

Cardiovascular technology and indication service



Today's topic:

**Blood Pressure & Pulse Wave Measurement  
combined in one procedure  
Re-classification of risk patients**

Series: Hypertension Management in the Medical Practice

## Paradigm shift in blood pressure measurement – the path of arterial stiffness

Arterial stiffness is an independent and distinct “biomarker” of vascular health and prognostically relevant for cardiovascular risk. The fundamental physical characteristics of pulse waves in the cardiovascular system resemble those of acoustic waves. The form and velocity of the pulse wave essentially depend on the stiffness of the arteries. Starting from the heart, the vascular tree tapers off into the periphery (funnel effect), which leads to an increase of blood pressure amplitude, an effect called “blood pressure amplification”. In young age when arteries are more distensible, blood pressure amplification is more pronounced. Whereas in older age, central Blood Pressure (cBP) increases and at the same time amplification decreases. This process is caused by a greater extent of arterial stiffness when human grow old.

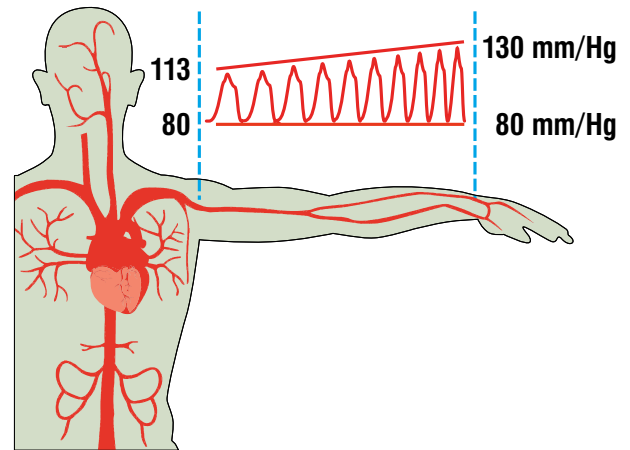


Fig. 1: Blood pressure amplifies from proximal to distal among healthy persons.

Various measured parameters such as aortic pulse wave velocity and augmentation index provide additional predictive values associated with risk of heart attack and stroke. They are therefore superior to risk stratification based on classic factors such as blood pressure, age or cholesterol. Every contraction of the left ventricle generates a pulse wave. Stiffening of the arterial vessel wall leads to early wave reflection in systole which in turn leads to an increase of central aortic pressure. Increased central blood pressure signifies an unfavourable increase of cardiac afterload, reduces the diastolic coronary blood flow and myocardial microcirculation. Recent research suggests that other organs such as the kidneys, eyes and brain can also be damaged because of this increased blood pressure associated with increased arterial stiffening.

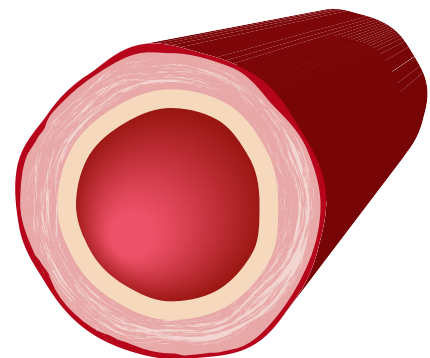


Fig. 2: Blood pressure 137/91 mmHg

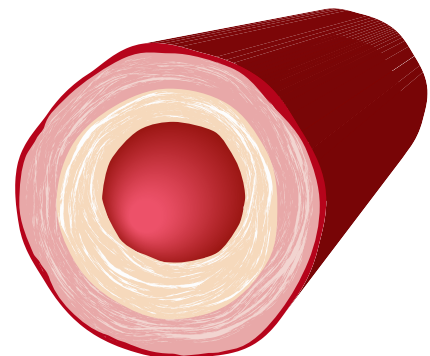


Fig. 2.1: Blood pressure 137/91 mmHg  
Morphological differences of the vessel wall (Arteriosclerosis) are recorded through the Blood Pressure<sup>PWA</sup> measurement.

