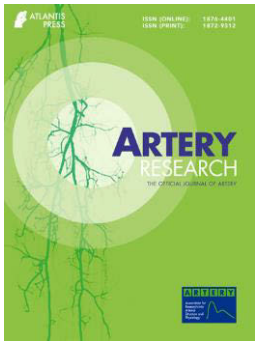

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P84: HIGH-FRAME RATE VECTOR FLOW IMAGING: RELATIONSHIP BETWEEN CAROTID BIFURCATION GEOMETRY AND FLOW PATTERNS

A. Alfredo Goddi, L. Luca Aiani, Y. Yigang Du, X. Xujin He, Y. Yingying Shen, L. Lei Zhu

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Results: 5 female SCAD patients and 9 healthy controls (C) were enrolled (age 45 ± 9 vs 45 ± 13years, $p = 0.95$; BMI 21 ± 3 vs $23 \pm$ kg/mq, $p = 0.22$; mean BP 77 ± 5 vs 85 ± 10 mmHg, $p = 0.053$). 2nd interface peak was reduced in the SCAD group (97 ± 29 130 ± 19, $p = 0.04$), whereas RMSE/mean was increased (1.89 ± 0.68 vs 0.97 ± 0.30, $p = 0.02$). Similar values were found for the 1st interface. IMT (0.165 ± 0.031 vs 0.125 ± 0.022mm, $p = 0.03$), but not AT (0.095 ± 0.020 vs 0.081 ± 0.020mm, $p = 0.20$) and IMAT (0.260 ± 0.049 vs 0.206 ± 0.030mm, $p = 0.053$), was significantly higher in SCAD.
Radial internal diameter and wall/lumen ratio were similar: conversely WCSA was increased in SCAD (1.69 ± 0.48 vs 1.07 ± 0.37mm^2, $p = 0.02$).
Conclusions: Radial arteries of SCAD patients were characterized by increased wall thickness. Furthermore, the 2nd echogenic layer exhibited loss of echogenicity and inhomogeneity, features similar to FMD patients.

P82
IMAGE-BASED CHARACTERIZATION OF PLAQUE LIPID CONCENTRATION CHANGES IN TIME AND THE ROLE OF STATIN THERAPY

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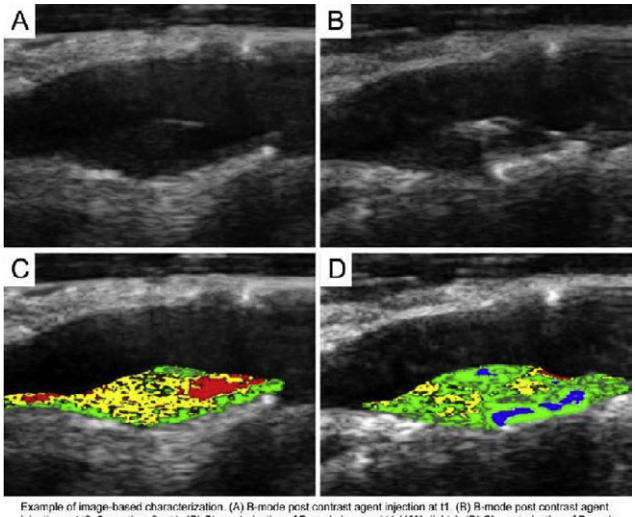
Introduction: Carotid artery atherosclerosis is an established risk factor for cerebrovascular events. Core lipid-rich plaques are considered at a higher risk of embolization compared to fibrous or calcified lesions. Contrast enhanced ultrasound (CEUS) is effective for studying carotid plaques, providing a virtual histology [1]. Here we assess the behavior of non-surgical carotid plaques in terms of lipid variation over time.
Methods: Eleven patients were enrolled (University of Turin) with a 50—69% (ECST) carotid asymptomatic stenosis. Seven patients were on statin therapy. All patients signed an informed consent and underwent standard carotid ultrasound (MyLab25 Gold, Esaote). A 1.5ml bolus of SonoVue (Bracco Spa) was injected; then a 5ml saline flush. Post-contrast Bmode images (180s after injection) were saved and analyzed offline. All patients repeated this protocol after 6 months.
The plaques were segmented, intensity normalized [2], and characterized according to a previous method [3].
Results: We evaluated small cohorts according to lipid concentration changes, identifying four categories. One patient had a plaque showing no lipid variation; four patients showed a slight decrease; four patients a remarkable decrease; two patients an increase.
Seven patients with a decrease in lipid concentration were on statin therapy, while both patients with an increase in lipids were not.



