

ADAPTIVE EFFICIENCY-OPTIMIZED SELF NAVIGATION (ADIOS) FOR FREE-BREATHING NON-CONTRAST ABDOMINAL MRA

Yibin Xie^{1,2}, Zhaoyang Fan¹, Yutaka Natsuaki³, Gerhard Laub⁴, Rola Saouaf¹, and Debiao Li¹

¹Cedars-Sinai Medical Center, Los Angeles, California, United States, ²University of California, Los Angeles, Los Angeles, California, United States, ³Siemens Medical Solutions, Los Angeles, California, United States, ⁴Siemens Healthcare, Los Angeles, California, United States

Target audience: Developers and physicians interested in non-contrast MRA, abdominal imaging, and/or self-navigation.

Introduction: Non-contrast MRA (NC-MRA) based on bSSFP and slab-selective inversion has become an attractive alternative for imaging abdominal arteries without the use of potentially nephrotoxic contrast agents [1-3]. Although this technique has been developed for over ten years, it has not become a routine clinical exam. One of the major hurdles has been the lack of optimal approach to alleviate respiratory motion artifacts. Currently, abdominal bellow triggering and diaphragm navigator gating are the commonly used methods. However, abdominal bellow triggering increases patient preparation time and disables the usage of ECG triggering, leading to suboptimal inflow effect. Diaphragm navigator significantly complicates exams due to navigator setup, scout scans, and acceptance window adjustment. It fails in certain patients due to poor navigator signal, low acceptance rate and extensive motion artifacts. It also causes signal loss in abdominal arteries due to cross-pair saturation bands. Previously a self navigation (SN) technique [4] was used to overcome the limitations of the aforementioned free-breathing methods. In this work, we developed an adaptive efficiency-optimized self navigation (ADIOS) method to maintain high scan efficiency and minimize respiratory motion artifacts.

Methods: An SN readout line in the superior-inferior (SI) direction without partition or phase encoding is inserted at the end of each 3D bSSFP readout block (Fig. 1A). Fourier transform of the SN readout line is the 1D projection of the entire imaging slab onto the SI axis, which serves as the ‘fingerprint’ of the current respiratory phase (Fig. 1B). The reference projection profile is defined in the first two repetitions in the scan with breath-hold at expiration. In each subsequent repetition, correlation coefficient (CC) is calculated between current projection profile and the reference profile. Respiratory motion is detected if the CC value drops below a defined threshold and current image lines will be rejected and reacquired in the next repetition. In order to compensate for signal drift and maintain scan efficiency, the threshold is dynamically adapted using a heuristic algorithm in real time. The algorithm stores the ten most recent CC values sorted in descending order. The threshold is constantly updated to the fourth highest CC values resulting approximately 40% of acceptance rate. Outliers CC with very low values caused by deep breath, bulk motion etc. are excluded from the calculation. Nine healthy volunteers with IRB approval were scanned on a 3T clinical scanner (MAGNETOM Verio, Siemens AG Healthcare, Erlangen, Germany) with the following scan parameters: repetition = 700-900 ms; TI = 550-750 ms; acquisition time = 4-7min depending on heart rate; TE/TR = 1.9/3.8 ms; 3D transverse slab with left-right readout; FOV = 400x250 mm², matrix = 304x192, slice thickness = 2.2 (1.1 interpolated) mm, yielding isotropic resolution = 1.1 mm³; iPAT = 2; bandwidth = 780 Hz/pixel; FA = 90. For comparison, conventional diaphragm navigator gated bSSFP MRA images were acquired immediately afterwards using same parameters.

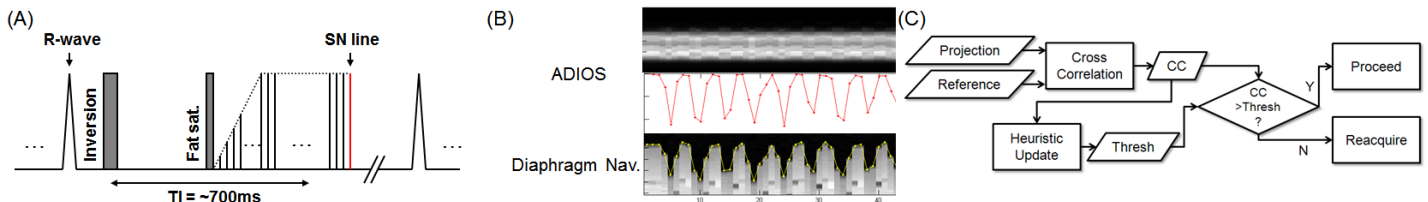


Fig. 1. (A) Pulse diagram of ADIOS bSSFP NC-MRA. (B) CC values (middle) derived from SN projections (top) match diaphragm navigator signal (bottom), both showing underlying respiratory motion. (C) Flow chart of ADIOS adaptive gating algorithm.

Results: SN projections clearly show the underlying respiratory motion and are highly matched with diaphragm navigator (Fig. 1B). Excellent depiction of the intra- and extra-renal arteries are achieved using ADIOS with no navigator saturation bands (Fig. 2). No statistically significant difference was found in nine healthy volunteers between the two gating methods regarding SNR and CNR, as well as qualitative reviewer scores (Tab.1).

	SNR	CNR	Score (5)
ADIOS	44.7±7.3	31.2±5.8	4.67±0.71
Diaphragm Nav.	41.3±10.7	28.2±8.7	4.56±0.73
T-test	0.08	0.13	0.35

Tab.1. Image quality comparison statistics.

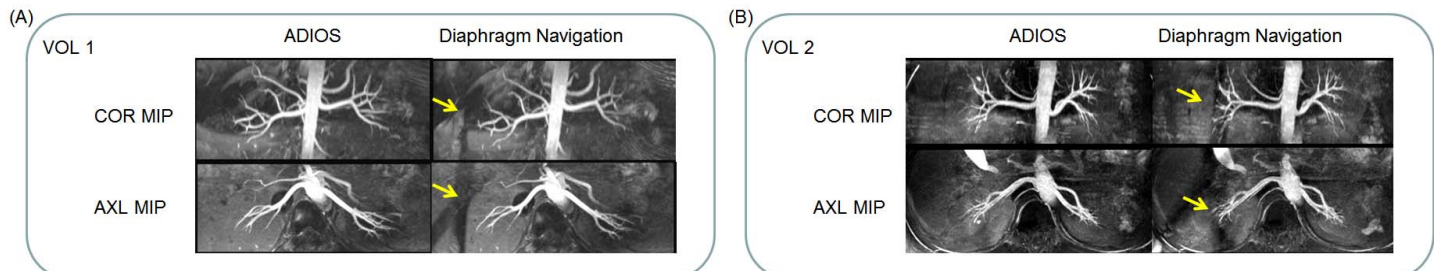


Fig.2. Representative healthy volunteer scans comparing image quality of ADIOS and conventional diaphragm navigator gating. Note the saturation bands caused by diaphragm navigator (arrows) and degraded distal renal artery visualization in a volunteer (B).

Conclusion: Preliminary results of ADIOS bSSFP NC-MRA have demonstrated comparable overall image quality to conventional navigator gated acquisition and the elimination of saturation bands. It reduces the overall patient time with much simplified imaging planning and efficiency-optimized gating. It may potentially provide more reliable and consistent image quality and diagnosis in patient studies, which are currently under investigation.

References: [1] Miyazaki M, et al., Radiology 08. [2] Braendli M, et al., AJR 03. [3] Katoh M, et al., Kidney Int. 04. [4] Xie Y, et al., ISMRM 11.