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P2.13: FOOT TO TOE PULSE WAVE VELOCITY WITH POPMETRE® INDEPENDENTLY CORRELATES WITH GLOMERULAR FILTRATION RATE IN RENAL TRANSPLANT PATIENTS

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Methods: 135 Patients were enrolled in a longitudinal, prospective study of arterial stiffness and cardiovascular risk in a cohort suffering from chronic kidney disease stages 2 to 4. Office measurements of bSBP and aSBP were assessed by a validated oscillometric device. Prognostic factors of survival were identified by use of Cox proportional hazards regression models.

Results: After a mean follow up duration of 42 months (range: 30 to 50 months) 13 patients died. In univariate Cox analysis, bSBP did not significantly predict mortality, only aSBP assessed using measured mean and diastolic pressure calibration was significantly associated with mortality (HR=1.027, p=0.008). This remained significant in multivariate analysis after adjustment for age, sex and anthropometric measures. More important, adding bSBP to the multivariate model (HR=0.91, p=0.003), lead to a significantly increased prognostic and statistical power of aortic systolic pressure (HR=1.097, p<0.001) and indicated that differences between bSBP and aSBP are of potential interest.

Conclusion: Within our cohort, only aSBP assessed with measured mean and diastolic pressure predicted mortality and provided highly significant prognostic value.

P2.10

ASSESSMENT OF CAROTID PULSE WAVE VELOCITY BY ULTRASOUND: A WAVE INTENSITY ANALYSIS-BASED APPROACH

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Local carotid pulse wave velocity (cPWV) is a parameter increasingly investigated. The diameter-velocity loop (InD-V loop) could represent a valid approach for cPWV evaluation, since it requires the use of the ultrasound (US) equipment only. Aim of this study was to develop a fully-automatic system for assessing cPWV which is based on the InD-V loop and the use of the Wave Intensity Analysis (WIA).

US scans were obtained from 27 healthy subjects (44.1±17.8 years, 44.4% males, BMI 25.5±3.9 kg/m²). Diameter and flow velocity instantaneous values were achieved from B-mode and PW-Doppler images using edge-detection and contour-tracking techniques. Single-beat mean diameter and velocity were calculated, time-aligned using an automatic technique and plotted together providing the InD-V loop. The WIA, as introduced by Parker in 2009, was performed: the two local maxima (W1 and W2) were used to locate the two reflection-free linear parts of the loop. From the corresponding slopes, early-systolic (PWVes) and late-systolic PWV (PWVls) were calculated; moreover, a carotid stiffness (CS) value was obtained for each subject using Bramwell-Hill equation. PWVes values (5.16±1.57 m/s) were lower than CS (5.86±1.50 m/s) and PWVls (6.65±3.28 m/s) assessments: the difference was significant for PWVes-PWVls comparison (p<0.05) but not for PWVes-CS and PWVls-CS comparisons. Both PWVes and PWVls values were significantly correlated with CS ones (R=0.90, p<0.001 and R=0.76, p<0.001, respectively).

The proposed approach, based on US images only and the WIA, allows an evaluation of the stiffness in two different phases of the cardiac cycle, reflecting the pressure-dependent changes in cPWV.

P2.11

ASSESSMENT OF CAROTID DISTENTION WAVEFORM AND LOCAL PULSE WAVE VELOCITY DETERMINATION BY A NOVEL OPTICAL SYSTEM

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Measurement of structural and functional properties of the arterial tree produce important clinical indexes for the assessment of cardiovascular risk, vascular adaptation, and therapeutic efficacy. An optical system for non-contact measurement of skin surface vibrations with the distension in the carotid artery, that allows the determination the pulse wave velocity (PWV) and pulse waveform analysis (PWA), is promising nowadays.

A comparison between optical system and an invasive intra-arterial catheter were performed. The waveforms acquired by both systems show a strong correlation (mean value of 0.95805), the small differences emphasize the effect of the energy dissipation during the heart cycle that occurs due to the viscous properties of the arterial wall.

A comparative test between the optical system and a gold-standard method in PWV assessment (Complior®) was carried out. Lower values were

expected for PWV in the carotid site than the PWV in a carotid-femoral measurement and the results proved that there are systematic lower values but with strong correlation (r = 0.819, p<0.001).

Trial tests were developed in a large group of healthy subjects for study the correlations between the population characteristics and their hemodynamic parameters measured by the optical system. The results confirmed an increase of PWV with age; the negative correlation between the Augmentation Index and the heart rate and lower values for the dP/dtmax.in female subjects.

The optical system proved to be able to measure the arterial pulse waveform in a reliable way and demonstrated a good consistency in the determination of clinical parameters using dedicated algorithms.

P2.12

ARTERIAL STIFFNESS MEASURED WITH POPMÈTRE® IN PRIMARY ANTI-PHOSPHOLIPIDS SYNDROME

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Arterial stiffness (AS) is an independent predictor of cardiovascular events. It can be estimated easily by a new technique: pOpmètre® (Axelife-SAS-France). Some data suggests an increase in AS in anti-phospholipids syndrome (APS) patients.

