FBI-Navi for Easy Determination of Diastolic and Systolic Triggering Phases in Non-Contrast Fresh Blood Imaging (FBI)

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PURPOSE

Due to the recent association of gadolinium contrast agent dose and nephrogenic systemic fibrosis (NSF) disease, there have been increasing interests in using non-contrast MRA techniques as alternatives. A non-contrast MRA technique, known as flow-spoiled fresh blood imaging (FS-FBI), allows separation of arteries from veins in peripheral run-offs [1]. In FS-FBI, diastolic triggering provides bright blood arteries and veins, while systolic triggering results in black blood arteries and bright blood veins. Therefore, subtraction of diastolic from systolic images provides images depicting the arteries only. In order to find the appropriate delay times for systolic and diastolic triggering, respectively, a single slice multiple phase scan (ECG-prep) is applied prior to the 3D FS-FBI acquisition [2]. In the process of determining diastolic phase, the systolic phase, which shows black blood, is subtracted from all single shot images. Then, the user determines that the phase displaying the highest arterial signal is diastole. This procedure of finding the lowest arterial phase, subtraction of all phases from the systolic phase, and determining diastolic phase by choosing the highest signal of the artery qualitatively, is quite cumbersome. In addition, there is an inherent delay when using peripheral pulse gating (PPG) to the lower extremity as compared to ECG gating, which makes extremely difficult to select both phases. In this study, we have developed a new software algorithm, FBI-Navi, to determine the diastolic and systolic trigger delay times for effortlessly navigating to 3D FBI scan.

THEORY

The FBI-Navi algorithm is shown as follows;

1] Determining a basic phase t_0

2] Producing subtracted images Ps(x,y,t) of the basic phase t_0 from each phase images.

$$P_s(x,y,t) = \left| P(x,y,t) - P(x,y,t_0) \right|$$

3] In Ps(x,y,t) images, producing a maximum intensity projection (MIP) image, Pm(x,y), in all phase images.

4] For a Pm(x,y) image, performing the threshold processing to produce two set of values and producing a mask image, Pb(x,y).

5] For all phase images, producing an average value by multiplying with a mask image.

$$M(t) = \frac{\sum_{x,y} P_b(x,y) \times P(x,y,t)}{\sum_{x,y} P_b(x,y)}$$

MATERIALS and METHODS

Since the arterial signal changes drastically from systolic to diastolic phases, the mask image should show the large difference in arterial signal intensity. Therefore, the average value by multiplication of the mask image to all different phase images from the result of ECG-prep scan should be indicating the arterial signal variation. Thus, the smallest in the average value, M(t), is systolic and the largest value should be diastolic phase. To validate the algorithm, FBI-Navi was performed using both ECG and PPG peripheral gated experiments. All experiments were performed on a 1.5T clinical imager on healthy volunteers and patients. Four experienced operators analyzed the comparison studies of FBI-Navi on both ECG and PPG with the manual procedure.

RESULTS and DISCUSSION

Figure 1 shows the results of ECG and PPG scan using the FBI-Navi algorithm software. The arbitrary signal intensity vs. ECG or PPG times is plotted in the FBI-Navi software. The highest signal intensities represent diastolic delays and lowest signals represent systolic delays. All 4 operators agreed that FBI-Navi was easy to use and determine the both phases as compared to the manual method. Particularly, using PPG examinations, FBI-Navi was found easier to select highest and lowest signal phases without consideration of the pulse delay time. However, on the iliac region, due to a misregistration error in an MIP procession, peristalsis may cause higher signal intensity changes than the arterial signal change. In these cases, a region of interest (ROI) can be placed in the area without peristalsis movement for better calculation.

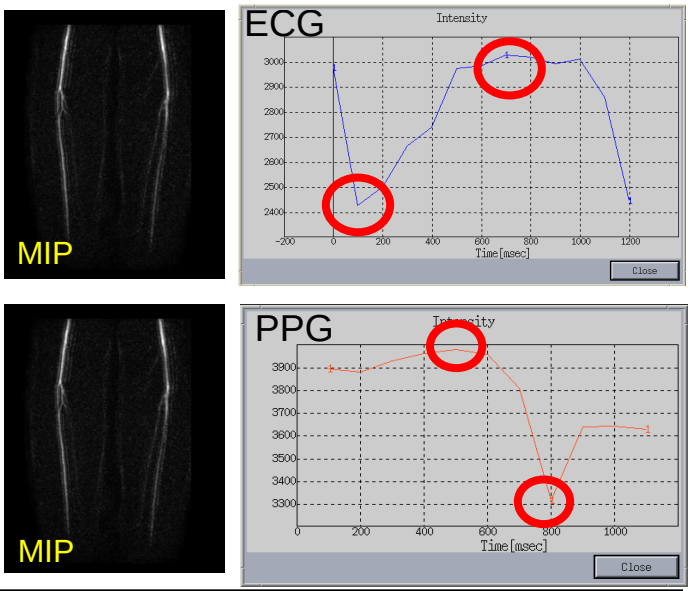

Fig. 1 FBI-Navi results using ECG and PPG gating. Note that the highest and lowest signals are seen in the graphs, as indicated in red circles.

CONCLUSION

The FBI-Navi is easy to use and less cumbersome for the operators. Even examinations with PPG gating, FBI-Navi allows easy judgment of accurate delay times for FS-FBI experiments.

REFERENCES

1] Miyazaki M, et al., Radiology 227:890-896, 2003.

2] Miyazaki M, et al., JMRI 12:776-783, 2000.