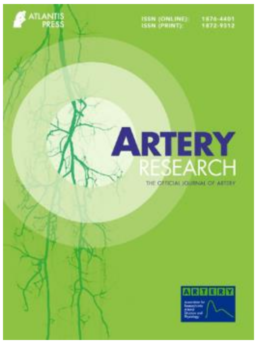

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P10.07: VERIFYING THE NEWTONIAN ASSUMPTION FOR BLOOD FLOW IN ANEURISMAL GROWTH MODELLING

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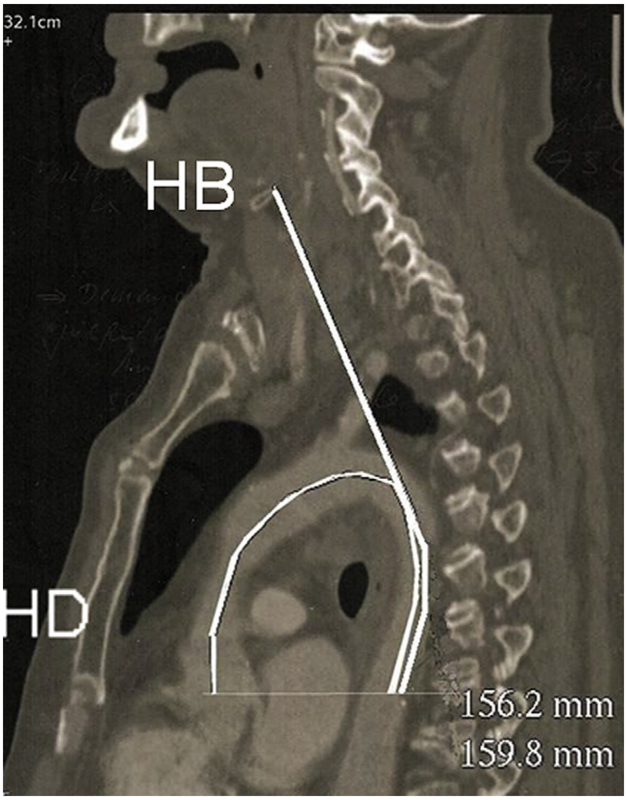
and crossing the descending aorta at mark HD (see figure), and 2) the distance between the HD mark to the Hyoid Bone (HB).



Results: There was a correlation between the AV-HD distance and the HD-HB distance (non parametric r = 0.66, p <0.0001) and the AV-HD distance were positively correlated to the height of the subjects (r = 0.60, p < 0.002).
Conclusions: 1- The AV-HD distance projects to a constant anatomical landmark (i.e. the hyoid bone) 2- The size of this arterial segment is significantly correlated to the height of the subjects. These preliminary results could be useful for a more accurate determination of the pulse wave velocity.

P10.06
IS THE BACKWARD REFLECTED WAVE DETRIMENTAL TO LEFT VENTRICLE PERFORMANCE?

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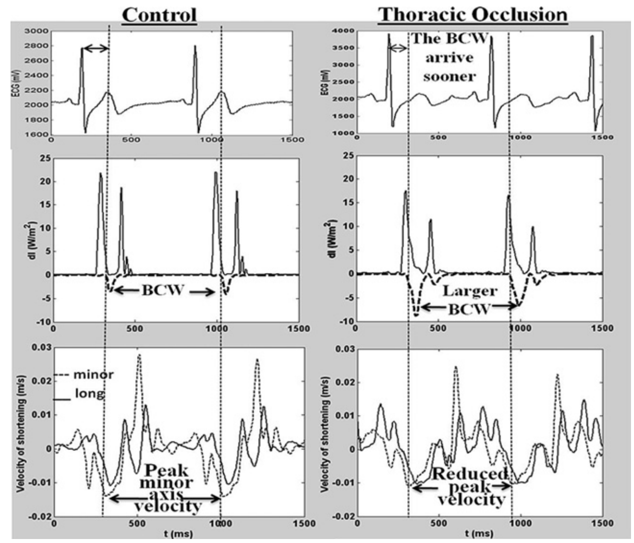
The effect of the backward reflected wave (BCW) on left ventricular (LV) performance is a highly debated area. The aim of this study was to establish whether the arrival of a BCW has a detrimental effect on LV axis shortening.
Methods: Invasively acquired ascending aortic velocity, pressure and LV long and minor axes dimensions were measured simultaneously in 11 open-chest anaesthetised dogs. LV axes dimensions were measured by sonomicrometry and differentiated with respect to time to identify maximum shortening velocity. Wave Intensity analysis was used to identify the arrival time of BCW. Data were acquired during control and during occlusion conditions of the proximal thoracic aorta, created using a snare. Statistical agreement was assessed using the concordance correlation coefficients (CCC).
Results: During control the BCW arrived back at the heart at the time of LV minor axis maximum velocity of shortening (difference 3±4ms, CCC=0.96). Aortic occlusion was associated with a large increase in the magnitude and earlier arrival of the BCW. LV minor axis' maximum velocity of shortening was attenuated by 20% and also occurred earlier, at the time of BCW arrival (mean difference 3±5ms, CCC=0.98). The LV long axis was less affected by arrival of BCW (Figure).
Conclusions: The arrival of BCW results in deceleration of the rate of shortening of the LV minor axis but does not cause deceleration of the long axis. The BCW appears to be detrimental to the canine LV minor axis function.



