Lesions in the SFA characterized with velocity ratios using Vector Flow Imaging

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I have the following potential conflicts of interest to report:

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Stocks: Le Maitre
Doppler - Angle-Dependent flow imaging

Fails to estimate flow at 90°

\[ v = \frac{v_z}{\cos(\theta)} \]

\[ \cos(90°) = 0 \]
VFI vs. Doppler

90° beam to flow angle

Color and spectral Doppler can be used to localize and assess the severity of possible stenoses by estimating the blood flow velocity.
Transverse Oscillation
Dual angle technique with focused pulse emissions

VFI provides simultaneously the axial and transverse velocity components of the blood flow. A conventional ultrasound pulse for flow estimation is transmitted, and the received echoes are beamformed to yield three beams in parallel.

*One uses conventional beamforming* for estimating the axial velocity, and the other *two beams* are used *for estimating the transverse velocity component*.

By combining the velocity components along the two axes, 2-D vector velocities are obtained.

Transverse Oscillation

- Angle independent velocity estimation
- No assumptions of flow angle
- Estimation of flow at 90°
- Visualization of complex flow patterns

Vector velocity ultrasound is angle independent and provides flow information that may potentially improve the diagnosis of stenoses.
Aim
Evaluation of VFI for SFA

• To investigate VFI and Velocity ratios in SFA occlusive disease

• The stenosis degree was determined from DSA and compared to the velocity ratios
VFI derived velocity ratios:
Peak velocities within the stenosis and in adjacent normal vessel segment

DSA derived lumen ratios:
Lumen in the stenosis and in adjacent normal vessel segment

Hansen PM, First Clinical Investigations of New Ultrasound Techniques in Three Patient Groups: Patients with Liver Tumors, Arteriovenous Fistulas, and Arteriosclerotic Femoral Arteries. DTU 2015
Non-linear correlation VFI vs. DSA

\[ r^2 = 0.52 \]

Hansen PM, First Clinical Investigations of New Ultrasound Techniques in Three Patient Groups: Patients with Liver Tumors, Arteriovenous Fistulas, and Arteriosclerotic Femoral Arteries. DTU 2015
16 stenotic SFA

Non-linear correlation VFI vs. DSA

$r^2 = 0.52$  
Velocity ratio

Linear correlation VFI vs. DSA

$r^2 = 0.87$  
Velocity concentration
A 15 sec record was made. The recording contained flow both in the lesion and proximal/distal to the lesion. Disturbed flow was defined as vortices, flow in multiple directions and/or suddenly occurring aliasing indicating increasing flow velocities.

VFI provides 2-D images of the blood flow, where each pixel contains quantitative information about direction and velocity with superimposed vector arrows to facilitate flow visualization.
The VFI recordings...

- ....were analyzed off-line with in-house made MATLAB-scripts (MathWorks, Natick, MA, USA) with a point-and-click interface providing the velocity and direction for each pixel.
Dias 14
Vector Flow Imaging

• Measure laminar flow at any angle up to complex flow
• Improve measures already available by conventional Doppler ultrasound,
• Velocity & volume flow estimation

- Less operator dependent
- No angle dependency
- New insonation windows
- More data for flow estimations

Systolic secondary flow in the ascending aorta
Vector Flow Imaging

- Measure laminar flow at any angle up to complex flow
- Offers new parameters for flow characterization
- using angle independent vector velocities

- Flow complexity
- Vorticity
- Shear stress
- Pressures

Systolic secondary flow in the ascending aorta