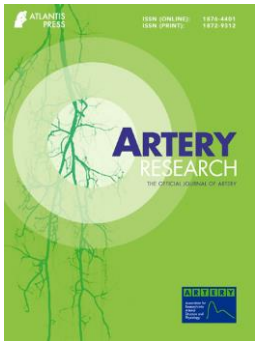

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P2.07: VALIDATION OF A NOVEL METHOD TO ASSESS ENDOTHELIAL FUNCTION

E.A. Ellins, K. New, S. Bundhoo, B.N. Datta, D.A. Rees, J.P. Halcox

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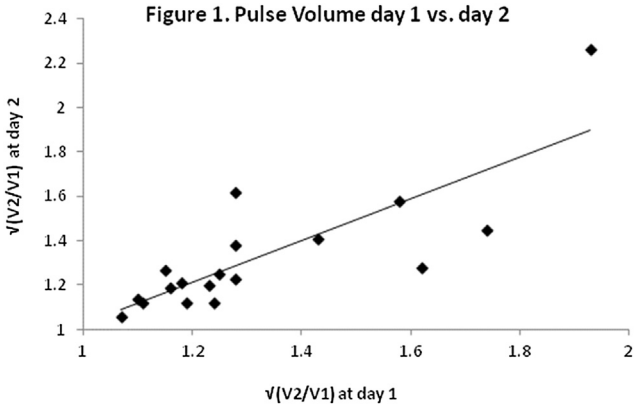
Results: Part 1: An average change in PV of 74±82% was detected in response to forearm ischaemia (P=0.003). Within-visit repeatability was acceptable, with a mean (±SD) difference in √V2/V1 of 0.03±0.25 (P=0.6), and a high correlation between studies (r=0.64; P=0.004). Between-visit reproducibility was high, with a mean difference of 0.004±0.17 (P=0.9) and a strong correlation between readings (r=0.81; P<0.0001; Figure 1). Part 2: There was a modest association (r=0.14, P=NS) between hyperaemic responses assessed using the different methods.
Conclusion: The Endocheck can reliably assess changes in brachial PV during hyperaemia. Further studies are required to determine whether the observed changes reflect endothelial function.



P2.05
CAROTID PULSE WAVE VELOCITY CAN BE MEASURED USING MAGNETIC RESONANCE IMAGING IN PATIENTS WITH CAROTID ARTERY DISEASE

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Objectives: Carotid artery stiffness has been suggested to alter local haemodynamic and arterial remodelling. It has also been shown to be associated with ischaemic stroke. The aim of this pilot study is to assess the feasibility of measuring carotid pulse wave velocity (cPWV) using magnetic resonance imaging (MRI) in patients with carotid stenosis.
Methods: Patients with stenosis (30-99%) at the carotid bifurcation on duplex ultrasonography were recruited. Non-segmented through-plane velocity was acquired perpendicular to the internal and common carotid arteries to maximise velocity acquisition. Flow images were analysed to convert signal intensity to velocity. The time delay between the pulse waves was determined by plotting the velocity-time curve. The distance travel by the pulse waves was measured on carotid artery time-of-flight images.
Results: 22 patients (14 men, mean age 73±8) with at least one carotid stenosis between 30% and 99% were assessed. Both the intra-class correlation for image acquisition reproducibility and flow data analysis were 0.99 (p<0.001). The median (range) cPWV was highest in 30-49% (7.56 m/s (range 4.49-10.64)) and 50-59% (6.47 m/s (range 4.71-19.74)) stenosis with mean path length of 46mm.
Conclusion: Carotid pulse wave velocity in patients with carotid artery stenosis is feasible to be measured using MRI. This method is highly reproducible with good intra-observer consistency. Further work is needed to explain the pathophysiology of cPWV in patients with mild and moderate carotid stenosis.

P2.06
A NOVEL INFLATION TEST TECHNIQUE AND OPTICAL FLOW ESTIMATION FOR IN VITRO DETERMINATION OF THE CROSS-SECTIONAL DEFORMATION OF ARTERY

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Objectives: Determination of the cross-sectional mechanical properties of artery is crucial for correlating regional arterial stiffness with the biological components such as collagen, elastin, and deposited calcium. While ultrasound imaging has been used to determine these properties from the arterial deformation, the accuracy of the measurements is limited due to non-direct imaging on the arterial cross-section. Therefore, we designed a novel inflation test technique allowing this direct imaging.
Methods: The test system provides internal pressures to an artery ring using a pump connected to a pressure transducer and a balloon tube (Figure 1). The cross-sectional deformation of the artery is captured using a camera. The images are then analysed using optical flow estimation which determines the deformations from pixel motions. This optical flow technique has been validated with images of a ring structure undergoing known deformations.
Results: This test system has been tested with pig aortas. The regional strains of an aortic ring sample are shown in Figure 2.
Conclusions: This inflation test design and the optical flow estimation allow *in vitro* determination of arterial regional strains at physiological pressures. A finite element model will be developed to correlate the deformations between the experiments and models to determine the regional mechanical properties of the artery. This approach will be used to investigate the associations of ageing-induced arterial stiffening with regional structural changes such as calcium deposition and elastin fragmentation, promoting the determination of target biological components for drugs.

