Carotid plaque imaging: source of motion artifact and correction

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Introduction:

Little information is available regarding image quality and reproducibility for high resolution MR atherosclerotic plaque imaging of carotid arteries (1). Publications do not report variation in image quality although investigators orally reveal bad image quality making interpretation impossible in 10 to 50% cases. The goal of the study was to investigate the potential sources of bad image quality in the imaging of carotid arteries and to suggest possible solutions. To achieve such a goal, we semi-quantified carotid artery wall motion related to arterial pulsation, breathing, and swallowing. We also assessed whether the use of a navigator based sequence (2) would result in a reduction of motion related to swallowing.

Material and method:

Motion artifacts: Five healthy volunteers and 5 patients (20 to 75 years old) with atherosclerotic desease were scanned on a Philips Intera 1.5T system. A surface coil (∅=47mm) was positionned around the carotid artery bifurcation and a single shot balanced-Fast Field Echo (bFFE) sequence was used to acquire real-time axial views of the carotid artery wall. Three images per second were acquired over a period of 20 to 30s. A 3 step acquisition protocol was performed in order to analyse separatly the 3 types of motion: 1- arterial pulsation (acquisition: no EKG gating, breath hold, no swallow), 2- breathing (acquisition: EKG gating, free breathing, no swallow), 3- swallowing (acquisition: EKG gating, no breathing, swallow). An acquisition with breath hold, EKG gating, and no swallow was also performed to evaluate whether artery motion could be entirely removed. Motion amplitude of the carotid artery iso-center either in the x or y direction was measured. Motion frequency was reported for each patient (figure 1A).

Avoiding motion artifacts: To assess whether suppression of swallowing or breathing related motion would be feasible, additional scans were performed on 3 volunteers and 3 patients with the same protocol as described above but using a navigator pulse for motion tracking. The navigator was applied prior to every bFFE shot and was positionned either in the posterior part of the tong or perpendicular to the diaphragm for the swallowing and breathing related experiment respectively. Sagittal images 1- along the tong and 2- perpendicular to the diaphragm were acquired and analysed together with the navigator curves to assess the efficacy of data rejection during the swallowing and breathing period (figure 1B and C).

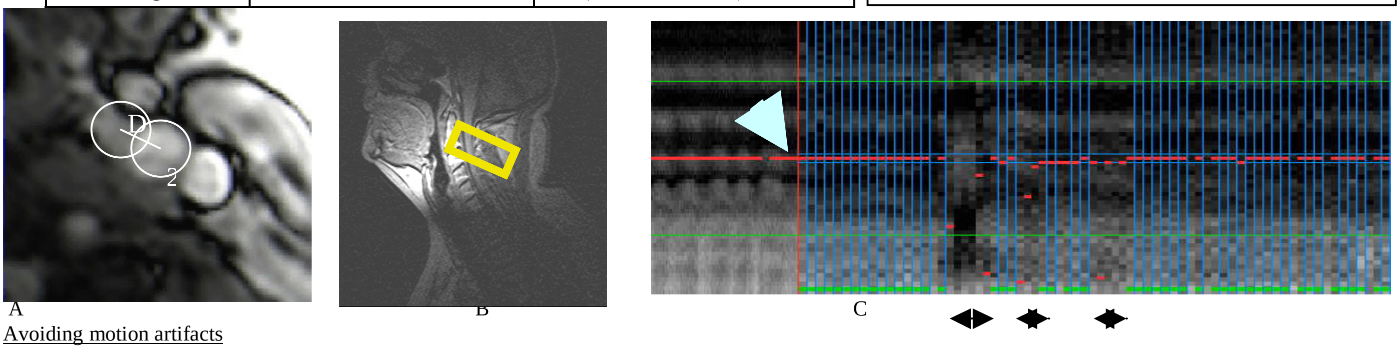
Results:

Motion artifacts

Significant motion could be visualized related to arterial pulsation, breathing, and swallowing as reported in table 1. We found that swallowing related motion was of the highest amplitude but with the lowest frequency, pulsation related motion the lowest amplitude but the highest frequency, and breathing related motion intermediately high and frequent. The use of breath hold, EKG gating, and no swallowing did consistantly eliminate all motion artifact.

Table 1	Motion frequency (min-1)	Motion amplitude (mm)
Vessel wall (cardiac cycle)	45-100	0-1 (mean 0.7, SD 0.3)
Breathing	10-30	1-3 (mean 1.6, SD 3.2)
Swallowing	0-5	2-7 (mean 4.2, SD 3.4)

Figure 1: A: position 1 (before swallowing) and 2 (during swallowing) separated by a distance (D) of 5mm. B: Navigator beam (rectangle) detecting motion of the tongue during swallowing. C: Position of the tongue (arrowhead) changing during swallowing and data rejection (black arrows).



Avoiding motion artifacts

The positioning of a navigator beam on the tongue (figure B, rectangle) allowed to reject data acquired from the beginning to the end of the swallowing period in 4 of the 6 patients. However, the quality of the navigator signal when positioned perpendicularly to the diaphragm was not good enough to enable data rejection neither during inhalation nor exhalation.

Discussion :

Our study shows that carotid artery wall motion during MR imaging can occur with a high frequency and a high amplitude. Although pulsation might not be of a significant issue in patients with thick atherosclerotic plaques and low compliance, our data shows that breathing and swallowing provide significant motion on all carotid arteries which leads to image degradation. Although breathhold and short acquisition time to avoid swallowing are very efficient ways to avoid such motion, such methods are not compatible with long turbo spin echo sequences that are usually recommended for high resolution plaque imaging. A navigator positioned in the back of the tong might be usefull to reject data when swallowing and this at a low cost in time. A position perpendicular to the diaphragm is likely to be a more complex configuration, especially because of the large distance between the carotid artery and the diaphragm and the limited distance over which the main field is homogeneous.

Conclusion:

We have demonstrated that pulsation, breathing and swallowing are the source of a significant motion of the carotid artery wall and are likely to be responsible for significant image quality degradation when high spatial resolution acquisitions are performed. Our study shows that a navigator beam positionned on the tongue is a feasible technique to avoid swallowing related motion. Such method might also be of interest for respiratory related motion.

References: (1) Yuan C, et al. Circulation 2002;105(2):181-5. (2) Botnar RM et al. Circulation 2000;102(21):2582-7.