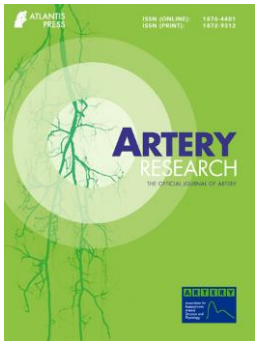

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9.10: STRUCTURAL AND FUNCTIONAL ARTERIAL ABNORMALITIES IN FIBROMUSCULAR DYSPLASIA ARE IN THE CONTINUUM OF HYPERTENSION: AN IMAGING AND BIOMECHANICAL STUDY

Louise Marais, Pierre Boutouyrie, Hakim Khettab, Chantal Boulanger, Aurelien Lorthioir, Mickael Franck, Ralph Niarra, Jean-Marie Renard, Yann Chambon, Xavier Jeunemaitre, Mustapha Zidi, Pierre-François Plouin, Stéphane Laurent, Michel Azizi

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9.7
THORACIC AORTA PWV ASSESSMENT BY USING 4D FLOW IN MRI

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Purpose: In MRI, thoracic aorta pulse wave velocity (TAPWV) is usually estimated by 2D phase contrast (PC) with either in plane or through plane velocity acquisition. Thanks to technological improvement, 4D PC with full coverage of the TA and 3 dimension velocity encoding thought time can be now achievable in 10min. Our aim was to compare estimation of TAPWV using 4DPC or 2DPC on healthy volunteer.
Methods: Acquisitions were performed on a 3 Tesla scanner (GEHC, 750w). 2DPC was done with through plane velocity encoding on an axial oblique slice perpendicular to ascending and descending TA. 4D acquisition covered the full TA volume from the aortic valve to diaphragm. Segmentation and velocity estimates were done by using cloud computing (Arterys). Optimal data view sharing was applied to obtain 8ms and 16ms temporal resolution for 2DPC and 4DPC, respectively. Flow data curves where further computed on homemade software (artfun) to assess PWV for both 2D and 4D acquisition.
Results: 31 healthy volunteers (13 male, age 50.9y ±18.6) were included. Correlation coefficient between 4DPC and 2DPC PWV was 0.69 ($p<0.001$) with small underestimation of 4D vs 2D (-0.17m/s limits of agreement [-3.85 ; 3.50]). A strong correlation with aging was obtained for both 4D and 2D PWV($r=0.75$ $p<0.001$ and $r=0.74$ $p<0.001$ respectively)
Conclusions: TAPWV can be accurately estimated by 4D flow MRI, since close relation with 2DPC and aging have been obtained. By using the same data set, TAPWV should be estimates in association to other stiffness and geometric parameters of the TA.

9.8
NEAR INFRARED SPECTROSCOPY (NIRS) CAN DETECT IMPROVEMENTS IN ARTERIAL FUNCTION FOLLOWING 6-MONTHS OF MARATHON TRAINING

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Background: Endurance training improves vascular function and skeletal muscle perfusion. NIRS can measure changes in oxygenated haemoglobin (oxy-Hb) in the skeletal muscle microvascular bed. Therefore, combined with arterial occlusion, NIRS has the potential to assess microvascular function within skeletal muscle. However, NIRS measurements are strongly influenced by adipose tissue thickness (ATT) at the measurement site.
Methods: Vascular function was tested in healthy individuals prior to marathon training oxy-Hb changes were measured by NIRS (Portamon, Artinis) during a 30-second arterial occlusion and the subsequent hyperemic response. ATT was assessed at the site of measurement using ultrasound (Vivid I, GE).
Participants underwent the same test after completing the marathon. Post-occlusive time-to-peak oxy-Hb response and Δoxy-Hb concentration were compared pre- and post-marathon and the effect of ATT on each parameter was assessed. Results are meanSD a paired t-test was used for comparison and β-coefficients used to compare the ATT relationships.
Results: 34 participants (18=male, 30±3 years old) completed vascular testing and ATT measurements. The Δoxy-Hb value was more strongly attenuated by ATT than time-to-peak oxy-Hb (β-coefficients: -0.58, $p<0.0001$ and -0.14, $p=0.45$, respectively). 27 participants (15=male, 313 years old) completed the marathon and underwent testing at both time points. Time-to-peak hyperemic response was significantly faster post-marathon (Δ1.95±4.07seconds, $p=0.01$) but there was no difference in Δoxy-Hb(0.83±6.23 μM, $p=0.5$).
Conclusions: Endurance training has a positive effect on reperfusion rates following short duration ischemia. Improvements can be detected using NIRS to measure oxy-Hb changes. Comparing the time-to-peak response overcomes some of the limitations of ATT on the NIRS measurements.