P10.07
VERIFYING THE NEWTONIAN ASSUMPTION FOR BLOOD FLOW IN ANEURISMAL GROWTH MODELLING

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A few number of studies have examined the effect of hemodynamic factors on the initiation and growth procedure of cerebral aneurysms. The Newtonian behaviour is assumed for blood flow in almost all of the mentioned investigations. Since the majority of intracranial aneurysms occur at bifurcations, to verify this assumption, we constructed a 3D model of the basilar artery bifurcation that includes the luminal hemodynamics and the arterial wall response within a computational fluid-structure interaction (FSI) framework. The arterial wall was assumed to be elastic and isotropic. The flow was considered steady, laminar, and incompressible. The blood flow was assumed to behave both Newtonian and no-Newtonian following Carreau model (Cho, YI, Kensey, KR, Biorheology, 28:241—262, 1991). The fully coupled fluid and structure models were solved with the finite elements package ADINA 8.5. The blood pressure and velocity and the wall shear stress (WSS), effective stress and deformation distributions were compared in two cases. The results show similar patterns except the WSS magnitudes which were under-estimated with the Newtonian assumption. This difference was evident in the low velocity regions like the apex of the bifurcation (about 20%) which is a probable position for the aneurysm formation. WSS is one of the critical hemodynamic factors affecting aneurismal initiation and development. Therefore, we believe that it is worth to consider the non-Newtonian behaviour of blood flow in order to investigate the detailed relationship between hemodynamic factors and vascular diseases, and it may affect the growth procedure of cerebral aneurysms.

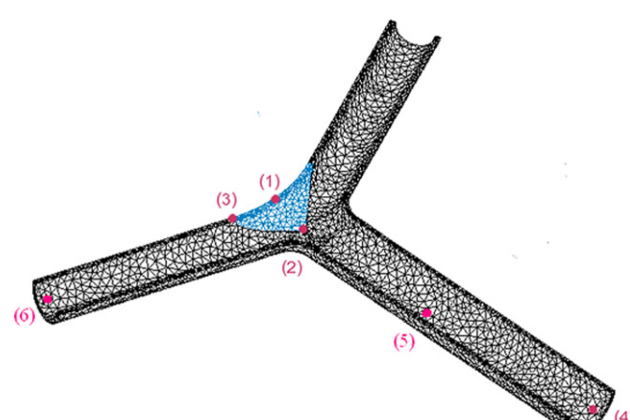

Figure 1 Position of characteristic points

Table 1 Comparison of the WSS and pressure magnitudes of the characteristic points between Newtonian and non-Newtonian simulations

Point Number	Newtonian		Non-Newtonian		% Difference	
	WSS [Pa]	Pressure [Pa]	WSS [Pa]	Pressure [Pa]	WSS	Pressure
1	0.688	15831.600	0.852	15832.500	19.284	0.006
2	2.980	15783.900	3.236	15784.600	7.911	0.004
3	5.670	15616.300	5.989	15616.600	5.325	0.002
5	4.403	15851.600	4.717	15852.500	6.639	0.006

P10.08

COMPARATIVE INVESTIGATION OF MECHANICAL CHARACTERISTICS OF STABLE AND UNSTABLE CAROTID ATHEROSCLEROTIC PLAQUES

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The prognosis of patients with carotid atherosclerosis is determined by the factor of unstable atherosclerotic plaque. Change of longitudinal strain in junction place of healthy artery wall to plaque determined by local artery elasticity and leads to instability.

Aim of the study: Comparative investigation of mechanical characteristics of the stable and unstable plaques in a carotid artery.

Methods: In the main group (MGr) were studied 16 plaques with stenosis 70-90%, and control group (CGr) 33 plaques with stenosis 25-45%. Carotid ultrasound examinations (PHILIPS iU22) were performed for estimated structure and stenosis of plaques. The "healthy" wall stiffness (free from plaques -βhw) and plaques zone stiffness (in adventitia -βadv and in plaques surface -βpl) were estimated using echo-tracking method by ALOKAα7 in B/M mode ultrasound imaging.

Results: In the MGr majority of plaques had structure with hypoechogenic area (>50%) and calcification, third plaques had rough or ulcerated surface. In CGr dominated heterogeneous plaques with smooth surface. In both groups βhw was significantly lower, than βadv (MGr: 8,95±3,14 vs 22,73±10,43, CGr: 9,43±2,64 vs 14,45±6,7, p<0,001), βadv was significantly higher than βpl (MGr: 22,73±10,43 vs 7,7±5,04; CGr: 14,45±6,7 vs 11,69±6,84, p<0,001). Relative changes of plaques zone stiffness (100-βpl×100/βadv) was significantly higher in the MGr (51,28±24,17% vs 26,93±21,45%, p=0,036).

