# Total-body moving-bed cine phase-contrast MR angiography

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**Introduction:** Moving-bed, multi-station, total-body imaging methods have been recently introduced by various groups to provide head-to-toe images for tumor or metastasis screening[1] or for vascular assessment using a contrast agent[2,3]. These techniques have in common that only static *anatomical* information is obtained. To our best knowledge, no *functional* assessment has yet been performed for total-body applications. In this work, we propose a new method that provides functional flow information from the total body by thick-slab cine PCA.

**Methods:** Cine PCA was combined with moving bed imaging using 5 stations (head, thorax, abdomen, upper legs and lower legs). For each station, 2D thick-slab cine PCA with flow sensitivity in 3 directions was applied and complex-difference speed-images in 6 heartphases were acquired and reconstructed. Scan protocol: 2D water-selective segmented gradient-echo TFE-PCA, FOV 400 mm, matrix 160 (256 recon), resolution 2.5 x 2.5 x 140 mm, Venc=50-100 cm/s (3 directions), TR/TE/flip=20ms/6ms/15$^{o}$, retrospective triggering with 6 heartphases, scan time 41 seconds/station. Vector-cardiogram or finger-pulse triggering was used. The system body coil was used for signal reception. In the thorax station a free-breathing acquisition was performed using navigator triggering. All five stations were programmed with automated table motion into a complete procedure (ExamCard) and implemented on a clinical 1.5T MR system (Achieva, Philips Medical Systems, Best, NL). Total imaging time was approximately 5 minutes, including table movement and reconstruction. For evaluation, the resulting images were merged together to provide head-to-toe cine images.
The technique was evaluated in 12 volunteers (age 24 – 57, average 37 years). In each subject, the enhancement of the major arteries and veins (carotid arteries, sagittal sinus, aortic arch, vena cava, descending aorta, renal arteries, iliac arteries, femoral arteries, popliteal/tibial arteries) was measured by drawing an ROI in each vessel. Parameters such as pulsatility and time to maximum enhancement were derived. Cine movies with the speed images were created for each subject to evaluate the difference in enhancement of the respective blood vessels.

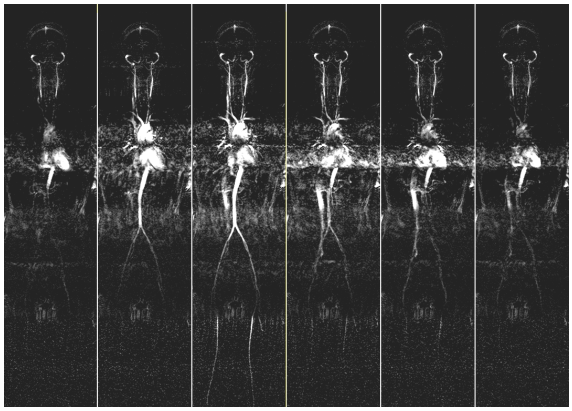

**Fig. 1**: Example of a total-body PCA, complex difference reconstruction showing enhancement of the major arteries and veins as a function of the cardiac cycle.

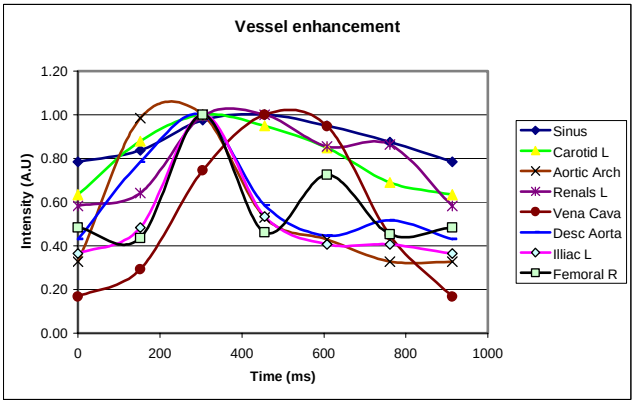


**Fig. 2**: Subject #4: Typical example of vessel enhancement as a function of time (cardiac cycle) in major arteries and veins of the total body.

**Results:** All scans were performed successfully and total body PCA speed images were obtained for each subject as a function of the cardiac cycle (see Fig.1). A typical example of the enhancement curves is shown in Fig.2 (normalized, subject #4). In most subjects, the order of enhancement was: aortic arch ($t_{enh}$ ~ 0.16 – 0.27 $t_{cardiac\_cycle}$), descending aorta, carotid arteries, iliac arteries. Renal arteries enhanced later ($t_{enh}$ ~ 0.38 – 0.55 $t_{cardiac\_cycle}$), finally the vena cava ($t_{enh}$ ~ 0.49 – 0.71 $t_{cardiac\_cycle}$). The highest pulsatility was observed in the aortic arch (mono-phasic) and femoral arteries (triphasic).The sagittal sinus had the most constant flow of all observed vessels.

**Discussion and conclusions:** We have presented a new method that allows functional assessment of flow in the total body in approximately 5 minutes scan time. The acquired data allow pulse-waveform analysis of the major arteries and veins and provide important information such as flow enhancement, pulsatility, and the time of maximum flow relative to other vessels. The technique is promising to quickly and non-invasively provide information about vascular functioning such as the propagation of flow waves and the lack of pulsatility or flow.

**References**: [1] Eustace et al. JMRI 1998;8:751-753, [2] Leiner et al, ISMRM 1999,#1226, [3] Goyen et al, Radiol. 2002;224:270-278