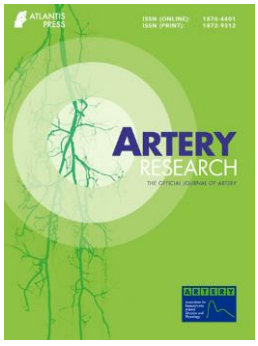

Artery Research

ISSN (Online): 1876-4401 **ISSN (Print): 1872-9312**
Journal Home Page: https://www.atlantis-press.com/journals/artres

P47: ABNORMAL FLOW PATTERN IN MARFAN PATIENTS IS RELATED TO AORTIC GEOMETRIC FEATURES: A 4D FLOW MRI STUDY

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To cite this article: Andrea Guala, Gisela Teixido-Tura, Jose Rodriguez-Palomares, Aroa Ruiz-Muñoz, David Garcia-Dorado, Artur Evangelista (2018) P47: ABNORMAL FLOW PATTERN IN MARFAN PATIENTS IS RELATED TO AORTIC GEOMETRIC FEATURES: A 4D FLOW MRI STUDY, Artery Research 24:C, 91–92, DOI: https://doi.org/10.1016/j.artres.2018.10.100

To link to this article: https://doi.org/10.1016/j.artres.2018.10.100

Published online: 7 December 2019

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Background: Masked hypertension (MH) is prevalent in young adults and is associated with similar vascular complications as sustained hypertension, but whether this is already evident in young adults is unclear. We therefore compared retinal vessel calibres and function in response to flicker light induced provocation (FLIP) in young healthy adults stratified by MH status and explored associations between these parameters.
Methods: We used data from the first 566 participants (aged 20—30 years) taking part in the African-PREDICT study. Participants were clinically normotensive (70% valid readings) were measured and MH status determined. The central retinal artery (CRAE) and vein equivalent (CRVE) were calculated from fundus images and retinal vessel dilation responses to FLIP determined.
Results: MH showed a prevalence of 16%. MHs' had a lower CRAE (155 $\pm$ 10 MU vs. 160 $\pm$ 12 MU, $p = 0.002$), but similar CRVE and vessel dilation in response to FLIP when compared to normotensives. The latter findings remained consistent upon adjustment for sex, ethnicity, age and body mass index. Multivariate regression analysis demonstrated an independent association between CRAE and the presence of MH ($R2 = 0.07$, $\beta = -0.10$ (-0.20; -0.01)). No further associations existed between retinal vessel parameters and MH status.
Conclusion: Already at a young age, healthy adults with MH show slight adverse changes in the retinal microvasculature. Considering the prevalence of MH in young adults, and the predictive value of reduced CRAE, our data emphasize the early identification of altered 24 hr blood pressure patterns.

P45
IMPEDANCE CARDIOGRAPHY EVALUATION IN ELDERLY HYPERTENSIVE PATIENTS

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Objectives: Vascular aging results from endothelial dysfunction and increased arterial stiffness, a independent determinant of cardiovascular (CV) events, that is amplified by the presence and progression of arterial hypertension (AH). Age related changes in hemodynamic variables1 may predict negative vascular outcomes.2 In this study, we evaluate hemodynamic variables in elderly hypertensive patients with impedance cardiography (IC) in order to infer opportunities for therapeutic optimization.
Methods: We retrospectively analysed hypertensive patients that were purposed for IC evaluation. The selected 75 patients were divided into two groups, above or below 65 years old, matched by anthropometric and blood pressure (BP) values. (Table 1) Antihypertensive therapy wasn't considered. For each group the mean of IC variables was obtained, and statistical analysis was performed by a T-student test.
Results: From the patients included, 25 have $\geq$65 years and 50 $<$65 years. In the elderly group mean age was 71 years, 52% were female and mean BMI 28,6 Kg/m^2. Mean BP was 142 mmHg *vs* 135 mmHg for systolic and 74 mmHg *vs* 83 mmHg for diastolic BP, heart rate 63 bpm *vs* 69 bpm in elderly and younger group respectively. Mean IC results showed statistically significance differences for cardiac output, cardiac index, systemic compliance, left ventricular ejection time, velocity index and acceleration index between the groups. (Table 2)
Conclusions: BP determination and control may not signify adequate hemodynamic state. With this study, elderly hypertensive patients present different hemodynamic behaviour, compared with younger ones, in variables of blood flow, resistance and contractility. These data could have potential implications on the pharmacological optimization of BP treatment.