Conclusions: Our results confirm presence the significant gradient of stiffness in junction place of healthy artery wall to plaque. In group with unstable plaques this gradient was significantly higher, that allows considering the possibility of the unstable plaques criteria developing by echo-tracking method.

P10.09

ANALYZE OF A STOCHASTIC ANISOTROPIC FIBROUS CONSTITUTIVE LAW EFFECT ON THE HUMAN ARTERIAL PRESSURE

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This research work deals with a stochastic approach using the entropy maximum principle to investigate the effect of parameters uncertainties on the arterial pressure. Motivated by a composite constitutive law with collagen fiber families [1], a set of uncertain parameters describing the mechanical behavior of the artery wall was considered. On the light of the available information, probability density functions were considered for the random variables governing the constitutive law in order to describe the dispersion of mechanical model response. Numerous realizations were performed according to the probability distributions and the corresponding arterial pressure results were compared to human non invasive clinical data recorded over a mean cardiac cycle. To prove the convergence of the probabilistic model, simulations of Monte Carlo were performed [2]. The different realizations were useful to define a reliable confidence region in which the probability to have a realization is equal to 95%. The obtained results demonstrate that the error in the estimation of the arterial pressure can reach 35% when the estimation of model parameters is subjected to an uncertainty ratio of 5%. Eventually, a sensitivity analysis was performed to discuss the influence of every uncertain parameter on the arterial pressure to identify the main parameters which contribute significantly in the constitutive law for a better understanding and characterization of the arterial wall mechanical behavior.

[1] I. Masson, P. Boutouyrie, S. Laurent, J.D. Humphrey, M. Zidi, *Characterization of arterial wall mechanical behavior and stresses from human clinical data*, Journal of Biomechanics 41, 2618-2627, 2008.
[2] A. Eddhahak-Ouni, I. Masson, E. Allaire, M. Zidi, *Stochastic approach to estimate the arterial pressure*, European Journal of Mechanics - A/Solids 28, 712-719, 2009.

P10.10

THE INFLUENCE OF ANTIHYPERTENSIVE TREATMENT ON ARTERIAL STIFFNESS AND SELECTED MATRIX METALLOPROTEINASES PLASMA ACTIVITY

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The aim of the study was to compare the effects of 5 selected drugs on arterial stiffness and matrix metalloproteinases (MMPs) plasma activity in patients with essential arterial hypertension (HT).Material and methods: 95 pts. with HT stage 1 and 2, (N=19 in each treatment group) were treated for 6 months by: quinapril 20-40 mg/d (group-1), amlodipine 5-10mg/d (group-2), hydrochlorothiazide 12,5-25mg/d (group-3), losartan 50-100 mg/d (group 4), bisoprolol 5-10 mg/d (group-5). Before and then after 1,3 and 6 months of treatment office blood pressure (BP) was measured using Omron M5-I device. Carotid femoral pulse wave velocity (PWV) was measured using 3 devices Complior®, Sphygmocor® and Arteriograph^{TM}. Plasma concentration of (MMPs): MMP1, MMP2, MMP3, MMP9 and MMPs tissue inhibitor (TIMP1) was measured twice i.e. before and after 6 months of treatment using micro- ELISA method. Results: At the baseline no differences between groups were observed in BP, PWV and MMPs activity. ANOVA for repeated measurements revealed for all groups during treatment significant decrease in systolic BP (p<0.001), diastolic BP (p<0.001), PWV (p<0.001), MMP2 (p<0.05) and MMP3 (p<0.001) and increase of TIMP1 (p<0.001) plasma concentration. No between treatment groups differences were observed in above mentioned effects. Decrease of PWV was in significant relation to its baseline value (B= 0.498, p= 0.00041), decrease of MMP3 (B=0.211, p=0.0021 and increase of of TIMP1 (B=0.263, p= 0.0052). Conclusion:Antihypertensive treatment reduces arterial stiffness proportionally to its baseline value and independently of the used drug. The reduction of arterial stiffness depends on decrease of extracellular matrix degradation.

P10.11

THE EFFECT OF WALL MOTION ON THE HAEMODYNAMICS OF MIDDLE CEREBRAL ARTERY (MCA) ANEURYSM

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External forces, accelerations and displacements, due to sudden motions of head or traumas, may affect the haemodynamics and flow patterns in a cerebral aneurysm. Despite several studies on blood flow dynamics and arterial wall mechanics in intracranial aneurysms, limited investigations considered the external forces or motion of the arterial wall. Therefore in this study, we have numerically analyzed the effects of wall movement on cerebral aneurysms with the fluid and structure interaction (FSI) theories. A 3Dimentional Model of Middle Cerebral Artery (MCA) aneurysm (geometry adopted from R. Torii et al., *Int. J. Numerical Methods in Fluids*, **54**:995—1009, 2007) was constructed and exposed to a realistic head motion in sagital plane. Blood was considered as a homogeneous, incompressible