5.1: INERTIAL-VISCOELASTIC MINIMAL MODEL OF THE ARTERIAL SYSTEM RECONCILES ARTERIAL COMPLIANCE ESTIMATIONS

Timothy Phan*, John Li, Maheshwara Koppula, Izzah Vasim, Swapna Varakantam, Julio Chirinos

Methods: Aortic pressure and flow were measured in anesthetized, open-chest dogs (n = 5). Wave reflections were modified with i.v. infusion of methoxamine (MTX) to increase reflections and nitroprusside (NTP) to decrease reflections. In a human sample (n = 226), central pressure and flow were measured using carotid tonometry and phase-contrast MRI, respectively.

Results: Under conditions of baseline and increased reflections in both dogs and humans, peak of the forward wave (FWA) consistently occurred after time of peak flow (P < 0.001). FWA was systematically greater than peak flow multiplied by aortic characteristic impedance ($Q_{max}Z_c$) in dogs (P < 0.01) and humans (P < 0.01). Only when wave reflections were abolished vasoactively (NTP) in dogs was time of FWA and peak flow the same, leading to insignificant differences in FWA and $Q_{max}Z_c$ (P = 0.59).

Conclusion: In steady-state, wave reflections set up in previous cardiac cycles, wave re-reflections at the aortic root, and proximal reflections contribute to both the P_f and P_b waves, even during early-systole. Most importantly, peak aortic flow is also determined by aortic input impedance, which includes effects from properties distal of the proximal aorta. Under steady-state conditions, forward wave amplitude and morphology cannot be attributed solely to the LV and proximal aorta.

4.5

A SYSTEMATIC REVIEW AND META-ANALYSIS OF CENTRAL TO BRACHIAL BLOOD PRESSURE AMPLIFICATION IN PATIENTS TYPE 2 DIABETES MELLITUS

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Background: Brachial blood pressure (BP) may not reflect central BP due to systolic BP (SBP) amplification. Patients with type 2 diabetes mellitus (T2DM) elicit vascular irregularities that may affect SBP amplification or other central BP indices (including pulse pressure [PP], augmentation pressure [AP] and augmentation index [AIx]). By systematic review and meta-analysis, this study aimed to determine the magnitude and variation of central-to-brachial SBP and PP amplification, AIx and AP in T2DM compared to non-diabetic controls.

Methods: Online databases were searched for published studies reporting invasive or non-invasive central and brachial SBP in T2DM and non-diabetic controls. Random effects meta-analyses and meta-regression were used to analyse the studies.

Results: We identified 17 studies with a total of 2,711 T2DM and 10,460 non-diabetic controls. There was no significant difference in SBP amplification between groups (T2DM = 10.8, non-diabetic = 10.2 mmHg; pooled estimate = 0.6 mmHg, 95%CI −0.3, 1.5, p = 0.21), but large variation in both (T2DM range = 2.0−16.6 mmHg, non-diabetic range = 1.0-16.1 mmHg). In the meta-regression, duration of T2DM explained 16.3% of the variance in the pooled data (p = 0.15); the difference in amplification between groups increasing by 0.3 mmHg per year of T2DM. PP amplification was not significantly different between groups (p = 0.16). AP, AIx and AIx corrected for heart rate were significantly higher in T2DM (p < 0.05 all).

Conclusions: Patients with T2DM have increased AP and AIx, but no difference in SBP (or PP) amplification compared to non-diabetic individuals. However, SBP amplification is highly variable and increases with duration of T2DM; altogether confirming that central systolic loading cannot be reliably estimated from brachial BP in T2DM.

4.6

RELATIONSHIP OF CAROTID ARTERIAL FUNCTIONAL AND STRUCTURAL CHANGES TO LEFT ATRIAL VOLUME INUNTREATED HYPERTENSION

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The contribution of arterial functional and structural changes to left ventricular (LV) diastolic dysfunction has been the area of latest research. There are some studies on the relationship of arterial stiffness (a.s.) and left atrial (LA) remodeling as a marker of diastolic burden. Little is known on the association of arterial structural changes and LA remodeling in hypertension (H).

