Accuracy and Precision of a Plane Wave Vector Flow Imaging Method in the Healthy Carotid Artery - DTU Orbit (02/08/2019)

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The objective of the study described here was to investigate the accuracy and precision of a plane wave 2-D vector flow imaging (VFI) method in laminar and complex blood flow conditions in the healthy carotid artery. The approach was to study (i) the accuracy for complex flow by comparing the velocity field from a computational fluid dynamics (CFD) simulation to VFI estimates obtained from the scan of an anthropomorphic flow phantom and from an in vivo scan; (ii) the accuracy for laminar unidirectional flow in vivo by comparing peak systolic velocities from VFI with magnetic resonance angiography (MRA); (iii) the precision of VFI estimation in vivo at several evaluation points in the vessels. The carotid artery at the bifurcation was scanned using both fast plane wave ultrasound and MRA in 10 healthy volunteers. The MRA geometry acquired from one of the volunteers was used to fabricate an anthropomorphic flow phantom, which was also scanned using the fast plane wave sequence. The same geometry was used in a CFD simulation to calculate the velocity field. Results indicated that similar flow patterns and vortices were estimated with CFD and VFI in the phantom for the carotid bifurcation. The root-mean-square difference between CFD and VFI was within 0.12 m/s for velocity estimates in the common carotid artery and the internal branch. The root-mean-square difference was 0.17 m/s in the external branch. For the 10 volunteers, the mean difference between VFI and MRA was -0.17 m/s for peak systolic velocities of laminar flow in vivo. The precision in vivo was calculated as the mean standard deviation (SD) of estimates aligned to the heart cycle and was highest in the center of the common carotid artery (SD=3.6% for velocity magnitudes and 4.5° for angles) and lowest in the external branch and for vortices (SD=10.2% for velocity magnitudes and 39° for angles). The results indicate that plane wave VFI measures flow precisely and that estimates are in good agreement with a CFD simulation and MRA.

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