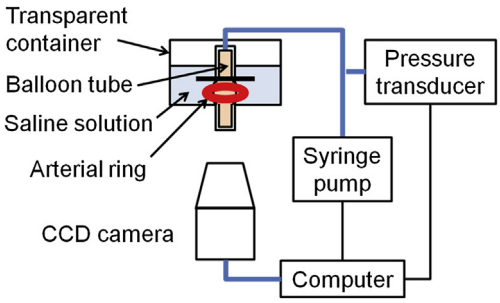

Figure 1 Inflation test system.

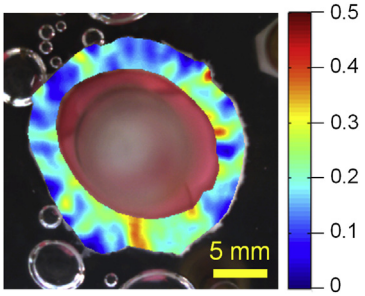

Figure 2 Calculated arterial strains.

P2.07
VALIDATION OF A NOVEL METHOD TO ASSESS ENDOTHELIAL FUNCTION

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Objectives: Assessment of pulse wave velocity (PWV) is normally used as a measure of arterial stiffness. However, measurement of change in PWV before and after a period of reactive hyperaemia may enable the technique to be harnessed as a measure of endothelial function as flow-mediated slowing (FMS). The aim of this study was to validate this approach as a novel method of endothelial function assessment.
Methods: FMS and flow-mediated dilatation (FMD) of the brachio-radial arterial tract was assessed in 25 young healthy subjects on two separate occasions to assess reproducibility. To assess the ability of the technique to investigate acute vascular dysfunction FMS and FMD was assessed before and after a 20-minute period of ischaemia-reperfusion (IR) in 15 healthy subjects. Finally, 12 Familial Hypercholesterolaemia patients undergoing lipoprotein apheresis had FMS assessed pre and post treatment.

Results: *Reproducibility* -Baseline PWV and FMS% showed good reproducibility (CV 3.3% & 7.2% respectively). There was no correlation between baseline brachial artery diameter and PWV visit 1 r=0.325 p=0.113 visit 2 r=0.335 p=0.192 or FMD and FMS visit 1 r= 0.27 p=0.192 visit 2 r=-0.425 p= 0.053. *Ischaemia Reperfusion* — There was a significant decrease in FMD following IR (-28.5% p=0.04). The trend to a reduction in FMS post-IR was not significant (-13.2% p=0.112). Following lipoprotein apheresis there was a 28.2% increase in FMS (from 18.8% to 24.1% p=0.006).
Conclusions: FMS is a reproducible technique. The ability of the method to detect changes in endothelial function shows considerable promise but requires further investigation.

P2.08
ESTIMATION OF LONGITUDINAL WALL MOVEMENT IN COMMON CAROTID ARTERY USING ROBUST BLOCK-MATCHING WITH AN EXTRA BLOCK

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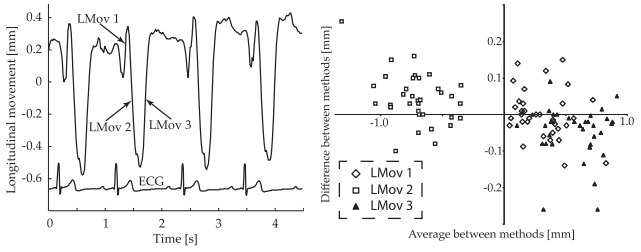
Technological developments made it possible to detect a longitudinal motion of the arterial wall. Our previously presented method can estimate this motion with high accuracy, but the method requires ultrasound images of very high quality. The aim of this study was to evaluate a novel method for estimating the longitudinal movement with respect to both robustness and accuracy.
The developed method uses ultrasound B-mode information to give a sub-pixel estimation of the movement of an area chosen in a cineloop. The method was evaluated in vivo on the right common carotid artery of healthy volunteers (2 measurements each on 10 males; age 27—57 years and 10 females; age 25—49 years).
Figure 1 shows the longitudinal arterial wall movement of one volunteer. Three phases of longitudinal wall movement can be detected; an antegrade movement (LMov1) in early systole, a following retrograde movement (LMov2), and a subsequent antegrade movement (LMov3). The magnitude of the three phases of movement was mean 312 μm (SD 197), -706 μm (222) and 577 μm (218), respectively. The intra-observer variation for the different phases of movement was 21%, 13%, and 17%, respectively, compared to 14%, 13%, and 16% using our previously presented method. Figure 2 shows a Bland-Altman plot comparing the two methods. While the new method could make estimations in all cineloops, our previously presented method failed in six of them.
The study shows that the new method seems to be more robust than our previously presented method with similar tracking accuracy.