9.9
FLOW-MEDIATED SLOWING AS A NOVEL METHOD FOR THE NON-INVASIVE ASSESSMENT OF ENDOTHELIAL FUNCTION

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Background: Flow-mediated slowing (FMS) assesses the slowing of pulse wave velocity (PWV) in response to reactive hyperaemia, to provide a measure of endothelial function. We assessed the reproducibility of FMS and whether the technique is sensitive to the influence of age. FMS was compared to the commonly used, but technically demanding, alternative measure of endothelial function, flow-mediated dilatation (FMD).
Methods: PWV was measured using the Vicorder device, with cuffs placed around the upper arm and wrist. FMD was assessed in the contralateral arm. The reproducibility of FMS was assessed in 23 subjects on two separate occasions. FMS and FMD were also assessed concurrently in 23 younger subjects (mean age 22±2years, 11 males) and 13 older subjects (mean age 69±6years, 7 males), all of whom were normotensive and not taking vasoactive medication. Response to glyceryl trinitrate (GTN, 25 μg administered sublingually) was also assessed with both techniques.
Results: FMS was reproducible, with positive correlations between repeat visits ($r=0.56$, $P=0.003$). FMS and FMD did not correlate ($r=0.23$, $P=0.18$) whereas GTN mediated responses did ($rho=0.42$, $P=0.01$). Comparisons between younger and older groups demonstrated that FMS, FMD and GTN-mediated slowing were all significantly attenuated in older subjects ($P<0.01$ for all) but there was no age-related difference in GTN-mediated dilatation ($p=0.7$).
Conclusions: FMS is a reproducible technique that is sensitive to the influence of age, but does not correlate with FMD. The extent to which FMS represents endothelial function is worthy of further investigation.

9.10
STRUCTURAL AND FUNCTIONAL ARTERIAL ABNORMALITIES IN FIBROMUSCULAR DYSPLASIA ARE IN THE CONTINUUM OF HYPERTENSION: AN IMAGING AND BIOMECHANICAL STUDY

Louise Marais [2], Pierre Boutouyrie [2], Hakim Khettab [2], Chantal Boulanger [2], Aurelien Lorthioir [5], Mickael Franck [3], Ralph Niarra [3], Jean-Marie Renard [2], Yann Chambon [3], Xavier Jeunemaitre [4], Mustapha Zidi [1], Pierre-François Plouin [5], Stéphane Laurent [2], Michel Azizi [3]
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Fibromuscular dysplasia (FMD) is a non-atherosclerotic non-inflammatory arterial disease of unknown origin. We previously showed the presence of triple signal (TS) at ultrasound within common carotid artery (CCA) wall. We aimed at coupling TS presence with microconstituents of the vessel wall.
We included 50 patients with multifocal FMD, 50 essential hypertensive (HT) patients and 50 healthy subjects (HS) matched for age, sex, ethnicity and BP (HT and FMD). TS score from the right and left CCA were assessed from 15-MHz echotracking system coupled with aplanation tonometry. 14 microconstituents of the CCA, representing geometry, perivascular tethering, and wall material coefficients were derived from fitting of the pressure-diameter curve.
In multivariate analysis, age, hypercholesterolemia and IMT were significantly associated with TS, explaining 9.5% of its variance. TS was more frequent in FMD than HS (49% vs 16%, $p<0.01$), and HT (32%, $p=0.08$). When considering the whole population ($n=150$), several microconstituents appeared correlated with age and BP: particularly, residual stress was higher, and collagen fibers were stiffer with increasing age and BP ($p<0.01$). TS was positively associated with circular collagen mediated-stiffness ($p<0.01$), independently of age and BP.
We confirmed that FMD is associated with higher frequency of TS, but with overlap with matched HT and HS. The strong association between TS and

