2.2: DETERMINATION OF THE RESTENOSIS DEGREE INSIDE THE IMPLANTED STENT WITH INTEGRATED WIRELESS PULSE WAVE VELOCITY (PWV) SENSOR

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Results: diastolic BP, was used to calculate AP (difference between the second and rotid pressure, obtained by tonometry calibrated from peripheral mean and P. Hoppmann a, K. Stock a, K.-L. Laugwitz a,b, U. Heemann a, A. Kastrati a,b

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Brachial ambulatory blood pressure monitoring (ABPM) provides greater predictive value for cardiovascular (CV) events than clinic blood pressure (BP). However, 24hour ambulatory central BP (central ABPM) may be more closely related to surrogate markers of CV risk than brachial ABPM. The aims of this study were to determine usual values of central ABPM in apparently healthy, unmedicated individuals and to determine whether these relate to two established markers of CV risk, left ventricular (LV) mass and carotid intima-media thickness (cIMT). 24hour brachial and central ABPM was undertaken in 730 healthy individuals aged 18-88 years, using the Mobil-O-Graph device, together with clinic-based measurements of BP. A sub-set of individuals underwent assessment of LV mass (n=356) and cIMT (n=483), by ultrasound. Central pulse pressure (PP) increased and PP amplification decreased significantly at night (P<0.001 for both). Daytime central, but not brachial, ABPM was significantly and independently associated with cIMT (R\textsuperscript{2}=0.37, P=0.01) and, in general, correlations between central or brachial ABPM parameters and cIMT were stronger in younger (<50years) than older individuals. The association between 24hour central ABPM and LV mass was of borderline significance (R\textsuperscript{2}=0.16, P=0.05). However, the associations between central or brachial ABPM parameters and LV mass were only significant in older individuals. The variation in PP amplification within individuals over 24hours, indicates that brachial and central BPs are differentially affected by the activities of daily living. Moreover, central, rather than brachial ABPM is more strongly related to surrogate markers of CV risk.

2.2 DETERMINATION OF THE RESTENOSIS DEGREE INSIDE THE IMPLANTED STENT WITH INTEGRATED WIRELESS PULSE WAVE VELOCITY (PWV) SENSOR

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Patients with implanted stents were often (approx. 30 %) faced with the restenosis. By now no alternative to clinical examination is known to get a quick diagnosis for the actual state of possible and probable in-stent-restenosis. At Fraunhofer IPA in Stuttgart a simple method to measure and to determine the restenosis degree was invented and implemented. The Proof of principle was conducted on the experimental rig on an artery model. The approach is based on an inductive coupling between the external detection unit and implanted sensors. Two passive sensors were integrated in a stent and consist of a capacitive pressure sensor and an air-coil. Connected they form an oscillating circuit, the resonance frequency of which functionally depends on the local pressure. The extra-corpal detection unit generates an alternating magnetic field by 35 Hz. The spreading pulse wave changes the resonance frequency of the passive oscillating circuits inside the vessel.
The short resonance inside the sensor circuit crosses the frequency of the externally applied field and shifts the impedance measured at the excitation coil. As the distance between the two sensors is known the PWV can be determined. The PWV of the narrower vessel is the higher the PWV. A model based approach determines out of the PWV signal the restenosis degree inside the implanted stent. All further measurements are referenced to the first initial value done after the stent implantation. This approach is robust and has mean cross dependences because no absolute pressure measurement is required.

2.3 LOCAL STIFFNESS OF THE CAROTID ARTERY IS ASSOCIATED WITH INCIDENT CARDIOVASCULAR EVENTS AND ALL-CAUSE MORTALITY—A SYSTEMATIC REVIEW AND META-ANALYSIS

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Introduction: It has been suggested that local carotid stiffness is independently associated with cardiovascular (CV) events and mortality. However, consistent evidence for such an association is lacking. We therefore performed a systematic review and meta-analysis of longitudinal studies on the association between local carotid stiffness, incident CV events and all-cause mortality.

Methods: Medline and Embase were searched for articles published up to June 1, 2014. All studies were included which evaluated the association between local carotid stiffness (as determined by ultrasoundography) on the one hand and incident CV events and mortality on the other. We used random-effects models to calculate hazard ratios (HRs) and 95% confidence intervals (95%CIs) for pooled data.

Results: We included 10 studies with data for 19,191 participants and 177,136 person-years of follow-up. The pooled HRs (95%CIs) for one SD higher carotid elastic modulus were: for CV events (fatal and nonfatal combined) 1.19 (1.06-1.33); 10 studies, n = 19,496); for CV mortality 1.34 (1.15-1.55; 4 studies, n = 3,501). All results were adjusted for age, sex, blood pressure (SBP and/or MAP), and CV factors. Results were qualitatively similar when HRs were pooled for lower carotid distensibility and compliance instead of higher elastic modulus.

Conclusion: The present meta-analysis shows a strong association between local carotid stiffness and incident CV events, CV mortality and all-cause mortality. In a next step, we will do an individual participant meta-analysis to evaluate whether the association between local carotid stiffness and CV events and mortality is independent of carotid-femoral pulse wave velocity.

2.4 RELATIONSHIP BETWEEN ADULT TRANSFER FUNCTION DERIVED CENTRAL AORTIC SYSTOLIC PRESSURE AND MEASURED SYSTOLIC PRESSURE IN THE HEALTHY CHILDREN POPULATION

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Background: A non-invasive method, that used a general transfer function (TF), has been shown to accurately predict central aortic pressure from peripheral tonometry measurements in the adult population. However applying the same TF to estimate central aortic systolic pressure (aSP) in children has not yet been fully evaluated. This study aimed to assess the usage of adult TF to estimate aSP in children (aSPres.ch) by establishing and testing different single linear/multivariate regression models between the adult TF estimated aSP in children (aSPref.ch) and the measured aSP (aSPmeas.ch).