P2.09
CHEMICAL FIXATION ALTERS THE MACRO- AND MICRO-STRUCTURE AND MECHANICAL BEHAVIOUR OF THE COMMON CAROTID ARTERY

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Background: Arterial stiffening is an important predictor of cardiovascular risk. In order to identify the pathogenic mechanisms it is necessary to characterise arterial micro-structure and —mechanical properties. Here, we test the hypothesis that chemical fixation (employed in microscopical preparation regimens) may adversely influence arterial structure and stiffness.
Methods: Common carotid arteries (CCA) from young male Wistar rats (225-250g, n=4) were excised. Gross stiffness was determined by wire myography for arterial segments untreated (CON), pre-treated by paraformaldehyde fixation (4%)(FIX) or snap frozen (FRZ). Cryo-sections 5μm thick were prepared from bisected fixed (FIX) or untreated (CON), frozen CCA. Acoustic wave speed (related to tissue elastic modulus) was then characterised by scanning acoustic microscopy (SAM) whilst vessel morphology was quantified from H&E stained sections.
Results: Fixation increased both medial layer thickness (CON 38±3, FIX 55±10 μm, $P<0.05$) and lamellar spacing (CON 11±4, FIX 15±6 μm, $P<0.05$) but had no effect on lumen diameter (CON 331±2, FIX 314±29 μm, $P>0.05$). Fixation significantly increased incremental elastic modulus whilst freezing alone had no effect (CON 0.86±0.15, FIX 1.39±0.10, FRZ 0.99±0.04μm, $P<0.05$). SAM demonstrated increased stiffness with fixation (CON 1697±21, FIX 1776±32 ms^{-1}, $P<0.05$) which was pronounced within the inter-lamellar regions (inter-lamellar CON 1629±9, FIX 1678±10 ms^{-1} $P<0.05$).
Conclusions: The chemical fixation steps commonly used in microscopical preparation regimens can induce localised changes in the structure and stiffness of arterial compartments. We suggest therefore that cryo-preservation, which preserves the gross-mechanical behaviour of the intact artery, may also maintain the micro-structural and micro-mechanical characteristics of the vessel.

P2.10
CUFF-BASED ASSESSMENT OF CAROTID-FEMORAL PULSE WAVE VELOCITY: COMPARISON WITH A WIDELY-USED TONOMETRIC METHOD

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Objective: To compare measurements of carotid-femoral pulse wave velocity (PWV) using two cuff-based devices (Vicorder and XCEL), with a widely-used tonometric method (SphygmoCor).
Methods: Comparative measurements of PWV were made using the SphygmoCor, XCEL and Vicorder devices in 91 individuals (mean±SD age 62±18 years; range 20-89 years). All path length and PWV measurements were made as per manufacturers' instructions, following at least 10min supine rest. Readings were made in triplicate with each device and the average values compared. The order in which devices were used was random. Since the Vicorder includes an optional algorithm to adjust for the influence of the additional femoral segment on measured PWV, both unadjusted (Vicorder) and adjusted (Vicorder_adj) values were analysed.
Results: PWV ranged from 4.47m/s-14.60m/s (SphygmoCor), 3.70m/s-14.03m/s (XCEL), 4.40m/s-14.20m/s (Vicorder) and 3.60m/s-16.63m/s (Vicorder_adj). The XCEL and Vicorder PWV values were significantly correlated with SphygmoCor values (Figure 1). PWV measured with the XCEL was significantly lower than SphygmoCor-derived PWV (mean±SD of difference 0.42m±1.74m/s, P=0.03), whereas Vicorder (-0.21±1.88m/s) and Vicorder_adj (0.07±2.21m/s) were not significantly different from SphygmoCor, albeit with somewhat higher SDs.
Conclusion: Cuff-based devices provide reasonable estimates of PWV when directly compared with a widely used tonometric method. Use of the correction algorithm in the Vicorder device resulted in a closer estimate of the average PWV as measured with SphygmoCor, but a greater spread of values around the mean.

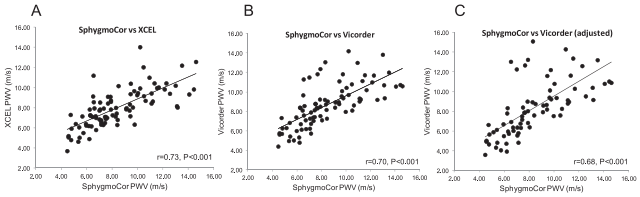

Figure 1 Correlation between SphygmoCor-derived PWV and XCEL (A), Vicorder (B) and Vicorder-adj (C) PWV values.