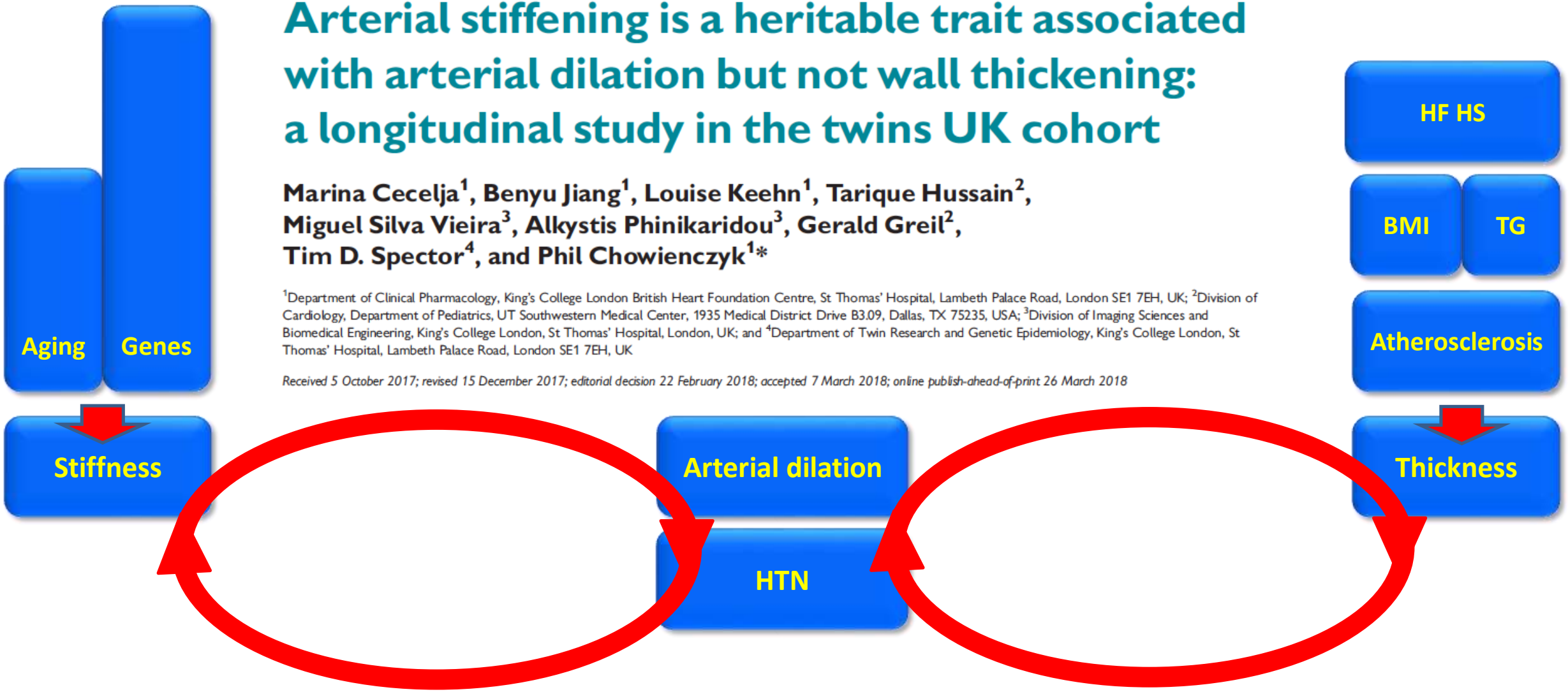


Exercise

CR Mimetics

Aging

Genes

Stiffness

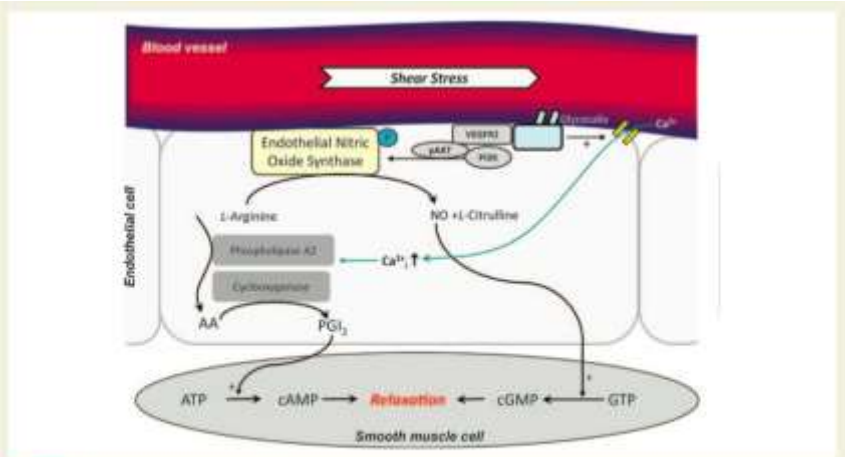
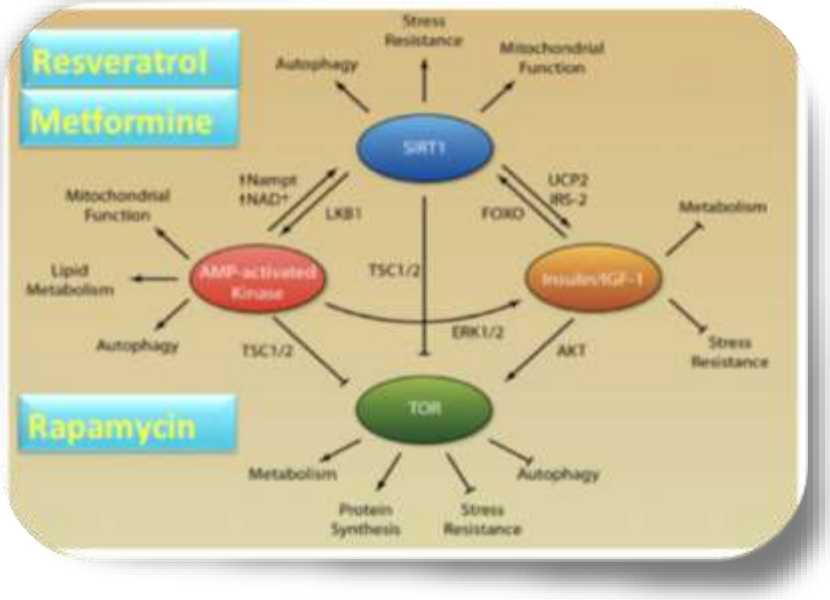


Figure 3 The majority of exercise effects on the vascular endothelium are mediated by intermittent increases of laminar shear stress. On the luminal side of the endothelial cells, direct signaling can occur through deformation of the glycocalyx activating phospholipase activity via an increase in intracellular Ca^{2+}, prostaglandin I2 (PGI2) release, and cAMP-mediated smooth-muscle-cell relaxation. VEGF receptor 2 (VEGFR2) can activate PI3K to phosphorylate Akt and induce AKT-mediated eNOS phosphorylation, leading to higher NO production. Akt indicates protein kinase B; AA, arachidonic acid; VEGF, vascular endothelial growth factor.



HF HS

BMI

TG

Atherosclerosis

Thickness


5

Scientists finally concluded that the chicken came first, not the egg, because the protein which makes the egg shells is only produced by a hen.

PROCEEDINGS

Structure and Function of Systemic Arteries: Reflections on the Arterial Pulse

Michael F O'Rourke,[1,2] Audrey Adji,[1,3] and Michel E. Safar[4]

"Structure and Function of Arteries"—is a topic of great importance to those who deal with arterial hypertension, since it links the source of flow, the left ventricle of the heart (whose output is pulsatile) to the peripheral tissues (whose flow is near continuous). The arterial tree acts passively as a conduit and cushion, and the interaction of heart, arterial tree, and organs is conventionally gauged on the basis of blood pressure measured by cuff in a conveniently located place (the brachial artery). For any precision and perspective to be gained, measurements of brachial systolic and diastolic pressure need be supplemented by other information. When such information is gained, one can understand how beautifully the arterial tree is tuned to the beat of the heart in animals of different size and shape and in humans at age 30 through the first third of a 3 billion beat lifetime. After age 30, the beats themselves progressively destroy the human arteries and their tuning to the heart, with emergence of clinical syndromes. In this review, the subject is tackled quantitatively on the basis of published numerical, physical, physiological, and pathophysiological basis, with principal focus on the beat of the heart, the pulse of the arteries, and their interaction.

Keywords: arterial function; blood pressure; hypertension; wave reflection.

