"Shoot and Scoot": A Segmented Volume Acquisition Method for High-Resolution Multi-station Imaging of Peripheral Vasculature

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Abstract

Shoot and Scoot (SNS) is a method for improving the image quality of peripheral run-off 3D-MRA examinations by decreasing the time between bolus detection and acquisition of distal runoff vessels. This is accomplished by collecting data over two passes; the central 30-40% of k-space is acquired first during the arterial phase, followed by acquisition of the remainder of k-space on a subsequent pass for the proximal stations. The ability to optimize each station with independent scan prescription, transmit and receive gains, and coil selection improves arterial SNR and reduces venous contamination. The entire k-space is acquired for the distal station.

Introduction

Conventional bolus chase peripheral MRA techniques utilize traditional 3D data acquisition schemes with scan times typically ranging from 20-50 seconds per station [1-3], where the acquisition of k-space must be complete before the table is moved to the next position. The contrast delivery rate is adjusted so that the injection duration is approximately 80% of the total imaging time (60-120 seconds to image 3 overlapping stations). Slower injection rates are required to eliminate venous contamination and prolong arterial enhancement during data acquisition, resulting in lower arterial concentration of bolus material and reduced vessel SNR. Thus, these methods require the operator to compromise spatial resolution (i.e. imaging time) with the concerns of arterial contrast concentration (i.e. contrast material injection rate(s) and contrast media dose). Using conventional bolus chase schemes, visualization of the arteries in the last and most distal station is often unreliable as they are most affected by the aforementioned selections [3].

Foo et al [4] have demonstrated that the acquisition of more proximal stations can be segmented to reach the terminal station faster to achieve higher arterial S/N and reduce venous contamination in the most distal station. However, the initial work could not vary the scan parameters on a per station basis. The aim of this study was to demonstrate further improvements to "Shoot and Scoot" (SNS) that allow each station to be independently prescribed with different obliquities, matrix size, number of partitions, and coil selection to maximize acquisition efficiency.

In a three-station exam, for example, 30-40% of the center of k-space is acquired in a reversed elliptical centric phase order for the initial abdominal station. An elliptical centric order is used for the subsequent stations. Independent acquisition parameters (coil selection, pre-scan parameters and initial k-space fraction) tailor each station to optimize the signal and imaging times. With this scheme, the terminal station is reached within 20-30 seconds from the detection of the bolus in the abdominal aorta rather than in 50-60 seconds with conventional MRA techniques. Note that the ability to adjust receiver and transmitter gains on a per station basis accounts for changes in coil loading, improves SNR and permits fat-suppression to be used on all stations. The entire k-space is acquired for the distal station, followed by the acquisition of the outer portions of k-space for the proximal stations.

Methods

In this IRB-approved study, seven healthy volunteers (3 men; 4 women; average age = 38.6 ± 9.2 years; average wt = 72.4 ± 8.9 kg) underwent 3D-SNS peripheral MR angiography. All experiments were performed on a 1.5T Signa CV/i MR system (GE Medical Systems, Waukesha WI) equipped with high performance gradients (40mT/m max amplitude, 150T/m/sec max slew rate). A fast 3D rf phase-spoiled gradient-recalled pulse sequence was modified to allow acquisition of user-determined percentages of outer or central k-space in elliptical centric or reverse elliptical centric acquisition orders. Scanning was triggered by automatic bolus detection in the abdominal aorta (MR SmartPrep), and table motion between stations was initiated by the pulse sequence immediately after completion of data acquisition to minimize inter-station delay. Typical acquisition parameters were: TR/TE:3.9/3.1msec, FA:50, 256x224 matrix, 0.5 NEX, FOV:40cm. The central k-space fraction to be acquired on the initial pass, as well as transmit gain, and selection of the coils were optimized for each station individually. Gadoteridol (ProHance, Bracco Diagnostics, Princeton NJ) was administered at a dose of 0.2mmol/kg diluted to 45mL and a rate of 1mL/sec. The total acquisition period was approximately 1.5min for both passes. All images were processes using a maximum intensity projection (MIP) algorithm after mask subtraction to generate MR angiograms.

For a three-station study, initial k-space fraction of 40% was used for the abdominal station with reversed elliptical centric view order, while 30% were used for the thigh station with elliptical centric view order. The remaining k-space data of these stations was acquired after data acquisition (100% of k-space) of the most distal station was complete.

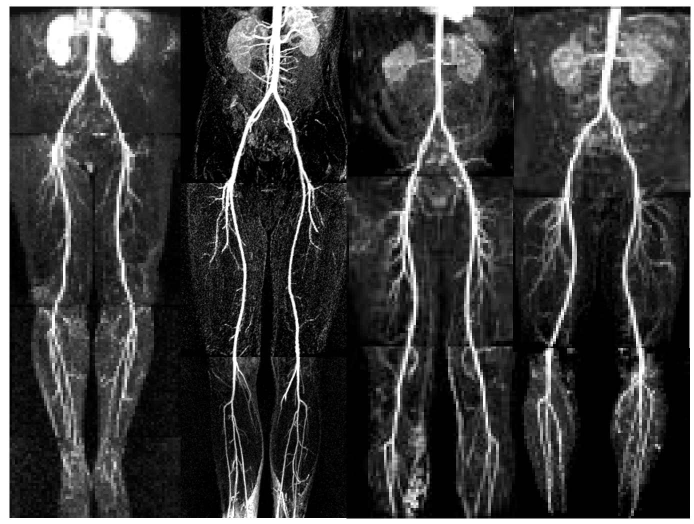

Figure 1: Frontal projection of 3D-SNS MIPs

Results and Discussions

3D-SNS was successful in all cases. Renal arteries were well visualized in all cases and accessory renal arteries were noted in two cases using partition thicknesses of 2-2.6mm for the abdomen. Illiac and femoral arteries, together with smaller accessory vessels were well visualized in the thigh station using 1.8mm-2.6mm partitions. The terminal station was reached 20-30seconds after detection of the bolus in the abdominal aorta. Reaching the terminal station within this short period allowed data acquisition to complete entirely in the arterial phase of contrast circulation with minimal or no venous contamination. Using partition thicknesses of 1.2-1.4 mm, the tibioperoneal arteries were well delineated with high arterial SNR due to optimized pre-scan parameters, matrix, and when a phased array coil was used on this station. Minimal or no venous contamination was noted in all studies.

Conclusion

Station tailored 3D-SNS allows data collection from all three stations during the arterial phase of the contrast injection for peripheral runoff MRA and yields high-resolution images of proximal and distal stations with minimal venous contamination. The current implementation allows individual stations to be customized to the anatomic requirements of each patient, thus maximizing SNR while minimizing time. The ability to optimize each station with independent scan prescription, transmit and receive gain controls, and coil selection, allows for optimization of contrast bolus delivery (faster injection rates and potentially lower contrast doses), reduced venous contamination, and higher arterial SNR, thus better image quality of all arterial segments. In conclusion, SNS provides a customizable approach for MR angiography in evaluating peripheral vascular disease.

References:

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