Poster session I — Models, methodologies and imaging technology I
P46
ELONGATION OF THE PROXIMAL AORTA DURING THE CARDIAC CYCLE PLAYS AN IMPORTANT ROLE IN THE ESTIMATION OF AORTIC COMPLIANCE

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Background and Aims: Arterial volume compliance is a major determinant of cardiac afterload. More than 50% of the arterial volume compliance resides in the proximal aorta. Researchers often use area compliance for the estimation of volume compliance, assuming an invariant vessel length over pressure changes. Recent studies have provided evidence to question this simplification, showing that the extension of the proximal aorta along its long axis during systole produces significant longitudinal strain, which could lead to erroneous estimation of arterial stiffness. The aim of the present study was to test this hypothesis in a computational environment.
Methods: The 3-D proximal aortic geometry of a healthy young male was reconstructed and meshed and the original zero-pressure geometry was restored. Material behavior was approximated based on the model of (1). Viscoelastic support conditions were introduced along the aortic wall and aortic root motion, estimated from the cardiac-gated CT data of a healthy subject, was enforced at the proximal boundary. The simulation was run for an input pressure ranging from 80-110mmHg. Volume compliance of the vessel as obtained by integrating the area compliance over the centerline length (both variable and invariable) was subsequently compared to the ground truth (which was imposed by the material stiffness).
Results: Integration of the area compliance over an invariable centerline length led to an underestimated average distensibility by -68%. After taking into account the elongation, the error was improved to -25% (Figure 1).
Conclusion: The elongation of the aorta during cardiac cycle was found to affect significantly the estimation of arterial compliance.

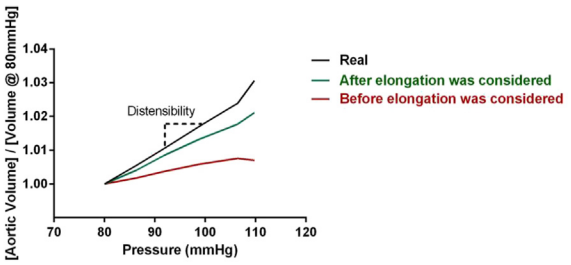

Figure 1. Relative volume, -normalized for the reference value at 80mmHg,- as a function of pressure during systole, calculated before and after considering the axial extension of the aorta.

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P47
ABNORMAL FLOW PATTERN IN MARFAN PATIENTS IS RELATED TO AORTIC GEOMETRIC FEATURES: A 4D FLOW MRI STUDY

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Introduction: Ascending aorta aneurysm and dissection are the most common cardiovascular complications affecting Marfan syndrome patients (MFS). Recent large increase in life expectancy of MFS driven the growing prevalence of descending aorta (DAo) dilation and dissection. Despite local abnormal vortices in the proximal Dao were related to local dilation, their origins have never been explored. We investigated the link between aortic geometrical characteristics and abnormal flow pattern in the thoracic aorta of MFS.
Methods: Fifty-tree MFS without significant aortic valve disease and forty age-matched healthy volunteers (HV) were prospectively included in 4D flow-MRI study, obtaining flow field and angiography. Spatial distribution of flow (in-plane rotational flow (IRF) and systolic flow reversal ratio (SFRR))

and geometric (diameter, ellipticity and curvature) parameters were investigated.
Results: Compared to HV, MFS presented larger aortic diameters only in the proximal AAo ($p < 0.001$) and DAo ($p = 0.028$). Increased ellipticity and a more distal location for the peak of aortic curvature were evident, even in the absence of dilation. Through most of the thoracic aorta, IRF was substantially lower in MFS, while SFRR was larger. Interestingly, non-dilated MFS had decreased IRF in the thoracic aorta compared to HV, although SFRR was not increased. Statistically-significant bivariate relations were found between arch IRF and arch ellipticity ($R = -0.34$) and proximal DAo peak curvature ($R = -0.35$). Local diameter was negatively correlated with local IRF ($R = -0.3$) and positively correlated to local SFRR ($R = 0.605$).
Conclusions: MFS presented altered ellipticity and curvature distribution, which are related to abnormal flow patterns even in the absence of dilation.

P48
COMPARISON BETWEEN INVASIVE AND NON-INVASIVE METHODS: TO EVALUATE AORTIC STIFFNESS BY PULSE WAVE VELOCITY

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Objective: To investigate if invasively measured aortic pulse wave velocity (PWV) is accurately estimated by non-invasive methods purporting to assess it.
Methods: One-hundred and two patients (30% female, age 65 ± 13 years) planned to undertake coronary angiography were evaluated with the following non-invasive devices: BPLab (Petr Telegin, Russia), Complior Analyse (Alam Medical, France), Mobil-O-Graph (IEM, Germany), pOpmètre (Axelife, France), PulsePen-ET, PulsePen-ETT (Diatecne, Italy) and SphygmoCor (AtCor, Australia). Aortic PWV was measured by aortic catheterization and simultaneous measurement of pressure waves above the aortic valve and at the aortic bifurcation (FS-Stiffcath, Flag Vascular, Italy).
Results: The devices evaluating carotid-femoral PWV showed a very strong agreement between each other ($r2 > 0.65$) and with invasive aortic PWV (mean difference ± SD with invasive PWV: -0.73 ± 2.83 m/s ($r2 = 0.41$) for Complior-Analyse; 0.20 ± 2.54 m/s ($r2 = 0.51$) for PulsePen-ETT; -0.04 ± 2.33 m/s ($r2 = 0.61$) for PulsePen-ET; -0.61 ± 2.57 m/s ($r2 = 0.49$) for SphygmoCor). The finger-toe PWV, evaluated by the pOpmètre, and the PWV measured by BPLab showed a weak relationship with invasive PWV (respectively $r\ 2 = 0.12$, 0.05), with carotid-femoral PWV measurements ($r\ 2 = 0.11$, 0.010) and with age ($r\ 2 = 0.10$, 0.06). PWV estimated with Mobil-O-Graph through a proprietary algorithm showed a good agreement with invasive PWV (mean difference ± SD = -1.01 ± 2.54 m/s; $r2 = 0.51$) and appeared to be strictly dependent on age-squared and peripheral systolic blood pressure ($r2 > 0.99$).
Conclusions: Methods estimating carotid-femoral PWV should be considered the only non-invasive approach to reliably assess aortic stiffness. Aortic PWV values estimated by Mobil-O-Graph algorithm are also significantly related to invasive PWV, but do not offer any additional information on top of what provided by age and systolic blood pressure levels.