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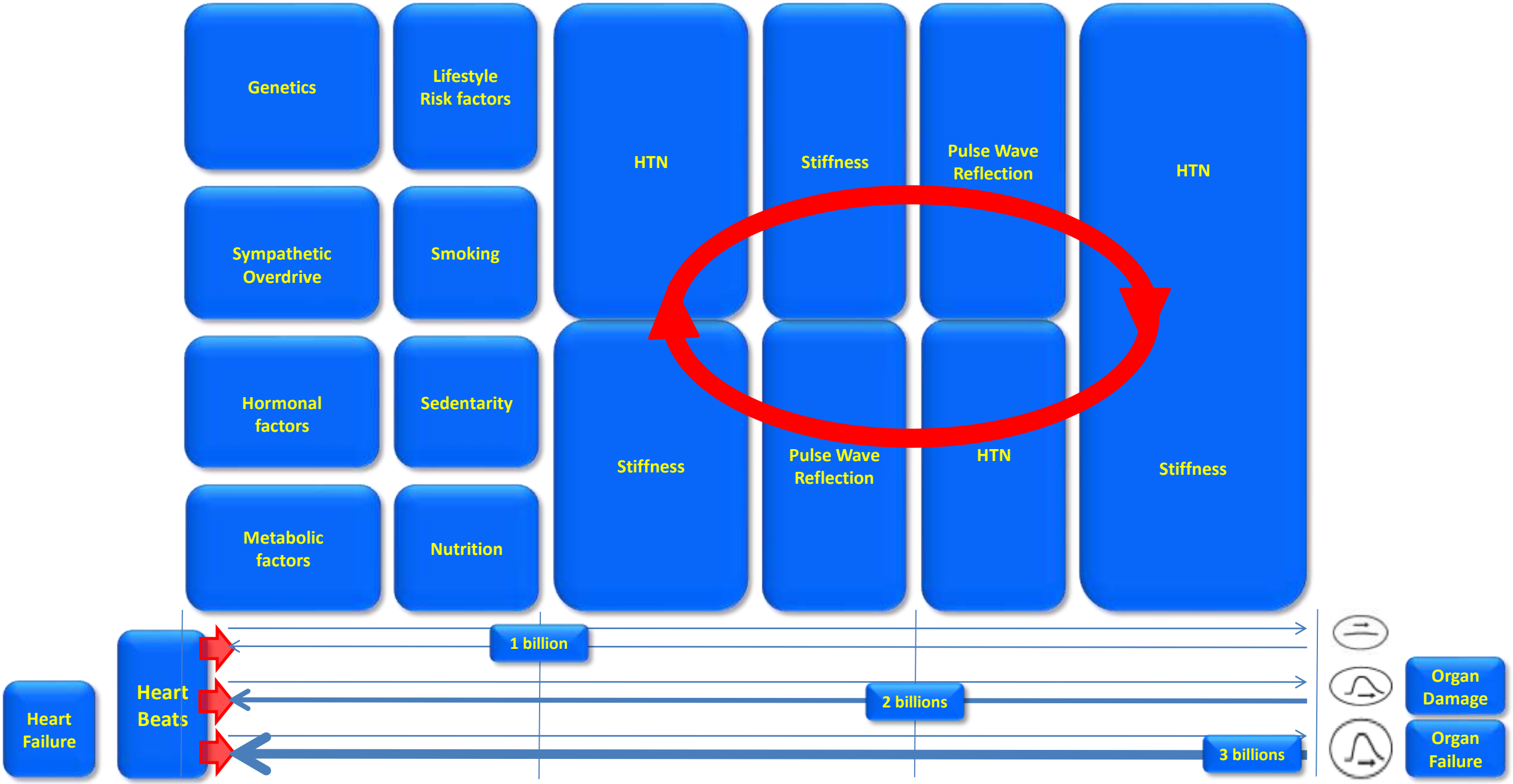
Genetics
Lifestyle Risk factors
Sympathetic Overdrive
Smoking
Hormonal factors
Sedentarity
Metabolic factors
Nutrition
HTN
Stiffness
Pulse Wave Reflection
HTN
Stiffness
Pulse Wave Reflection
HTN
HTN
Stiffness
1 billion
2 billions
3 billions
Heart Beats
Heart Failure
Organ Damage
Organ Failure