To study the relationship between AS indices, and blood anti-phospholipids antibody levels in patients with primary APS vs controls with an history of thrombosis.

Aortic impedance (Physioflow® Esaote-Italy), Intima-media thickness (IMT) ultrasound, and foot to toe PWV, blood pressure, ABPI and the aPL antibody titers were measured in 20 APS patients and 20 controls with a distal deep vein thrombosis history.

The two groups were comparable for brachial blood pressure and ABPI (1.15 ± 0.04 vs 1.12 ± 0.03, ns), as well as the age. The APS group had a greater IMT (0.59 ± 0.02 versus 0.53 ± 0.01 mm, p <0.004). AS impedance (10.3 ± 0.6 versus 8.1 ± 0.6 m / s, p <0.02) and pOpmètre® ftPWV (13.2 ± 0.9 vs 10.5 ± 0.6 m/s; p <0.004) was increased in the APS group. Age correlated with systolic blood pressure (SBP) (r2 = 0.1; p = 0.002), AS (r2 = 0.11, p = 0.002), pOpmètre® ftPWV (r2 = 0.23; p <10⁻⁴), IMT (r2 = 0.16; p = 0.0003), not with the BAPI (r2 = 0.03; p = 0.06). No correlation was found between with age and aPL.

Conclusion: In the APS patients, arterial stiffness measured by pOpmètre® is increased compared to controls and correlated with AS indices and IMT.

P2.13

FOOT TO TOE PULSE WAVE VELOCITY WITH POPMETRE® INDEPENDENTLY CORRELATES WITH GLOMERULAR FILTRATION RATE IN RENAL TRANSPLANT PATIENTS

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Aim: To evaluate the relationship between glomerular filtration rate and arterial stiffness using Pulse Wave Velocity (PWV) as an independent cardiovascular risk factor in renal transplanted patients.

Patients and methods: We studied transplanted patients followed in our outpatient clinic. After a medical examination, we measured blood pressure (Comfort Cuff- Skil-Care, USA), PWV (pOpmètre® - Axelife sas - France) after 10 min supine resting. pOpmètre® measures the finger to toe transit time, and according to a height chart, calculates the PWV. Three measurements were performed to study the repeatability. Estimated glomerular filtration rate (eGFR) was calculated using MDRD equation.

Results: Forty-four (30 men, 14 women) renal transplant recipients were included. No significant difference between men and women were found in age (M±SEM: 53.2±2.2 years), systolic blood pressure (SBP: 138±2 mmHg), diastolic blood pressure (DBP: 81±2 mmHg), eGFR (45.9±2.4 ml/min/1.73 m2) and PWV (10.4±1 m/s) [range: 6.0-15.7]. Repeatability expressed as the SD/mean of 3 measurements was very good: 5.4%.

PWV correlated positively with age (r²=0.16, p<0.009) and negatively with eGFR (r²=0.15, p<0.009). Using a stepwise regression model (including gender, age, SBP, DBP, height, weight), only age and pOpmetre PWV remained significantly associated with eGFR.

Conclusions: Glomerular filtration rate independently correlates with pulse wave velocity in renal transplant patients, supporting the hypothesis that kidney function plays a predominant role in arterial stiffness.

P2.14

ESTIMATION OF AORTIC ARCH PULSE WAVE VELOCITY IN MRI USING COMPLEX WAVELET CROSS-SPECTRUM

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Aims: Pulse wave velocity (PWV) requires the length traveled between two aortic locations and the corresponding transit-time. This study aimed to: 1) design a new wavelet-based approach to estimate transit-time and aortic arch (aoPWV_w) from MRI ascending (AA) and descending (AD) aorta flow curves, and 2) compare its performances in terms of associations with: age, tonometric carotid-femoral PWV (cfPWV), and local AA Bramwell-Hill PWV (aaPWV_{BH}), against the time-domain aortic PWV (aoPWV_T), which is considered as the most relevant MRI approach.

Methods: We studied 74 healthy volunteers, (43±15years) who underwent MRI including: 1) multi-plane cine acquisitions to estimate aortic arch length and AA distensibility, converted into aaPWV_{BH}, and 2) through-plane velocity acquisitions which were automatically segmented to extract AA and AD flow curves, whose systolic-upslope was used to estimate transit-time using cross-correlation and the newly designed wavelet approach and subsequently to estimate aoPWV_T and aoPWV_w. First, cross-spectrum of AA and AD flow curves was calculated using wavelets which are more robust to insufficient temporal sampling of systolic-upslope than Fourier. Then the group delay was calculated by averaging the amplitude-weighted phases of systolic-upslope.

Results: Although strongly related ($r=0.82$, slope=1.15) associations with age, cfPWV and aaPWV_{BH} were stronger for the wavelet-based approach than aoPWV_T (aoPWV_w/aoPWV_T: $r=0.76/0.63$ with age; $r=0.60/0.57$ with cfPWV; $r=0.56/0.49$ with aaPWV_{BH}, $p<0.001$).

Conclusion: The wavelet-based arch PWV provides stronger associations with age and reference PWV than the previous time-domain estimate. These results suggest that considering supplementary signal information, results in a more reliable estimate of AA to AD transit time.

