Cardiovascular Whole-Body MRI with Parallel Acquisition Techniques (PAT) and Matrix-Coils at 3 Tesla: Comparison to 1.5 Tesla

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Introduction: Within the last few years it could be shown, that whole-body cardiovascular MRI is feasible without compromises in image quality compared to organ based MR exams [1]. Latest developments in MR hardware established the possibility to combine parallel acquisition techniques (PAT), matrix-coils and high field strength. The aim of our work was to evaluate the possibility of cardiovascular whole body MR imaging on a 3T whole body MR system while further increasing image quality.

Material & Methods: An existing and clinically approved cardiovascular MRI protocol including comprehensive cardiac imaging and whole-body-MR-angiography (WB-MRA) was implemented on a 3T 32-channel whole-body MR system (Trio, Siemens Medical Solutions, Erlangen, Germany). 35 individuals (53±7y, all male) participating in a healthcare program were examined between July and October 2005. All of them were referred by their companies medical officer and underwent yearly conventional routine exams like ECG, Doppler Ultrasound of the carotid arteries, ultrasound of the abdomen, chest x-ray etc. The combination of a matrix-coil system and high filed strength allowd to perform functional cardiac imaging of up to 11 short axis slices with a PAT acceleration factor of 4 and a temporal resolution of 48ms in only one breathhold [2]. Perfusion imaging in 4 representative slices of the left ventricular myocardium was performed with a PAT factor of 4 in only one breathhold as well. To complete the cardiac examination delayed contrast enhancement imaging was done 13 – 17 min after the last CA injection. WB-MRA was performed within 4 steps from the head down to the lower extremity in 85 seconds (**figure 1**). A special MRA protocol was used to exclude venous overlay. In this protocol first the carotid vessels and the lower extremity are imaged and then, in a second step, the abdominal- and thigh vessels. Spatial resolution of WB-MRA was reduced to <1.4x1.1x1.2mm^3 in all steps (**table 1**). In addition to high spatial resolution MRA dynamic MRA of the calves with an acceleration factor of 3, spatial resolution of 1.4x1.4x1.5mm^3 and temporal resolution of 3.7sec/frame was performed (**figure 2**). To complete the whole-body examination TOF MRA of the brain, T1 and T2 weighted, pre- and post-contrast imaging of brain, thorax and abdomen was performed with PAT. To evaluate image quality, MRA was divided into 26 vessel segments and judged by two blinded readers in terms of vessel conspicuity, artifacts and venous overlay on a three point scale. Results were compared to these from 1.5T WB-MRA. Inter-reader-agreement was calculated by the kappa statistics. Findings of conventional exams and the MRI exam were compared on a case-by-case level.

Results: Image quality could be improved and acquisition time reduced. Comprehensive cardiac imaging could be performed within 3 breathholds without any restrictions compared to cardiac based exams. MRA image quality increased compared to 1.5T exams, 88.46% of all vessel segments showed good vessel conspicuity, 89.86% showed no artifacts, in 93.71% no venous overlay occurred. Inter-reader-agreement was excellent with kappa values between 0.84 and 0.95 (**table 2**). In the small population of 35 individuals we detected 4 vascular pathologies, e.g. peripheral high grade stenosis and 50% renal artery stenosis. One previously unknown myocardial infarction as well as one kidney lesion suspicious for malignancy were additionally detected.

Conclusion: The recent technical improvements in MR hardware and cardiovascular imaging techniques enable a combination of different morphologic and functional techniques at 3T. A matrix coil system together with PAT offer the chance of whole-body disease specific imaging instead of organ based imaging. Due to the use of multi-element coils and higher acceleration factors for parallel imaging, image quality is in the same range as in single organ based exams.

region	PAT factor	acq. time	spatial resolution
carotids	3	00:20	1.0x1.0x1.0
abdomen	3	00:18	1.4x1.1x1.2
thigh	2	00:21	1.1x1.1x1.1
lower leg	2	00:26	1.0x1.0x1.0

Table 1: MRA parameters including PAT acceleration factor, acquisition time and spatial resolution

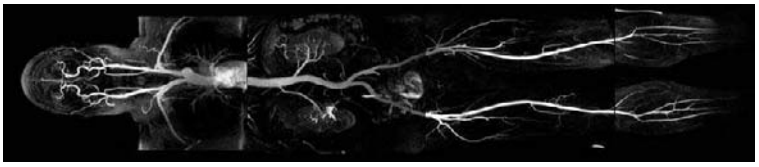

Figure 1: WB-MRA in 4 steps from head down to the lower extremity. All steps at a spatial resolution less than 1.4x.1.1x1.2mm^3 within 85 seconds.

1.5T

vessel conspicuity			artefacts			venous overlay		
	%	absolute		%	absolute		%	absolute
good	80.6	1624	none	92.9	1873	none	95.6	1928
moderate	15.3	309	mild	4.4	89	mild	4.4	88
poor	4.1	83	major	2.7	54	major	0	0
KAPPA		0.745	KAPPA		0.697	KAPPA		0.881

3T

vessel conspicuity			artefacts			venous overlay		
	%	absolute		%	absolute		%	absolute
good	88.46	759	none	89.86	771	none	93.71	804
moderate	11.54	99	mild	9.97	85	mild	6.29	54
poor	0	0	major	1.17	2	major	0	0
KAPPA		0.89	KAPPA		0.84	KAPPA		0.95

Table 2: Comparison of WB-MRA at 1.5T and 3T in terms of vessel conspicuity, artefacts and venous overlay. 3T MRA shows better conspicuity because of the signal increase at high field strength

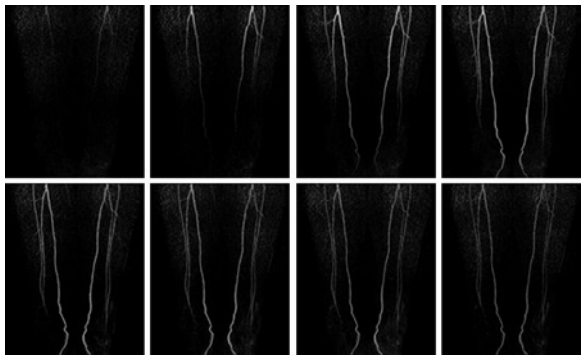

Figure 2: Time resolved echo shared angiography technique (TREAT) of the lower extremity with a spatial resolution of 1.4x1.4x1.5mm^3, a temporal resolution of 3,7sec, acquired in 1:14min

1. Kramer, H., et al., *Cardiovascular screening with parallel imaging techniques and a whole-body MR imager.* Radiology, 2005. 236(1): p. 300-10.
2. Wintersperger, B.J., et al., *Single breath-hold real-time cine MR imaging: improved temporal resolution using generalized autocalibrating partially parallel acquisition (GRAPPA) algorithm.* Eur Radiol, 2003. 13(8): p. 1931-6.