Scoutless step-table imaging of the peripheral arteries

W. Li[1], A. T. Vu[2], S. Tutton[1], B. S. Li[3], R. Bejm[1], L. Pierchala[1], R. R. Edelman[1]

[1]Radiology, Evanston Northwestern Healthcare and Northwestern University Feinberg School of Medicine, Evanston, Illinois, United States, [2]GE Healthcare, Waukesha, WI, United States, [3]GE Healthcare, Evanston, Illinois, United States

INTRODUCTION

A standard approach of step-table peripheral contrast enhanced MR angiography (CE-MRA) involves the acquisition of a series of MRA at different stations, in order to follow the passage of an intravenously administered contrast agent through the peripheral arteries. Because the data are typically acquired over a volume of finite thickness that is smaller than the thickness of the body part, the 3D imaging volume must be carefully positioned so as to encompass all the major arteries. The process of acquiring the scout images and then setting up the 3D acquisition volumes at each station may require more than 50% of total scan time (1), which is inefficient, uncomfortable for patients, and may result in motion artifacts. The purpose of this study was to describe a method, EZ-STEP, which eliminates the need for the acquisition of multiple scout images and manual positioning of the multiple imaging volumes, so that the scan time can be significantly shortened.

MATERIALS AND METHODS

Sequence: Basically, imaging procedure of EZ-STEP is similar to that of standard step-table peripheral CE-MRA, but the 3D spoiled gradient echo (Fast SPGR) pulse sequence was modified by implementing spatially non-selective RF pulses to minimize the TR/TE (Fig. 1). So that larger volumes of data can be acquired more rapidly. The coronal mask and angiogram were acquired sequentially at 3 stations with table moving speed of ~6 sec / 400 mm. The elliptical centric phase encoding order was used in the 2nd and 3rd station to avoid venous contamination. Zero-filled interpolation reconstruction **(**ZIP2) along slice direction was employed to reduce the effective slice thickness in all stations. Since the FOV, the position of each 3D volume, and table-shifts between stations were predetermined, no scout and manual positioning of imaging volumes are needed. **Subjects and MR scanner:** Fifteen subjects, including 8 healthy volunteers and 7 patients with occlusive peripheral artery disease, were scanned with EZ-STEP. Eight contiguous patients, who had standard contrast enhanced peripheral MRA, was retrospectively evaluated for quality-comparison purpose. EZ-STEP studies were performed with body coil or combined 8-channel body array (for calf only, n=3) on a GE Signa TwinSpeed 1.5 T scanner equipped with the EXCITE technology. **Two versions of EZ-STEP:** Two versions of EZ-STEP were established. In version 1, big 3D slab-volume / partition-thickness was applied for each station (228/3, 204/3, and 178/2.6 mm for pelvis, upper leg, and lower leg, respectively) to ensure that all tissue in 3 stations was covered. Seven healthy volunteers with large ranges of height (1.60 -1.96 cm) and weight (54 -109 kg) were imaged with version 1. In version 2, the 3D slab-volume / partition-thickness for each station was reduced to 182/2.4, 150/2.2, and 136/2.0 mm, respectively to achieve higher spatial resolution. This reduction was based on the most anterior and most posterior position of enhanced arteries in the 7 volunteers scanned with version 1. Although some soft tissue can be cut off with version 2, all arterial structures are still covered. Parameters used in version 2 are shown in Table 1. One healthy volunteer and seven patients (F=5, M=2, age 69~94, average =79.7 years) were scanned with version 2. **Contrast administration:** For each EZ-STEP subjects, 40 ml of gadopentetate dimeglumine was administered with a power injector. The first 20 ml of agent was injected at a rate of 2.0 ml/sec, the second 20 ml and followed 15 ml of saline at the rate of 0.5 ml/sec. Fluoro-triggered monitoring was applied in pelvic station. **Image quality analysis:** The subtracted images of EZ-STEP were obtained by subtracting the mask images from angiogram images, and were processed with maximal intensity projection (MIP). Overall image (MIP) quality of 15 EZ-STEP subjects and the 8 patients who had standard step-table peripheral CE-MRA was graded from 1 to 4 (1 = non-diagnostic, 2 = diagnostic, 3 = good, 4 = excellent), and scored in a blinded fashion by an experienced interventional radiologist. For each subject, the images of the pelvis, upper leg, and lower leg were scored separately. The average of the 3 scores is considered as the score of this subject.