Example of image-based characterization. (A) B-mode post contrast agent injection at t1. (B) B-mode post contrast agent injections at t2, 6 months after t1. (C) Characterization of B-mode image at t1 (40% lipids). (D) Characterization of B-mode image at t2 (13% lipids). Red: blood; Yellow: lipids; Green: fibrous; Blue: Calcified; Black: non-classified.

Conclusions: A method for asymptomatic carotid plaque characterization using CEUS is presented. We focused on plaque lipid variations and the possible influence of statin therapy. We showed that carotid plaques are rarely stable, but rather continuously change composition over time and how statins could play an important role in this process.

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P83
A PILOT STUDY TO ASSESS PEAK SYSTOLIC VELOCITY AS A POSSIBLE MARKER OF ATHEROSCLEROTIC BURDEN USING ULTRASOUND

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Introduction: Ischemic heart disease (IHD) has been associated with lower peak systolic velocity (PSV) on penile Doppler measurements [1]. This study establishes whether carotid ultrasound (US) PSV was associated with computational fluid dynamics (CFD) outputs, which in turn may contribute to IHD pathogenesis.
Methods: A sample of 57 subjects (with IHD: 27, without IHD: 30) had US velocity profiles (left- common carotid artery) determined between 10—12 equispaced points. Bezier curve fitting was used to fit the profile through the measured velocity points for a normalised diameter. PSV was correlated against CFD results such as wall shear stress (WSS) [2]. Difference in PSV between individuals with/without IHD was studied via t-test. Linear regression was carried out to see if peak systolic velocity was associated with CFD outputs. Any significant associations were analysed within stratified groups (with/without IHD).
Results: PSV was significantly lower ($p = 0.042$) in subjects with IHD (with IHD: 53.6 ± 17.3 cm/s, without IHD: 62.8 ± 16.1 cm/s). PSV was associated with carotid bulb average pressure drop ($p < 0.001$), area of average bulb WSS (<1 Pa: $p = 0.016$, <2 Pa: $p = 0.006$, <3 Pa: $p = 0.001$). All the above associations remained significant in individuals with IHD (average bulb pressure drop: $p = 0.001$, average bulb WSS (<1 Pa: $p = 0.013$, <2 Pa: $p = 0.008$, <3 Pa: $p = 0.003$). In subjects without IHD, PSV was associated with only average bulb pressure drop ($p = 0.016$).
Conclusions: This study suggests that further work on PSV and its associations with CFD outputs is required in individuals with and without IHD in various vascular beds.

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P84
HIGH-FRAME RATE VECTOR FLOW IMAGING: RELATIONSHIP BETWEEN CAROTID BIFURCATION GEOMETRY AND FLOW PATTERNS

A. Alfredo Goddi [1], L. Luca Aiani [1], Y. Yigang Du [2], X. Xujin He [2], Y. Yingying Shen [2], L. Lei Zhu [2]
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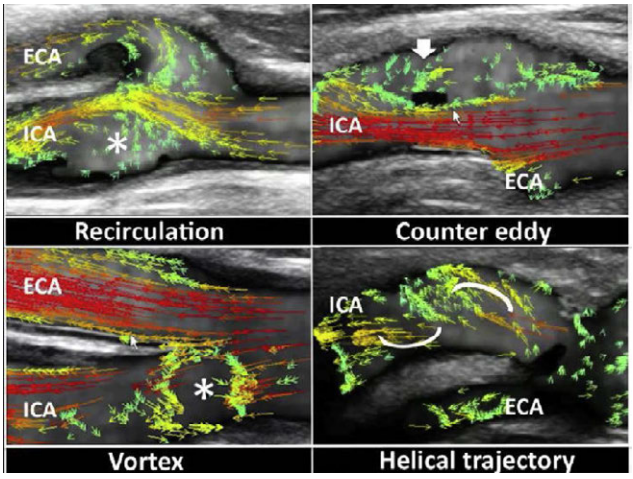
Background: The laminar flow movement in straight arteries is affected by anatomical factors such as bifurcation, lumen diameter changes or plaques.