The aim of this study was to examine the relationship of carotid a.s. and intimamedia thickness (IMT) to LA volume in subjects with H.

The study included 245 previously untreated hypertensives (166 women and 79 men, mean age 53.7 ± 11.8 years). Each patient was subjected to echocardiography with measurement of LA volume, evaluation of left ventricular hypertrophy (LVH) and LV systolic/diastolic function indices, integrated assessment of carotid IMT and echotracking of a.s. and wave reflection parameters.

Results: The following parameters were identified as independent determinants of indexed LA volume on multivariate regression analysis: diastolic blood pressure (beta = −0.229, p < 0.001), left ventricular mass index (LVMI; beta = 0.258, p < 0.001), E/e' index (ratio of early mitral flow wave velocity - E to early diastolic mitral annular velocity-e'; beta = 0.266, p = 0.001), augmentation index (AI; beta = 0.143, p = 0.008) and bodymass index (BMI; beta = 0.132, p = 0.017). No correlations between indexed LA volume and IMT were found.

Conclusion: There is a significant relationship of carotid arterial stiffness but not intima-media thickness to LA volume in patients with untreated hypertension.

5.1

INERTIAL-VISCOELASTIC MINIMAL MODEL OF THE ARTERIAL SYSTEM RECONCILES ARTERIAL COMPLIANCE ESTIMATIONS

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Background: The arterial system is viscoelastic rather than purely elastic. There exist various methods to characterize the purely elastic nature of arterial compliance, each method yielding different values. The pulse pressure method (C_{PPM}), estimating compliance by matching the pulse pressure (PP) of a two-element Windkessel to measured PP, yields consistently lower values than the pressure decay time method (C_{dec}) and diastolic area method (C_{area}). An alternative inertial-viscoelastic model (IVEMM) that is viscoelastic and frequency-dependent rather than purely elastic and constant has been shown in dogs to reconcile the various compliance estimation methods. We assessed the presumed merits of IVEMM compliance estimates in a clinically diverse human sample.

Methods: Central pressure and flow were measured using carotid tonometry and phase-contrast MRI, respectively, in 226 subjects. Arterial compliance was estimated using (1) C_{ppm}; (2) C_{dec}; (3) C_{area}; (4) $C_{IVEMM}(j\omega)$.

Results: C_{ppm} was nearly perfectly correlated with C_{IVEMM} evaluated at frequency of heart rate (Pearson coefficient (ρ) = 0.99; slope (B) = 1.00; P < 0.001). C_{area} (ρ = 0.979; B = 0.928; P < 0.001) and C_{dec} (ρ = 0.974; B = 0.954; P < 0.001) were very strongly correlated with C_{IVEMM} evaluated at 0 hertz (static compliance).

Conclusion: C_{PPM} is fit to PP defined in systole, when fast-acting phenomena are likely to elicit viscoelasticity of the arterial system. Its consistently lower values compared to C_{dec} and C_{area} are clarified by IVEMM to be the result of estimating viscoelastic compliance at frequency of heart rate. C_{dec} and C_{area} are estimates of static compliance. Consistent with dog studies, IVEMM appears to reconcile the three popular compliance estimation techniques.

5.2

SOLUBLE RECEPTOR FOR ADVANCED GLYCATION END-PRODUCTS AND AORTIC STIFFNESS IN GENERAL POPULATION

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It has been suggested that accumulation of advanced glycation end-products (AGE) is involved in several pathophysiological processes in the vessel wall. Soluble isoform of receptor for AGE (sRAGE) acts as a decoy for capturing circulating AGE, prevents them from binding to the cell-surface receptor and protects against the RAGE-AGE axis-elicited processes. We hypothesized that low sRAGE levels might be associated with increased arterial stiffness.