Table 1. Parameters of modified 3D Fast SPGR sequence used in EZ-STEP (version 2)

	T Position	TR (ms)	TE (ms)	Flip A	BW	EC	FOV(cm)	Matrix	NP	PT (mm)	ST (mm)	NEX	Time(s)	Pixel size
Pelvis	0	~2.0	~0.6	25º	±125	N	45*36	256*160	76x2	2.4/-1.2	182	1.0	~21	1.76*2.81 mm²
Upper leg	I 400 mm	~2.0	~0.7	25º	±125	Y	45*36	256*192	68x2	2.2/-1.1	150	1.0	~23	1.76*2.34 mm²
Lower leg	I 800 mm	~2.1	~0.7	25º	±125	Y	45*36	256*256	68x2	2.0/-1.0	136	1.0	~32	1.76*1.76 mm²

T Position=Table position; **Flip A**=flip angle; **BW**=bandwidth; **EC**=Elliptic Centric; **NP**=number of partitions; **PT**= partition-thickness; **ST**=slab-thickness

RESULTS

Angiogram images with coverage from renal arteries to the ankle level were achieved using either version 1 or 2 of EZ-STEP without imaging of scout (Figure 2). The time of table occupation was as short as 5 minutes for each exam, including "Prescan" (~2 min.), mask (~1.5 min.), and angiogram (~1.5 min.). The average scores of overall image quality for EZ-STEP version 1, version 2, and standard method are 3.5 (2.7 ~ 4.0, n=7), 3.5 (3.0 ~ 4.0, n=8), and 3.2 (2.0 ~ 3.7, n=8), respectively.

DISCUSSION AND CONCLUTION

EZ-STEP significantly shortens the scan time of standard step-table peripheral CE-MRA, and makes the examination more efficient, more comfortable for patients, and potentially less motion artifacts. The key of EZ-STEP is use of spatially non-selective RF pulses, which is typically shorter in duration than a spatially selective pulse. Vision 1 provides bigger anterior-posterior coverage, and version 2 gives better spatial resolution. The use of elliptical centric phase encoding order in the 2nd and 3rd station appears to be quite effective in minimizing venous contamination.

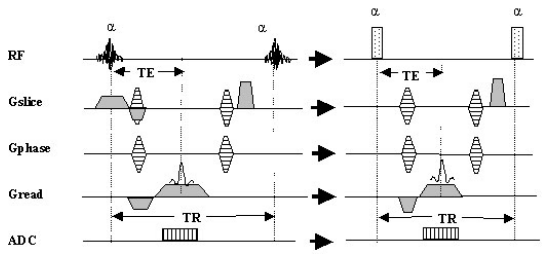

Figure 1. *SPGR 3D sequence and its modification for EZ-STEP (right)*

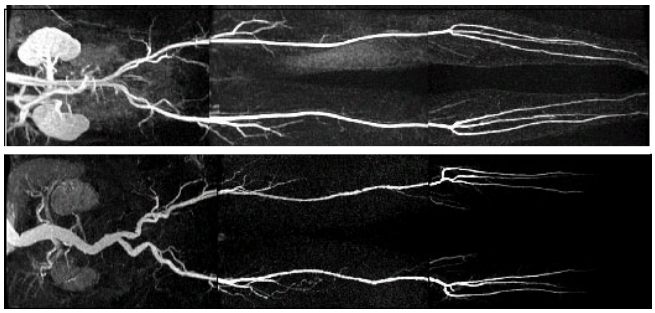

Figure 2. *MIP images obtained with version 1 (a healthy volunteer, top), and version 2 (a patient, bottom) of EZ-STEP*

REFERERENCES

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