Non Contrast 3D Volumetric Time-Resolved MRA in Renal Artery(CINEMA-RENAL)

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Introduction

Non-contrast MR angiography (MRA) has been an indispensible modality to examine diverse vascular disorders. In contrast, recent concern for contrast-enhanced MRA has discouraged more use of non-contrast MRA [1]. Non-contrast MRA with spin-labeling technique which discriminates arteries from veins, simultaneously suppressing signals from surrounding tissues, has been applied for exploring the renal and hepatic arteries [2, 3]. Currently available techniques for non-contrast MRA, however, enable only to gain static, single-frame images. Recently we have proposed 3D volumetric non-contrast time-resolved MRA technique termed Contrast inherent inflow enhanced multi phase angiography in renal artery (CINEMA-RENAL). CINEMA was developed as a technique that enables diachronic observation of hemodynamics as in Contrast-enhanced dynamic MR angiography and extensive 3D volume acquisition with the renal artery as a target. We present a preliminary study of CINEMA sequence and discuss its clinical relevance.

Methods

CINEMA sequence was performed combining Look-Locker (LL) techniques [4] with 3D segmented T1-weighted gradient echo sequence (3D T1 TFE). This sequence used a slice-selective LL inversion recovery (LL-IR) method. LL-IR impressed only once before the initial shot of the individual packages, at the start of cardiac cycle, to acquire serial data for every TI interval. Radial 3D stack-of-stars acquisition [5] was used to diminish the motion artifacts due to breathing. Background signals were inhibited by combining CINEMA-RENAL technique with PROSET that obviates the need for subtraction processes. Flow signals of the renal artery were acquired serially in 3D segmented multiphase T1 TFE readout with the alteration in blood flow which displayed as cine images at an interval of several 200 ms. CINEMA-RENAL was implemented with the following parameters: FOV=220×200mm^2, Matrix=224×162, 3D acquisition with 100×1mm slices, resolution =1×1×1 mm^3, flip angle=10°, TR=4.5ms, TE=2.2ms, TI/ΔTI/final TI=120ms/230ms/2000ms(2R), number of acquired time points = 9. The scan time was approximately 5min. The scans were ECG-triggered, and 5 to 10 phases with a step of 200 ms were acquired depending on the cardiac cycle. The study was approved by local-IRB, consisted of 10 healthy volunteers. All explorations were performed on a Philips Achieva 3.0 Tesla scanner with Nova Dual gradients and software release 2.6, with a 32 elements Torso cardiac coil. The alteration in longitudinal magnetization of stationary tissues and moving tissues (blood stream in this study) was converted into numbers by simulation. The signal strengths of stationary tissues and blood stream were measured from images obtained in volunteer studies and compared with the simulation models. The image quality of CINEMA-RENAL was evaluated comparing with 3D balanced SSFP (3D bSSFP) in terms of the description of anatomic details of the renal artery.

Results

Longitudinal magnetization and signal intensity of CINEMA-RENAL images from volunteer studies were found to be identical to the simulation result (Fig 2). CINEMA-RENAL can extract the blood flow in the renal artery at an interval of 100 ms and thus permitted us to observe vascular construction in full by preparing MIP images of axial, coronal, and sagittal acquisitions with 1 mm × 1 mm × 1 mm spatial resolution (Fig 3). Rotating read-out of k-space enabled significant reduction of motion artifacts, improving image quality and depiction of anatomic details when compared to the conventional Cartesian k-space sampling sequences. The quality of MIP images gained by 3D bSSFP technique and CINEMA-RENAL temporal frame were identical in depicting the main branches of the renal artery, while CINEMA-RENAL method provided additional temporal hemodynamic information (Fig 4).

Conclusion

Preliminary results gained from healthy volunteers have demonstrated the feasibility of this modality to depict details of anatomic features in dynamic images of the renal artery. CINEMA-RENAL enables to achieve ``four dimensional`` images without contrast agents. Patients with Reno vascular diseases are the subjects of next investigation.

Reference

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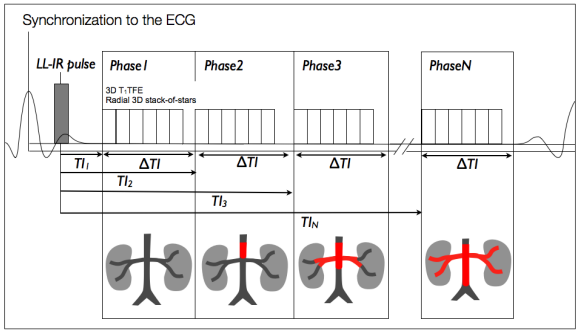

Fig 1. Schematic of the sequence for CINEMA-RENAL. Measurement is composed of electro cardio-Gram-gated 3D T1-TFE acquisitions with slice-selective LL inversion recovery pulse. 3D imaging volume was scanned in consecutive acquisitions.

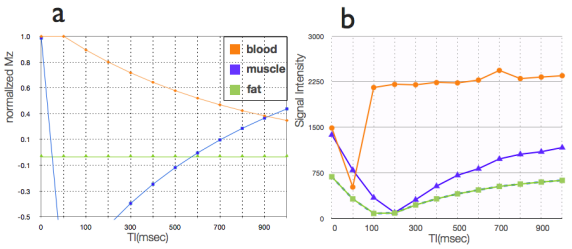

Fig 2. Simulated longitudinal magnetization (a) and signal intensity curves from volunteer studies (b).

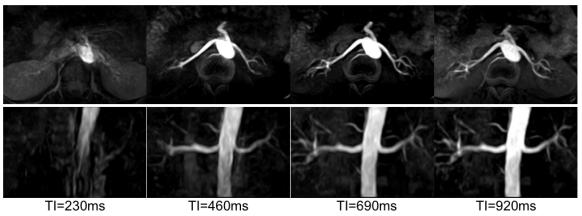

Fig 3. CINEMA-RENAL images acquired from a healthy volunteer. MIP images acquired at representative phases form one subject with a 230ms temporal resolution and 1×1×1mm3 spatial resolution.

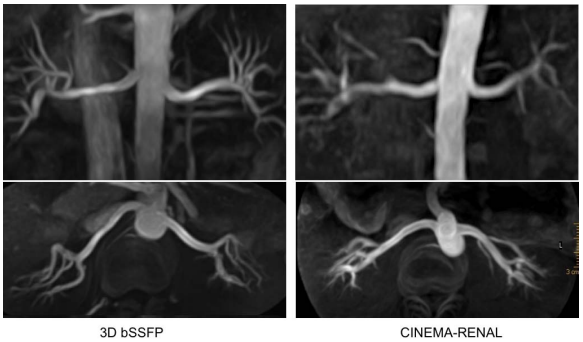

Fig 4. Comparison of a 3D bSSFP image and CINEMA-RENAL image. For volunteer, one temporal frame was selected from CINEMA-RENAL image sets. Note that the depiction of renal artery was comparable using these two techniques.