**"Increased central blood pressure is an expression of increasing arterial stiffness and is more expressive in terms of cardiovascular morbidity and mortality than the blood pressure value on the upper arm"**

## Clinical background – scientifically proven. What clinical and prognostic significance does arterial stiffness have?

The current **evaluation of the Framingham Heart Study<sup>2</sup>** (Mitchell et al.) illustrates a relationship between blood pressure and stiffness over a period of 7 years among 1,759 participants. It has been demonstrated that increased arterial stiffness was significantly associated with the future incidence of hypertensive blood pressure values. However, initial increased blood pressure values proved to be less helpful for predicting increasing arterial stiffness in the subsequent course.

In the **CAFE Study<sup>3</sup>**, antihypertensive effects of two different medications were analysed on the basis of central blood pressure in comparison with peripheral blood pressure in regard to mortality and morbidity. Blood pressure among 2,199 participants was measured on the arm as well as centrally in the ascending aorta. The pulse waveform and the blood pressure in the aorta were calculated from the peripheral pulse pressure curve by means of a generalised transfer function. Either amlodipine (plus perindopril as required) or atenolol (plus thiazide as required) was administered in the randomised study. A significantly more favourable influence of amlodipine on cardiovascular morbidity and mortality was shown after a 5½ year follow-up. This corresponded to the fact that the central Blood Pressure (cBP) was lowered much more effectively under amlodipine therapy in comparison with atenolol. Interestingly, no difference was observed in peripheral blood pressure, therefore suggesting that central pressure was more predictive of outcome and more accurately tracks the vascular changes through differential drug therapies.

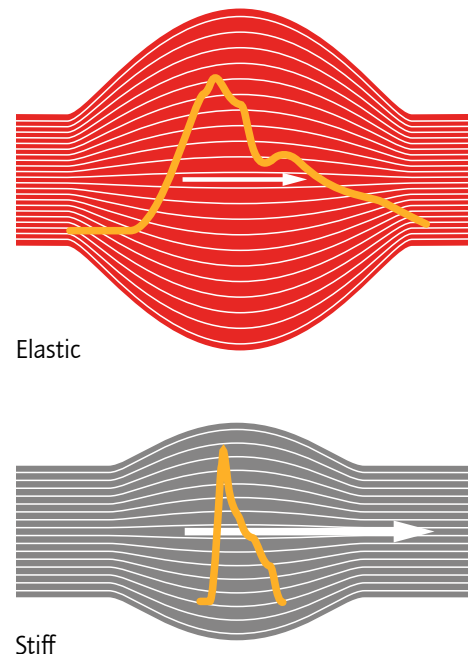


Fig. 3: Windkessel model

## What does the term "vascular age" mean?

The biophysical basis of cardiovascular diseases in connection with individual vascular age has been analysed in the **Nilson et al Study<sup>4</sup>**. Among young people, the elastic fibres (elastin) of the vessels which bring about the elasticity of vessels expand by 10% with every heart-beat. Material fatigue arises due to this mechanical stress (approx. 300 million expansions in 10 years). Because elastin is only reproduced extremely slowly, taut collagen is provided as a replacement, which ultimately leads to medial calcific sclerosis. The arteries become stiffer. However, vascular age not only increases with biological age but can also be increased due to the influence of genetics, bad lifestyle (lack of physical activity, smoking, wrong diet etc) or disease (diabetes, hypertension, ESRD, RA etc). This increased arterial stiffening at a young age is termed "early vascular aging" – EVA syndrome.

**"Scientific findings show that arterial stiffness is prognostically more predictive<sup>1</sup> than blood pressure measurement alone."**

## Simple measurement method – the most important aspects in short form

Arterial stiffness is quantified with the aortic Pulse Wave Velocity (PWV) (measuring unit: m/s). The stiffer the aorta, the higher the PWV. The prognostic significance of aortic PWV is very well documented.

Central aortic pressure (central systolic pressure, central pulse pressure) is a more accurate measurement of the actual haemodynamic burden of the heart and arteries together. Increasing arterial stiffness inevitably leads to an increase of central pressure values.