P49
QUANTIFYING WAVE REFLECTION IN CHILDREN: INVASIVE VS NON-INVASIVE CENTRAL AUGMENTATION INDEX AND REFLECTION MAGNITUDE AND THEIR ASSOCIATION WITH LEFT VENTRICULAR MASS

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Objective: The aims of this study in children were to 1) evaluate two brachial oscillometric devices for estimating central augmentation index (AIx) and reflection magnitude (RM), and 2) test whether AIx or RM are associated with left ventricular mass index (LVMI).
Methods: Intra-aortic (IA) AIx was calculated from high-fidelity pressure measured with a Verrata wire (Philips Volcano) in 60 children (9.2 ± 4.7 years) with unobstructed aorta undergoing clinically-indicated catheterisation. AIx was also obtained from SphygmoCor XCEL (SC, AtCor) and/or Mobil-o-Graph (MB, IEM) brachial oscillometric devices. RM(IA) was calculated via wave separation using a representative normalised flow waveform obtained from MRI in a separate group of normal adolescents, RM(SC) via the triangulation method, and RM(MB) provided by the proprietary software. LVMI was estimated via echocardiography.
Results: Invasive vs non-invasive AIx and RM are compared in the Table. AIx(IA) correlated weakly with AIx(SC) ($R = 0.27$, $P = 0.04$) but not AIx(MB) ($P = 0.4$). Neither RM(SC) nor RM(MB) correlated with RM(IA) ($P = 0.13$ and $P = 0.96$ respectively). RM(IA) was moderately correlated with AIx(IA) ($R = 0.69$, $P < 0.001$) and weakly correlated with AIx(SC) ($R = 0.36$, $P = 0.007$) but not AIx(MB) ($P = 0.7$). In a multivariable regression, height ($P < 0.001$) and RM (IA) ($P = 0.04$) were independently and positively associated with LVMI (adjusted $R^2 = 0.24$), whereas there were no associations of any AIx or non-invasively estimated RM with LVMI.
Conclusion: Central AIx and RM were poorly estimated by SC and MB in children. Unlike RM(IA), none of the non-invasive indices of wave reflection correlated with LVMI, likely due to inadequate estimation of the central pressure waveform shape in this age group.

Table: Mean±SD (range) of augmentation index and reflection magnitude

	Invasive	SphygmoCor	Mobil-o-Graph
Augmentation Index	6.8 ± 8.3 (−17.4, 26.2)	41.0 ± 14.5* (2.5, 82.0)	23.5 ± 17.8* (0.9, 58.0)
Reflection Magnitude	0.34 ± 0.07 (0.22, 0.61)	0.56 ± 0.11* (0.32, 0.94)	0.65 ± 0.13* (0.05, 0.79)

* P < 0.001 compared with invasive

P50
VALIDATION OF ULTRASOUND DETERMINATION OF LOCAL PULSE WAVE VELOCITY IN THE HUMAN ASCENDING AORTA AGAINST MRI MEASUREMENTS

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[3]*Department of Bioengineering, Imperial College London, UK*

Background: Pulse Wave Velocity (PWV) is a measure of arterial stiffness which predicts cardiovascular risk independently of blood pressure. Local PWV can be measured non-invasively in the ascending aorta of adults by means of Ultrasound (US), using successive recordings of Diameter (D) and the velocity (U) [1].
Aim: To test US measurements of local PWV in the ascending aorta of human adults against MRI measurements of local PWV.
Methods: PWV in the ascending aorta of 8 healthy volunteers (age 22—34 y, 3 females) was measured using a Siemens MAGNETOM Aera 1.5T MRI scanner as per standard protocols with cine and phase contrast imaging (sampling frequency 100 samples/cardiac cycle) and D and U were calculated using validated software [2]. US images were recorded using GE Vivid E95 scanner with a 1.5—4.5 MHz phased array transducer. PLAX was used for diameter recordings and A5CH for velocity. Measurements were recorded for 20 s during a breath-hold. D and U waveforms were extracted from each imaging modality to calculate PWV using the ln(D)U-loops technique [3].
Results: Average results are summarised in Table 1. The mean difference in PWV between MRI and US was 2.8 ± 0.3%.
Conclusions: PWV measured by US shows excellent agreement with MRI in the ascending aorta of adults. Given US availability, this technique offers an easy, affordable and non-invasive means of determining PWV and mechanical properties of the ascending aorta; thus, providing a tool for screening studies.