As a consequence of the local deceleration, the detachment of the boundary layer from the wall develops a disturbed flow, which impacts hemodynamics. It results in a non-uniform distribution of wall shear stress (WSS), which is responsible for atherosclerosis [1]. This phenomenon usually occurs in the carotid bifurcation (CB). Computational methods, MRI and conventional Doppler techniques have been used to establish the correlations between flow disturbance and plaque formation. We propose the use of a new method, called high-frame rate Vector Flow imaging (VFI), which dynamically visualises blood flow velocities in all directions, in the evaluation of the flow characteristics in the CB [2,3,4,5].

Methods: CB geometries and flow patterns in 30 healthy subjects of different age were evaluated using a commercial system equipped with high-frame rate VFI based on a frame rate of 600 Hz. The flow is represented by many coloured vectors, displayed as arrows, showing the different velocity, magnitude and direction at each site.

Results: The correlation between flow disturbances and carotid sinus diameter was confirmed: the more relevant the diameter, the more disturbed the flow. Different CB geometries, affecting the flow behaviours and generating complex flow, such as recirculation, counter eddy, vortex and helical trajectory, were identified (Fig 1).



Conclusions: High-frame rate VFI shows in detail the spatiotemporal characteristics of the flow and demonstrates the strong effect of vessel geometries on the flow patterns.

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P85

HIGH FRAME RATE DYNAMIC DISPLAY ULTRASOUND VECTOR FLOW IMAGING FOR QUANTITATIVE STUDIES OF HEMODYNAMICS OF CAROTID ARTERIES

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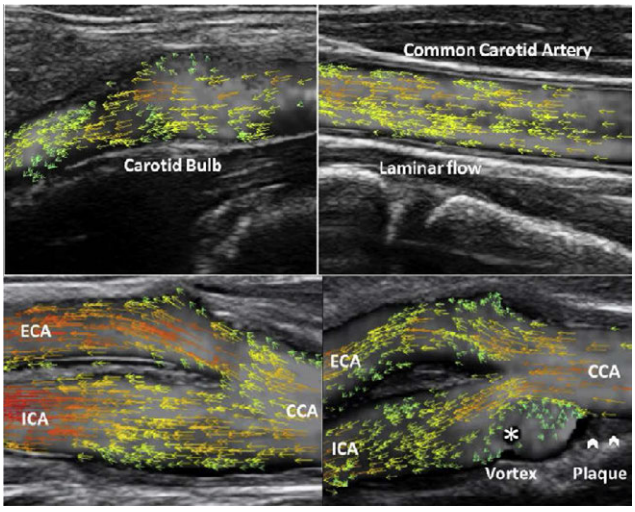
Advanced atherosclerotic patients are faced with significant risks of stroke, which are very likely to cause death or irreversible physical disability. However, the growth of artery stenosis usually needs a very long development. Early diagnosis is necessary and requires detailed and accurate quantitative hemodynamics to be supported. The paper proposes an angle-independent ultrasound flow imaging technique for carotid arteries, which allows true velocity vectors measurement, obtaining both value and direction of blood flow.

The proposed vector flow imaging is implemented based on multi-directional Doppler interleaved transmission [1,2], with high frame rate dynamic display [1] and zone sonography technology [3].

Hemodynamics becomes extremely complicated when plaques develop in the carotid bulb. The dynamic display with velocity vectors assesses flow patterns, e.g. laminar flow, vortex and turbulence (Examples are shown in the figure). The circular variance for the angles of vectors in a desired region of interest can be calculated, allowing disturbance quantification for the non-laminar flow. The method is capable of measuring volume flow (VF) and wall shear stress (WSS) at different locations. To ensure the accuracy both VF and WSS are calculated based on a frame rate of 400—600 Hz and vector velocities.



The high frame rate vector flow imaging has been implemented in a commercial ultrasound system. It provides various quantitative results such as circular variance, VF and WSS, which are useful for hemodynamics studies of complex flow. This could make the early prevention and diagnosis of carotid disease possible.

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Poster Session 1 — Models and Methodologies I

P120

A MODEL-BASED STUDY ON THE EVOLUTION OF BLOOD PRESSURE DURING AGEING

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Background: Hypertension being a major risk factor of cardiovascular mortality, there is a pressing need to understand the ageing mechanisms that lead to the continuous increase of pulse pressure and systolic blood pressure over time. Alterations in both forward and backward waves with age have been widely recognized as key features affecting the development of