carotid remodeling, independently of age and BP, suggests that it corresponds to the muscular transition of an elastic artery [1]. The association of TS with circular collagen stiffness suggests that TS has subtle but measurable mechanical consequences.

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9.11
VASCULAR PHENOTYPING BY MEANS OF VERY HIGH-RESOLUTION ULTRASOUND IMAGING: A FEASIBILITY ANALYSIS

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Background: The study of medium and small-size arteries might be useful in the characterization of vascular adaptation, remodeling and wall ultrastructure modifications occurring with aging and in the presence of cardiovascular risk factors. However, to date, these districts have not been extensively explored non-invasively, due to limited spatial resolution power of standard ultrasound (US) machines.
Methods: High-frequency US examination by Vevo MD (FUJIFILM, VisualSonics, Toronto, Canada) was performed in 5 healthy volunteers (2 men, mean age: 26.4±3.3 years). Images were obtained at the carotid, brachial and radial artery level, using the 48 MHz (for carotid and brachial) and 70 MHz (for radial) US probes. Mean diameter, relative distension and intima-media thickness (IMT) were obtained using edge detection and contour tracking techniques. Texture analysis was performed on carotid, brachial and radial US images. Contrast, correlation, energy and homogeneity were evaluated from the grey-level co-occurrence matrix calculated on the pixels belonging to the IMT.
Results: IMT and relative distension, as well as texture analysis, could be successfully assessed in all the arterial districts evaluated. Correspondent results are reported in Table 1.
Conclusions: The multidistrict assessment of wall ultrastructure and mechanics in medium- and small-size arteries is highly feasible in healthy individuals. This kind of analysis might provide novel insight on the development of vascular alterations in previously neglected arterial districts, as well as their clinical significance.

	Carotid artery	Brachial Artery	Radial Artery
Mean Diameter (mm)	5.9±0.74	3.22±0.65	2.03±0.24
IMT (mm)	0.42±0.05	0.14±0.02	0.12±0.01
Relative distension (%)	10.6±1.8	4±1.7	7.4±2.5
Contrast	0.05±0.008	0.04±0.01	0.05±0.01
Correlation	0.99±0.001	0.99±0.003	0.99±0.001
Energy	0.19±0.05	0.33±0.17	0.23±0.07
Homogeneity	0.97±0.004	0.97±0.005	0.97±0.005