PWV and central systolic pressure are measured tonometrically or with oscillometric systems. In principle, the measurement of blood pressure and Pulse Wave Analysis (PWA) in one device should be possible – Blood Pressure<sup>PWA</sup> measurement. The measurement accuracy compared with invasive catheter technology should be examined and published. Additional information about peripheral resistance and stroke volume shall be available with regard to the parameters of arterial stiffness, because it can provide support during the therapeutic decision.

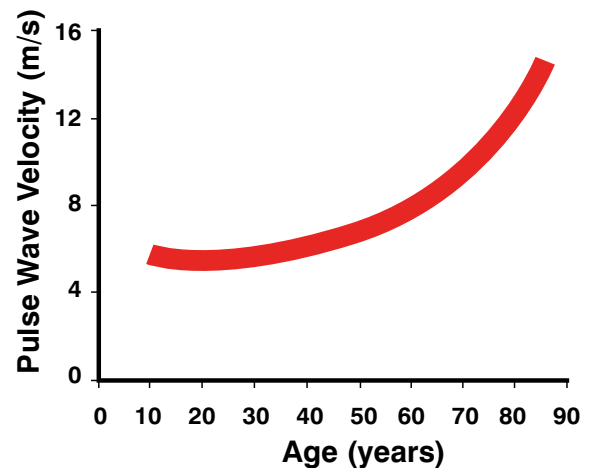


Fig. 4: Age-dependent development of Pulse Wave Velocity (PWV) among 998 normotensive<sup>7</sup> healthy subjects.

## The advantage in the medical practice – risk classification in accordance with ESC/ESH recommendations<sup>6</sup>

The early diagnosis of subclinical organ damage (OD; clinically still silent!) is of crucial importance in the classification of cardiovascular risk. Recording pulse wave velocity is a simple method for recording damage to the vascular system. If subclinical end-organ damage (EOD) is verifiable, patients in this high-risk patient group (class 4/5) should start comprehensive therapy<sup>7</sup> immediately. Aortic stiffness has independent predictive value for fatal and nonfatal CV events in hypertension patients. The additive value of PWV above and beyond traditional risk factors, including SCORE and Framingham risk score, has been quantified in a number of studies.<sup>6</sup>

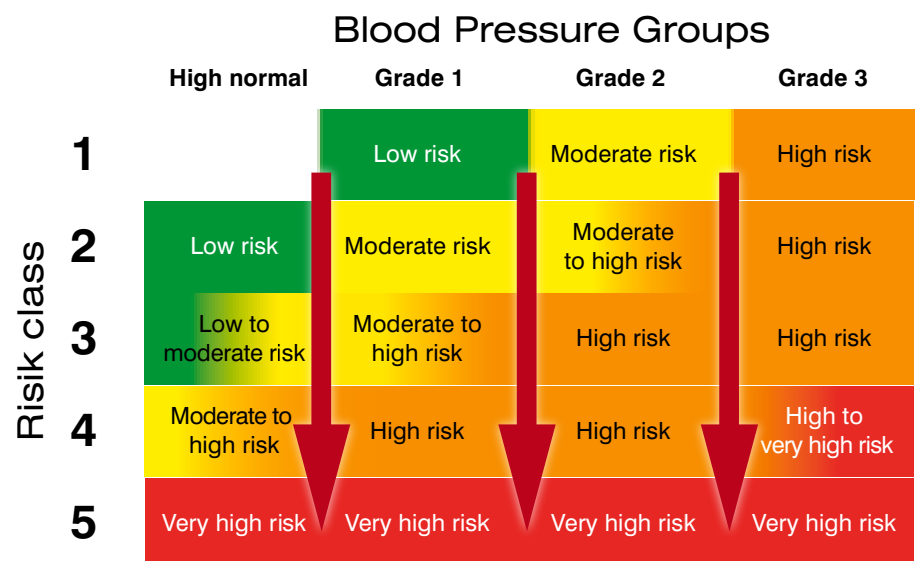


Fig. 5: Blood Pressure<sup>PWA</sup> measurement – elevated PWV/OD reclassified in risk class 4/5

**"Pulse Wave Velocity (PWV) expresses the measurement of arterial stiffness and is measured in m/s. Aortic PWV supports risk classification."**

