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Pulse wave analyses: which parts of the pulse wave are clinically relevant

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A heart cycle can be peripherally recorded as a single pulse wave. The classical analysis of the pulse wave can be done by the extremes: the pressure points that are called systolic and diastolic pressure. The past century was impressively dominated by these 2 points in terms of cardiovascular diagnosis and therapy. However, other parts of the pulse wave can be mathematically calculated. For example, a single pulse wave, recorded by cuff measurement at the brachial artery can be used to calculate the aortic pulse wave velocity as a measure of arterial stiffness (or arterial calcification), additionally to calculate the central pressure, the pressure the heart “sees” and has to fight against and many variables more. The clinical significance of the various parts of the pulse wave ranges, according to today's knowledge, from completely non-usefulness via very valid prognosis of heart attack/stroke/death ending up with the potency to redefine the cardiovascular killer no. 1 in the world (arterial hypertension) – all just using specific parts of a single pulse wave. Which parts of the pulse wave do bear these clinical relevance is the topic of the presentation.

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Validation of blood pressure measuring devices – clinical update: the German Hypertension League (Deutsche Hochdruckliga DHL®) Quality Seal Protocol for blood pressure-measuring devices: 15-year experience and results from 105 devices

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Hypertension is a major risk factor for cardiovascular disease and respective guidelines help making a proper diagnosis and choosing adequate treatment.
Automated measurement can be affected by differences in the quality of the components, including the workmanship of pressure transducers, valves, cuffs, and other hardware components.
Methods: The validation procedure has to be performed by three well-trained and experienced investigators. For reference measurements, standard BP auscultation with a mercury sphygmomanometer (Riva-Rocci-Korotkoff) and a dual earpiece teaching stethoscope for simultaneous auscultation is used. Ninety-six test subjects are selected based on age, sex, and systolic and diastolic blood pressure level according to protocol specifications. Wrist devices have to be tested additionally in 20 subjects with overt diabetes mellitus (10 men and 10 women) aged >56 years.
Results: From 1999 to 2014 a total of 105 blood pressure devices for self-measurement were tested according to the Quality Seal Protocol. Of these, 47.6% met all five validation criteria, 53.7% of the upper-arm devices (39 of 71) and 32.4% (11 of 34) of the wrist devices. Finger devices were not offered for testing. Forty-four devices (41.9%) failed multiple test criteria of the validation procedure. A sub-analysis with 51 devices tested showed that a stricter definition of the passing point score with a limit of ≥55% would slightly increase the consistency with the conventional criteria in comparison to a point score criterion ≥50% which was introduced in 2007.
Conclusion: The results illustrate the importance of a rigorous testing of blood pressure measuring devices used for home blood pressure measurement in order to prevent patients from erroneous treatment decisions.

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Non invasive blood pressure monitoring based on photoplethymographic signals

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The measurement of pulse the transition time is mostly performed to get information about the stiffness of the arteries. As the puls wave velocity also depends on the current blood pressure, several new methods and devices use pulse transition times for blood pressure monitoring. Some measure differences of the pulse arrival time at different sites. Onother way uses the de-composition of the measured pressure pulse in a direct and a reflected component. This paper describes an approach to get these two components out of the photo-plethysmographic pulse shape.
Based on a special micro-optical technology for emitter-receiver modules (MORES) the CiS Forschungsinstitut fuer Mikrosensirk GmbH developed a photoplethysmographic (PPG) sensor solution for reflective measurement at the auditory channel. The sensor device of only 5.4x3.2x0.7mm size fits into an individually prepared or a universal ear mold. The silicon sensor chip contains a receiver diode (5.45 mm^2) placed on one side of the sensor and two up to four LEDs of different wavelengths. The PPG signal is taken at the inside area of the tragus.
The initial goal was an in-ear monitoring system for pulse rate and blood oxygen saturation. In the course of an optimization of sensor geometry and signal acquisition the signal-to-noise ratio has been improved to allow detailed shape analysis of the recorded pulses. Several analysis methods have been tried to separate a direct and a reflected component out of the PPG shape, however without reliable results. Comparing the PPG wave with a simultaneously taken cuff-based pressure wave both appear completely different. Based on a modified “Windkessel” approach a model for the transfer of the pressure wave into the PPG wave has been developed. It allows also a simple backward projection of the PPG into an image of the pressure wave, which further can be analysed for transition times.