TODAY’S TOPIC
Blood Pressure & Pulse Wave Measurement Combined in One Procedure
Re-classification of Risk Patients

SERIES | Hypertension Management in the Medical Practice

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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 number of factors including greater extent of arterial stiffness when humans grow older.

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 increased central aortic pressure associated with arterial stiffening.

Available reference values for central aortic pressure support the identification of the respective risk for damage.

"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" 

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 PressurePWA 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.

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 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.

The advantage in the medical practice—
risk classification in accordance
with ESC/ESH recommendations

"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 PressurePWA 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.

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.

- Stratification—detection of subclinical end-organ damage
- Initiation of a personalised therapy
- Risk awareness through offering Vascular Age Measurement
Clinical background—scientifically proven. What clinical and prognostic significance does arterial stiffness have?

The current evaluation of the Framingham Heart Study² (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 Study³, 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 amiodipine (plus perindopril as required) or atenolol (plus thiazide as required) was administered in the randomised study. A significantly more favourable influence of amiodipine on cardiovascular morbidity and mortality was shown after a 5-year follow-up. This corresponded to the fact that the central blood pressure was lowered much more effectively under amiodipine 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.

The biophysical basis of cardiovascular diseases in connection with individual vascular age has been analysed in the Nilsson et al Study⁴. Among young people, the elastic fibres (elastin) of the vessels which bring about the elasticity of vessels expand by 10% with every heartbeat. 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 than blood pressure measurement alone.”

How can Blood PressurePWA Measurements reduce healthcare costs?

A personalized therapy can be initiated through an individual risk classification and knowledge of haemodynamics. The offer of Blood PressurePWA measurement in the medical practice leads to higher diagnostic accuracy and more personalized therapy. In a recently published pilot study by Sharman et al\textsuperscript{10}, 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 PressurePWA measurement reimbursed?

Blood PressurePWA measurement may be offered to patients as a “vascular age measurement”. The measurement can be utilised within the framework of prevention programs (for example during check-up programs), in order to recognise early vascular aging. Reimbursement for Blood PressurePWA measurement is expanding to many countries. In others, the examination is commonly paid for by the patients themselves.

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“Blood PressurePWA 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.”