## Why does the measurement of stroke volume help during the therapeutic decision?

All antihypertensive substance classes comparably reduce blood pressure. However, they differ in their haemodynamic characteristics with regard to heart rate, stroke volume and peripheral resistance. The pulse contour of the Blood Pressure<sup>PWA</sup> measurement provides information about the individually measured stroke volume. Certain antihypertensive agents lead to a decrease of peripheral vascular resistance, which leads to a relief of the strain on cardiac function (afterload) with simultaneous improvement of stroke volume. The randomised intervention study RD Smith et al. shows that therapeutic decisions on the basis of measured haemodynamics (stroke volume and peripheral resistance) achieve up to 69% better accuracy in blood pressure adjustment with the initial prescription<sup>8</sup>

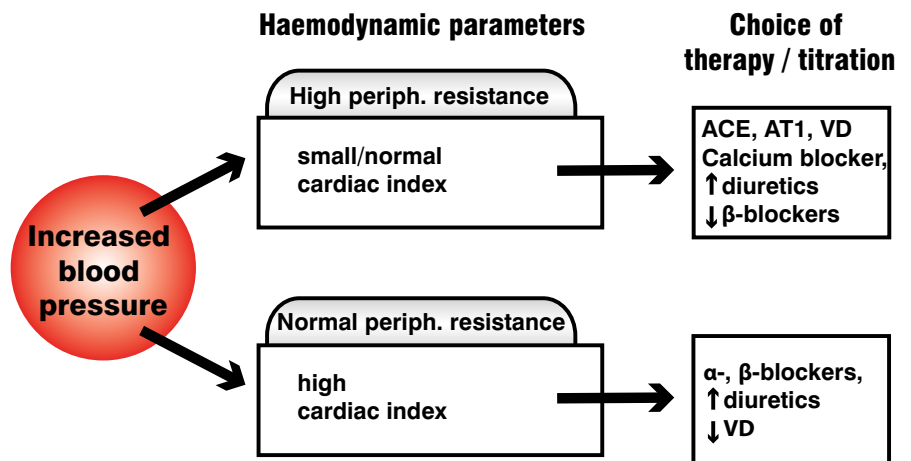


Fig. 6: Haemodynamic parameters

## Why is blood pressure pulse wave measurement so efficient?

The risk of cardiovascular events, particularly in people with medium risk, can be reclassified with the measurement. A better therapeutic decision can be made on this basis and patient management can be optimised.

- Screening – detection of subclinical end-organ damage
- Initiation of a personalised therapy
- Risk Awareness through offering Vascular Age Measurement

**"Blood Pressure<sup>PWA</sup> measurement supports a therapeutic decision according to risk class and haemodynamic characteristics of antihypertensive agents."**

## Which healthcare economic aspects does Blood Pressure<sup>PWA</sup> measurement offer?

A specific therapy can be initiated through an individual risk classification and knowledge of haemodynamics.

The offer of Blood Pressure<sup>PWA</sup> measurement in the medical practice leads to higher diagnostic accuracy and more specific therapy.

In a recently published pilot study by Sharman et al, the amount of medications per study participant dropped from 2.4 to 1.8 dosage units, once the antihypertensive treatment was based on central blood pressure values rather than on its brachial counterpart. Even though the amount of drugs was decreased significantly, a trend towards a decrease in left ventricular mass has been demonstrated in those patients treated for central blood pressure.

## How is Blood Pressure<sup>PWA</sup> measurement reimbursed?

Blood Pressure<sup>PWA</sup> measurement is offered to patients as a "vascular age measurement" and creates demand. The measurement can be utilised within the framework of prevention programmes (for example during check-ups) in order to recognise early vascular aging. The measurement will be paid "out of the pocket".

**Do you know  
your Vascular Age?**



Invest 5 minutes in your health  
and get your blood vessels tested  
according to the latest medical findings.



Fig. 7: "Vascular age" practice marketing

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**"Blood Pressure<sup>PWA</sup> Measurement with the cuff is more efficient than the standard method in routine practice. Specific therapy makes the measurement promising in terms of healthcare economics."**