Inter- and intra-observer variability in whole-body contrast-enhanced MRA cardiovascular analysis

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Introduction and Aims: Contrast-enhanced whole-body MRA (CE WB-MRA) enables high resolution imaging of the complete arterial tree excluding the coronary vessels, enabling characterization of cardiovascular disease in both local vascular and systemic contexts. Through contrast enhanced visualization of the arterial lumen detection of atherosclerotic stenosis can be achieved with a sensitivity and specificity comparable to the current gold standard of Digital Subtraction Angiography (DSA) [1]. As part of ongoing work in whole-body MRA analysis, this study aims to assess the reproducibility and inter-observer agreement between two cardiovascular radiologists in categorical stenosis grading and whole-body atherosclerosis scoring in i) screening, and ii) symptomatic patients groups using CE WB-MRA.

Methods: WB CE-MRA was performed on a 3.0 Tesla Magnetom Trio MRI scanner (Siemens, Erlangen, Germany). Image acquisition occurred over four stations; station one encompassed the head and thorax region, station two the abdomen, station three the pelvis and upper legs and station four the lower legs. A number of surface coils provided whole-body coverage (excluding the upper limbs), including head matrix, neck matrix, spine matrix, two body matrix coils and a peripheral angiography coil. TrueFISP sequences were used to acquire scout images of the four stations for planning of the next acquisitions. Intravenous contrast agent (Gadoteric Acid, Guerbet, France) was administered through a 20 G cannula placed in the right antecubital fossa. Contrast agent administered in a bi-phase injection protocol [2], with a total of 25ml of contrast agent delivered in two injections of 10ml and 15ml at a rate of 1ml/s followed by a saline flush of 20ml Maximum arterial enhancement was achieved through the 'bolus-chase' method; the first acquisition of stations two and four was triggered manually upon complete entry of the first contrast agent dose into the arch of the aorta. The second acquisition of station two and three was manually triggered upon contrast enhancement of the proximal abdominal aorta following the second injection. Coronal 3D Fast Low Angle Shot (FLASH) sequences were used for pre- and post-contrast acquisitions.

20 patients were imaged in total, with an age range 52-88 (mean 70.3 ± 8.4), 11 male, 9 female. Patients were divided into four equal subcategories; healthy, mild atherosclerosis, moderate atherosclerosis, and severe atherosclerosis. Atherosclerosis patients were selected on the basis of previous diagnosis of symptomatic peripheral arterial disease (PAD) and categorized into disease subgroups on the basis of previous whole-body analysis. Two cardiovascular radiologists with experience in analysing hundreds of MR angiograms performed manual stenosis analysis of 159 arterial sites in each of these patients. A categorical grading scale was applied to each of these sites (**0**: normal, **1**: 1-30% stenosis, **2**: 31-50% stenosis, **3**: 51-75% stenosis, **4**: 75-99% stenosis, **5** : complete occlusion, **U**: non-diagnostic) Each radiologist was blinded to patient history and identity. Analysis was conducted using Carestream PACS visualization software on a radiological workstation. Stenosis grading was conducted by a visual estimation of vessel diameter reduction at the point of maximum stenosis compared to the nearest distal healthy segment [3], and performed using maximum intensity projection *(Figure 1)* and multi-planar reformation images. A second analysis was performed a period of three weeks later to reduce memory bias. Whole-body atheroma burden scores [4] were calculated for each patient analysis by dividing the sum of the total grades by the number of segments analyzed, and multiplied by the number of stenotic segments to produce a systemic atheroma burden score.

Figure 1. Post-contrast whole-body maximum intensity projection in the coronal plane.

Figure 2.

Figure 2. A) Observer agreement in stenosis grading, by patient subgrouping. B) Observer agreement in whole-body atherosclerosis scoring.

Results and Discussion: Cohen's Kappa statistic (k) was used to assess agreement in categorical stenosis grading between each observer's initial and repeat analysis. The reproducibility of each observer's analysis was substantial in the analysis of the moderate and severe symptomatic patients groups (Observer 1 k=0.603 ± 0.029 moderate, k= 0.582 ± 0.024 severe; Observer 2 k= 0.559 ± 0.031 moderate , k= 0.626 ± 0.023 severe; P<0.001), but only fair in the grading of the healthy and mild atherosclerosis patients' groups (Observer 1 k= 0.404 ± 0.057 healthy, k= 0.501 ± 0.029 mild, Observer 2 k= 0.391 ± 0.061 healthy, k= 0.432 ± 0.034 mild; P<0.001). Analysis of inter-observer agreement also found moderate to substantial agreement was reached in the grading of the symptomatic patients groups, while a reduction in observer agreement was associated with grading of the healthy and mild disease patients *(Figure 2.A)*. Variability arose in the detection and grading of mild pathologies. Analysis of whole-body atherosclerotic scores found very high agreement between observers *(Figure 2.B)* indicating that variability in grading of mild pathologies does not significantly alter systemic scoring.

Conclusions: Radiological categorical grading of stenosis was associated with substantial intra- and inter-observer agreement in grading of clinically significant stenosis. Despite reduced agreement associated with the grading of minor pathologies, whole-body atherosclerosis scoring correlated very highly between observers.

References: [1] Schoenberg, S. et al. *Radiology*, 2005. 235: 687-698 [2] Waugh S. et al. *Journal of Magnetic Resonance Imaging*, 2009. 30 (5): 1059-1067 [3] Ferguson, G. et al, *Stroke*, 1999. 30: 1751-1758 [4] Lehrke, S. et al, *Journal of Cardiovascular Magnetic Resonance*, 2009. 11:36