Methods: 218 healthy, pre-pubescent children aged 8 years (113 male) had simultaneously measured central and carotid arterial pressure waveform recorded using the SphygmoCor device. Central aSPref.ch was estimated from the radial pressure using the TF (SphygmoCor, AtCor Medical), and the carotid systolic pressure taken as a surrogate for central pressure (aSPmeas.ch). The study group was divided into two groups: one to estimate the models (n = 50, 19 male); another to test the models (n = 168, 94 male). Models 1 and 2 were two simple linear regression models, whilst models 3 and 4 were two multivariate regression models.

Results: In the tested group, the aSPres.ch from all models showed high correlations and low average differences with aSPmeas.ch (model 1 R² = 0.88, difference = 1.6±2.6 mmHg; model 2 R² = 0.88 difference = 1.8±3.4 mmHg; model 3 R² = 0.89 difference = 1.6±2.5 mmHg; model 4 R² = 0.89 difference = 1.2±2.7 mmHg, all p < 0.0001). Conclusion: Central aSP in children can be estimated accurately using the adult TF from the radial pulse by incorporating the now defined linear relationship between aSPref.ch and aSPmeas.ch.

2.5 COMPARISON OF NON-INVASIVE AND INVASIVE MEASUREMENTS OF CENTRAL BLOOD PRESSURE IN PATIENTS WITH CHRONIC KIDNEY DISEASE

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Background: The blood pressure (BP) in the ascending aorta can be estimated non-invasively by pulse wave analysis using commercially available devices such as the SphygmoCor. However, this device has not been validated for use in patients with chronic kidney disease (CKD).

Objectives: Comparison of non-invasively obtained estimates of central BP with invasively measured central BP in CKD patients.

Methods: Patients with stable CKD stage 3-5 corresponding to an estimated glomerular filtration rate (eGFR) under 60 ml/min undergoing elective coronary angiography were included. Central BP was estimated by the SphygmoCor using four different calibrations: invasive aortic diastolic and mean BP (invasive), systolic and diastolic brachial BP (sys-dia), brachial diastolic and mean arterial BP (form factor 0.33) (ff-0.33), and brachial diastolic and mean arterial BP (form factor 0.4) (ff-0.4). Brachial artery BP was measured simultaneously with a validated oscillometric BP device.

Results: Forty-nine patients, 65% males, aged 61±13 (mean±SD) with a median eGFR of 18 ml/min (range 5-59 ml/min) were enrolled. Invasive BP was 150±62/75±41 mmHg while brachial BP was 147±3.19/86.0±10 mmHg (mean differences: -3.6±9.7/10.7 mmHg (P = 0.012)). Mean differences (invasive minus estimated central BP) with the four calibrations used were: -5.9±6.1/1.1±3.0 mmHg, P = 0.001 (invasive); -16.0±9.3/11.5±8.0 mmHg, P = 0.001 (sys-dia); -17.5±10.5/11.5±7.9 mmHg, P = 0.001 (ff-0.33); -7.5±10.2/11.6±7.9 mmHg, P = 0.001 (ff-0.4).

Conclusion: In CKD patients, we found a systematic difference between estimated and invasively measured central BP. Surprisingly, brachial systolic BP was very close to invasively measured central systolic BP and was even more accurate than estimates based on calibration with invasively obtained BP.

2.6 NON-INVASIVE ESTIMATION OF EXERCISE CENTRAL BLOOD PRESSURE BY RADIAL-TIROMETRY MAY BE UNDERESTIMATED DUE TO BRACHIAL-TO-RADIAL-SYSTOLIC-BLOOD-PRESSURE-AMPLIFICATION AND IS RELATED TO UPPER LIMB BLOOD FLOW VELOCITY

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Objectives: Both central blood pressure (BP) and light-moderate exercise BP are independently associated with cardiovascular risk, and measuring central BP during exercise may have clinical relevance. Brachial-to-radial systolic blood-pressure-amplification (B-R-SBPamp) could influence the accuracy of central BP estimation by radial tonometry during exercise. This study aimed to determine the influence of light-moderate exercise on B-R-SBPamp and consequence central BP estimation. Independent correlates of B-R-SBPamp were also explored.

Methods: Sixty healthy participants (39±16 years, 50% male) underwent testing during light-moderate intensity (40W, 50RPM) semi-recumbent cycling. SBP was identified by brachial and radial ultrasound (1st Doppler flow inflection = 1st Korotkoff sound during cuff deflation). Haemodynamics were recorded by ultrasound and tonometry. Bra-Rad-SBPamp was defined as radial minus brachial SBP.

Result: Exercise radial SBP was significantly higher than brachial SBP (144±121 versus 134±17 mmHg; p = 0.001). Exercise Bra-Rad-SBPamp was 10±11 mmHg and increased with advancing age (r = 0.360, p = 0.005). Exercise central SBP was significantly higher when radial tonometry was calibrated with radial SBP (accounting for Bra-Rad-SBPamp) versus brachial SBP (117±16 versus 110±13 mmHg, p = 0.001). Low brachial peak flow velocity relative to radial velocity was negatively associated with exercise B-R-SBPamp (r = 0.439, p = 0.001), independent of age, sex, heart rate and mean arterial pressure (r = 0.389, adjusted R² = 0.273, p = 0.003).