10.1
OPTIMAL AUTOMATED UNOBSERVED OFFICE BLOOD PRESSURE PROTOCOL: ONLY 6-MINUTES AND TWO READINGS MAY BE NEEDED

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Background: Automated office blood pressure (AutoBP) involving repeated, unobserved blood pressure (BP) readings during one clinic visit provides a practical alternative to daytime ambulatory blood pressure (ABP). However, the number of reading taken and measurement duration have varied across previously used AutoBP protocols. Therefore, the optimal AutoBP protocol taken in the least amount of time with the fewest BP readings is yet to be determined and was the aim of this study.
Methods: 117 patients (mean age 61.5±12.5 years) referred to a specialist BP clinic underwent AutoBP in a quiet room alone. Eight BP measurements were taken at 2-minute intervals immediately after sitting. The optimal AutoBP protocol with the highest concordance to daytime ABP was defined by smallest mean difference and highest intra-class correlation coefficient (ICC). The same BP device (Mobil-o-graph, IEM) was used for both AutoBP and daytime ABP.
Results: Average 15-minute AutoBP and daytime ABP were 138.4±18.1/84.8±12.2 mmHg and 140.9±15.2/86.2±10.6 mmHg, respectively. The AutoBP protocol with the highest concordance to daytime ABP was the average of two measures taken between two and six minutes of seated rest (systolic BP: mean difference = 0.3 (95%CI -3.0,2.4) mmHg, p=0.84; ICC=0.80; diastolic BP: mean difference = -0.42 (95%CI -2.0,1.1) mmHg, p=0.60; ICC=0.85). Daytime ABP tended to be overestimated by individual and the average of more than one AutoBP recorded before six minutes, however daytime ABP was underestimated after this time.
Conclusion: Only six minutes and two AutoBP readings may be needed to be comparable with daytime ABP.

10.2
EFFECTS OF INTER-ARM DIFFERENCES OF BRACHIAL SYSTOLIC BLOOD PRESSURE ON THE DERIVATION OF AORTIC SYSTOLIC PRESSURE

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Background: Inter-arm differences in brachial systolic blood pressure (SBP) should not theoretically translate to differences in calculated aortic SBP, there being only a single value of aortic blood pressure (BP) at any time.
Methods: This study assessed seated brachial and derived aortic SBP in 79 subjects (36±16 years, 40 male) using oscillometric brachial BP measurement and cuff volumetric displacement waveform recording. Measurements were taken simultaneously in left and right arm using identical SphygmoCor XCEL units (AtCor Medical, Sydney). Measurements were taken four times in each subject, swapping BP devices between arms.
Results: Brachial SBP was significantly higher in 11 subjects (average difference 5.4±0.7 mmHg) and in 18 subjects for aortic SBP (average difference 3.1±0.6 mmHg). Across all subjects, absolute inter-arm brachial difference in SBP, irrespective of direction, was 3.2±0.3 mmHg ($p<0.001$) and inter-arm aortic SBP difference 2.1±0.3 mmHg ($p<0.001$). Inter-arm SBP differences for brachial and aortic sites were correlated ($r^2=0.74$, $p<0.001$). Arm dominance accounted for 1.1±0.5 mmHg of inter-arm brachial SBP difference ($p=0.032$) but did not account for inter-arm aortic SBP difference ($p=0.163$). Average left arm SBP was not different to average right arm SBP for the whole cohort for brachial ($p=0.083$) or aortic ($p=0.789$) measurement.
Conclusions: The inter-arm absolute difference in brachial SBP translates to a significant but small (2.1 mmHg) difference in derived aortic SBP. Further studies are required to establish if this artefactual difference in derived aortic SBP is predominantly due to arm dominance or other factors associated with left/right difference in vascular properties.

10.3
USE OF MICROLIFE BP WATCH IS A FEASIBLE APPROACH TO DETERMINE INTER-ARM BLOOD PRESSURE DIFFERENCES IN A CLINICAL SETTING

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Aim: The aim of this study is to evaluate the feasibility of Microlife Watch BP for measuring bilateral blood pressure (BP) in a clinical setting.
Method: 339 patients (85% diabetic) scheduled for ambulatory blood pressure monitoring at the outpatient clinic for endocrinology, Silkeborg Regional Hospital, were examined with simultaneously bilateral BP measurements. A fully automatic, oscillometric device was used and two successive measurements were made.
Results: 9,1% of the patients had a clinically significant inter-arm blood pressure difference (IAD) of ≥10mmHg in the first set of measurements. Mean IAD in the first measurement was -0,3mmHg 6.6. Twenty-three patients had a normal IAD in the first set of measurements but IAD ≥10mmHg in the second set of measurements. Only one of the patients with an IAD ≥10mmHg had a change in the arm with the highest blood pressure. The