P2.15

IDENTIFICATION OF FRAMEWORK CONDITIONS IN CUFF BASED BLOOD MEASUREMENT SYSTEMS

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Background: Pulse wave analysis (PWA) using cuff based methods emerged within the last years. The combined analysis of PWA and magnetic resonance imaging (MRI) is very promising. Therefore long tubes from the cuff to the measurement system are needed. The aim of this work is the investigation of the effect of different cuffs and tubes with different lengths on the PWA results.

Methods: To evaluate the dynamic behavior of cuff based sensor chains we performed both tests on step response (similar to "pop test") as well as forced sinusoidal harmonic excitation by the means of a fully automated and standardized custom testing bench. The variation of cuff sizes, tube material and tube dimensions (diameter and length) was intended to account the influence of the framework conditions on the PWA results.

Results: The resonant frequencies of the evaluated cuff based systems are mainly based on the tube type and tube length. In detail the resonant frequency is reduced in proportion to the tube length. Furthermore in very large arrangements the pressure curve will be distorted. In particular PWA is very difficult with long tubes.

Conclusions: Based on our actual data especially the influence of the tube length has a major impact on the pressure measurement results. We suggest that a special design of the tubes can achieve proper results for PWA analysis also with long tubes.

P3.1

BENEFICIAL EFFECTS OF HYPERTRIGLYCERIDEMIA TREATMENT ON MICROVASCULAR ENDOTHELIAL FUNCTION IN TREATED HYPERTENSIVE PATIENTS

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Background: The relationship between increased levels of triglycerides (TG) and cardiovascular (CV) risk is controversial, and the effects on endothelial function are also unclear.

Objective: To investigate the effects of hypertriglyceridemia treatment on vascular function in treated hypertensive patients.

Methods: Thirty-six hypertensive patients with TG levels 150 to 499 mg/dl, both genders, aged 40-65 years, were randomized to receive active treatment (fish oil or fibrate) or placebo for 3 months. Systolic and diastolic blood pressure (SBP and DBP), brachial flow-mediated dilation (FMD), reactive hyperemia index (RHI) by peripheral artery tonometry, pulse wave velocity (PWV), carotid intima-media thickness (IMT) and central hemodynamic parameters were determined at baseline and after 3-month intervention.

Results: Treatment group presented significant decrease in SBP (139±17 to 134±12mmHg, $p<0.05$), DBP (86±11 to 81±9mmHg, $p<0.05$), TG levels (255±73 to 156±77mg/dl, $p<0.001$), carotid-radial PWV (10.9±1.8 to 10.2±1.2m/s, $p<0.05$) and aortic SBP (131±16 to 125±10mmHg, $p<0.05$) compared with control group. Treatment group showed significantly improvement in RHI (1.87±0.36 to 2.13±0.49 units, $p<0.05$). No significant effect was observed on FMD and carotid IMT. RHI increase was correlated with TG reduction ($r=-0.40$, $p=0.043$) and baseline TG/HDL ($r=0.44$, $p=0.023$), RHI ($r=0.40$, $p=0.041$) and aortic pulse pressure ($r=0.45$, $p=0.020$). After multiple linear regression, RHI improvement was only associated to TG decrease ($B=-0.001$, $p=0.043$) and baseline aortic pulse pressure ($B=-0.012$, $p=0.023$).

Conclusion: The treatment of hypertriglyceridemia was associated with improvement in microvascular endothelial function in treated hypertensive patients suggesting that TG levels reduction may have vascular protective effects in these patients.

P3.2

IMPAIRED SYSTOLIC FUNCTION IS ASSOCIATED WITH ALTERED FORWARD WAVE INTENSITY

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While parameters from pressure analysis could be related to arterial stiffness and prognosis in general populations, the results for patients with severely reduced ejection fraction (rEF) are rather puzzling. The aim of this study is to use wave intensity analysis (WIA), based on aortic pressure and velocity curves, and compare forward wave intensity in 61 patients with rEF and 122 controls with normal ejection fraction.

Typically WIA yields two distinct forward waves. The first (S-wave) is a compression wave (increasing pressure and flow) generated by systolic ventricular contraction. The second (D-wave) is an expansion wave (decreasing pressure and flow) occurring around valve closure. The ratio of these wave peaks (SDR) was calculated for patients matched for age, height, weight, gender, and brachial blood pressures with two methods: First, aortic pressure waves from the SphygmoCor system were aligned with Doppler velocity measurements from left ventricular outflow tract. Second, a flow model based on Windkessel theory was used to replace Doppler measurements.

In the whole group, SDRs, as calculated with both methods, showed highly significant direct relationships with measures of systolic function (ejection fraction, stroke volume, cardiac output, S' , invasive left ventricular dp/dt).

SDR, calculated using aortic pressure and Doppler velocity curves, was significantly reduced for the rEF group (2.9 vs. 5.3, $p<0.0001$). Using the flow model, a similar reduction could be found (2.9 vs. 4.8, $p<0.0001$).

These results suggest that peak forward wave intensity is capable to reflect reduced systolic ventricular function, even when Doppler flow measurements are omitted.