# Interactive Two-Dimensional Fresh Blood Imaging

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## INTRODUCTION

Fresh Blood Imaging (FBI) is a non-contrast enhanced MRA technique originally proposed by Miyazaki et al [1] primarily as a 3D subtraction method, with acquisitions times averaging 3-5 minutes. FBI is a flow dephasing technique, particularly useful in the detection of pulsatile blood flow within arteries. Single-shot fast spin-echo (SSFSE) is used in preference to other pulse sequences because of the long echo train which allows flow related dephasing to occur. Different degrees of dephasing occur in fast (systolic) and slow (diastolic) flow and the difference is used to generate vessel flow contrast. Because most veins have less pulsatile flow than arteries, FBI can be used to selectively generate arterial angiograms. Although the method can produce excellent anatomical results, these are influenced by the selection of accurate timings for image acquisition which usually require additional "prep" acquisitions that typically take several minutes and may not fully account for heart rate changes during the main 3D acquisition.

In conventional 3D FBI the "prep scan" consists of multiple triggered 2D SSFSE acquisitions to determine the appropriate systolic and diastolic trigger delays. Next, two 3D volumes are acquired with these delays (bright blood in diastole, dark blood in systole) and subtracted from each other to produce the 3D FB images. The 3D FBI technique can produce excellent non-contrast enhanced peripheral and whole body MRA. However, the use of the technique for fast interactive 2D projection angiography remains relatively unexplored.

This work aims to develop FBI as part of a comprehensive 2D interactive imaging examination, so that rapid localization of vascular structures of interest, and flow analysis followed by optimised FBI, can depict vessels and confirm their anatomy and patency.

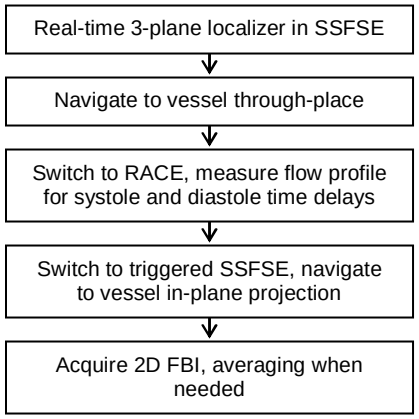


**Figure 1** Protocol for interactive 2D FBI

## METHODS

All studies were performed using a 1.5T clinical MRI body scanner (HDx, GE Healthcare, Waukesha, WI). A standard SSFSE pulse sequence was modified to perform 2D FBI and integrated in the vendor's proprietary real-time imaging interface (i/Drive Pro Plus, GE Healthcare). A rapid "prep scan" was implemented as a 1D gradient-echo flow-measurement sequence (RACE) [2]. The sequence allowed "on the fly" interactive switching between RACE and the 2D FBI acquisition to allow real-time optimisation [3].

The RACE method was used to measure the temporal flow dynamics in the vessel of interest. Sequence parameters were: TE/TR=~4/12ms; FOV=15cm; flip=30°; slice=4mm and x-resolution=256. In-house software was developed to download raw data from the scanner, reconstruct RACE data, calculate the flow profile from a region of interest and interactively output the appropriate trigger delay times. These trigger delays were used to set the delays for alternate, continuous systolic and diastolic acquisitions in the real-time FBI sequence. The 2D FBI SSFSE sequence parameters were: TE=34ms; TR=1500-2500ms; flip=90°/130°; FOV=20-35cm; slice=30-40mm; resolution=256x256 and gating=ECG/PPG. Complex subtraction of the systolic/diastolic raw data pair was performed before reconstruction to generate the fresh blood image.

The study was carried out in two parts: (1) to assess, in a pulsatile flow phantom, the validity of replacing the multiple 2D SSFSE prep scan with RACE; and (2) to demonstrate real-time 2D FBI in healthy volunteers' hand, leg and ankle.

## RESULTS

Ex vivo flow phantom experiments showed excellent correlation between RACE flow measurement ($T_{acq}$=1heartbeat) and 2D SSFSE flow signal intensity ($T_{acq}$=3heartbeats * no. of phases) (Figure 2).

Each fresh blood subtracted image takes approximately 5-7s to acquire, i.e. each image takes 2.5-3.5s, where the exact value depends on the TR and heart rate. Once localization of the vessel of interest was achieved, magnitude averaging of the reconstructed angiograms was used to increase SNR and vessel conspicuity. Eight-averaged images from volunteers are shown (Figures 3-5).

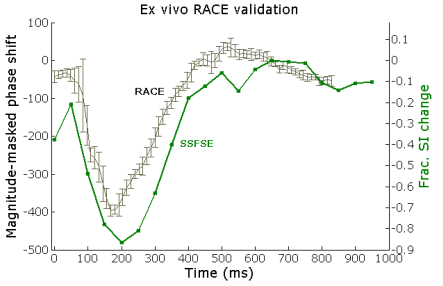


**Figure 2** Correlation shown between RACE flow measurement ($T_{acq}$=1heartbeat) and 2D SSFSE ($T_{acq}$=60heartbeats) flow relative signal intensity in a flow phantom.

## DISCUSSION

We have successfully demonstrated the feasibility of interactive FBI in various peripheral body areas. The validity of RACE as a rapid and effective substitute for multiple 2D SSFSE prep scan was verified. In a large FOV, where the flow profile of the vessel cannot be assumed to be the same throughout the FOV for the same instance, RACE can be used to optimise for the vessel part of interest. Future work includes evaluation of interactive FB technique in more challenging body parts in both healthy volunteers and patients.

## ACKNOWLEDGEMENTS

MRIS unit and the ACT.

## REFERENCES

1. Miyazaki M, et al. J Magn Reson Imaging. 2000;12:776-783.
2. Mueller E, et al. Proc Intl Soc Mag Reson Med. 1988; p 729.
3. Graves MJ, et al. Proc Intl Soc Magn Reson Med. 2007; p 1654.

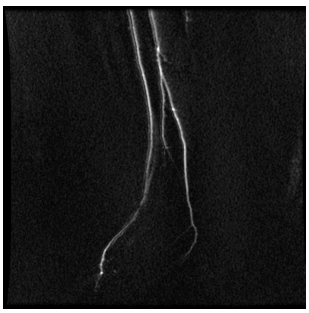

**Figure 3** Dorsalis pedis and anterior tibial artery, 40mm projection,$T_{acq}$~1min

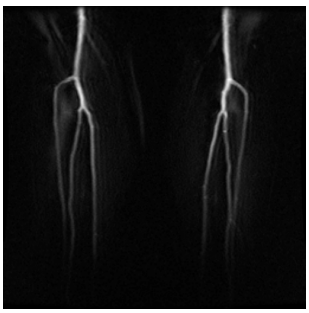

**Figure 4** Popliteal trifurcation, 30mm projection, $T_{acq}$~25s

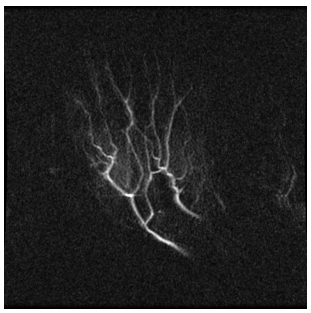

**Figure 5** Palmar arch, 30mm projection, $T_{acq}$~1min