# 3Tesla Inflow Inversion Recovery 3D SSFP for Robust Non-contrast MR Angiography Using Triple Triggering

Naoyuki Takei[1], Mitsuharu Miyoshi[1], Masayoshi Sugimura[2], Takayuki Masui[2], and Hiroyuki Kabasawa[1]

[1]*Global Applied Science Laboratory, GE Healthcare, Hino, Tokyo, Japan,* [2]*Radiology, Seirei Hamamatsu General Hospital, Japan*

## ***Introduction***

Inflow-enhanced slab selective inversion pulse sequence with 3D balanced Steady State Free Precession (bSSFP) has been recently introduced to evaluate abdominal vessels, especially renal arteries for non-contrast MR Angiography [(1,2)]. However, we have encountered a low or flow voided signal intensity in blood pools at descending aorta at 3.0T rather than 1.5T. The artifact is known as "dark flow artifact" that is seen on SSPF cardiac cine MR images to be caused by spin moving within an inhomogeneous magnetic field[(3)]. Although reshimming gradients or readjusting the center frequency is an effective way to eliminate the dark artifact, increased susceptibility effect in higher magnetic field makes difficult to tune these gradients and frequency. We hypothesize that data acquisition in slow or static spin reduce the artifact. In this study we propose a novel triggering procedure to enable consistent respiratory end-exhalation location and cardiac diastole timing in data acquisition despite the use of a long inversion time (TI) over 1 second.

## ***Materials and Methods***

Triple trigger procedure is composed of two respiratory triggers and one cardiac trigger. The peak of inhalation is set to the first respiratory trigger point where a selective inversion pulse is applied to suppress static tissues. The inversion pulse with slab thickness 40 cm in axial plane was applied including descending aorta and renal arteries. The second respiratory trigger switches to cardiac trigger at the point of the end- exhalation. The cardiac trigger synchronizes bSSFP sequence to cardiac cycle at diastole. Finally the MR data at the end-expiration of breathing and the diastole of cardiac cycle is acquired with a variable inversion time (VIT) of the selective IR pulse. For fat suppression, spectral Inversion pulse (SPIR) or short tau inversion pulse (STIR) was used. The 3D SSFP imaging parameters were FOV 36cm, slice thickness 2mm, Matrix size 256 x 256 x40. This was compared to a conventional respiratory triggered alone sequence (ConvRT) with constant TI. Firstly the apparent TI of the VIT was investigated as compared to the constant TI changing from 1000ms to 1800ms at 1.5T. Secondly the comparison was performed with the apparent TI at 3.0T. The study was approved by the institutional review board. Five healthy subjects on HDxt 1.5T(GE Healthcare, WI) and two healthy subjects on MR750 3.0T(GE Healthcare, WI) were scanned using a 8-channel body coil and a 32-channel body coil, respectively.

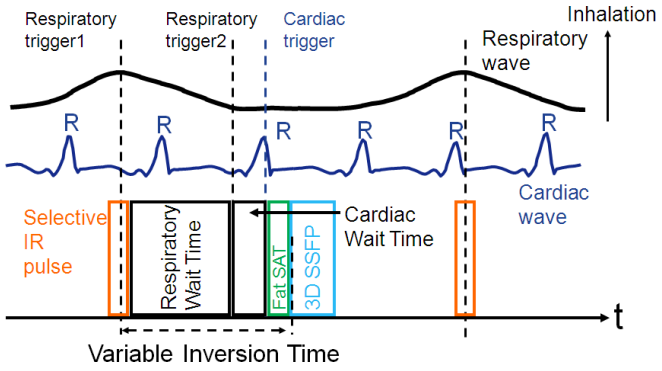


Figure.1: Triple triggering principal using variable inversion time.

## ***Results***

The inflow effect of the VIT was slightly higher than that of the 1800ms of constant TI in 4 out of the 5 volunteers. The image quality for uniform blood signal was better than ConvRT. There was no dark flow artifact on all the study at 1.5T. But the low and dark flow artifact was seen in all subjects at 3.0T. Figure 2 shows the inflow effect of the VIT and coronal MIP. The VIT provides uniform and higher blood signal with strong inflow effect. Figure 3 shows the comparison result at 3.0T. The flow void and low signal was seen at the descending aorta.

## ***Discussions***

The proposed triple triggering method successfully eliminated dark flow artifact by avoiding systolic data acquisition with cardiac triggering as it provides inflow effect with the apparent TI of 1800 ms. Compared to conventional respiratory trigger the advantage of the proposed approach is robust, uniform and high arterial blood visualization.

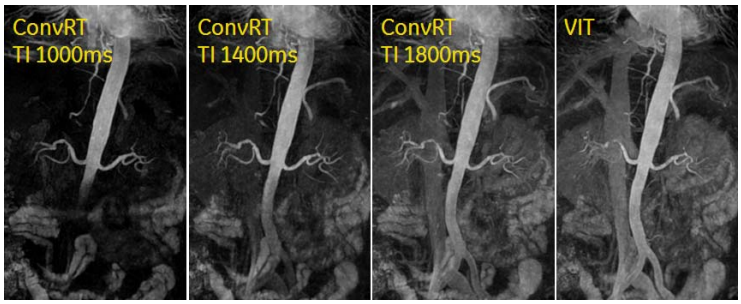


Figure.2 shows the inflow effect of triple trigger method as compared with conventional respiratory-triggered method with constant TI ranging from 1000ms to 1800ms. Note that there is no dark flow artifact at 1.5T with respiratory trigger alone. The same window range and level is used on coronal MIP images.

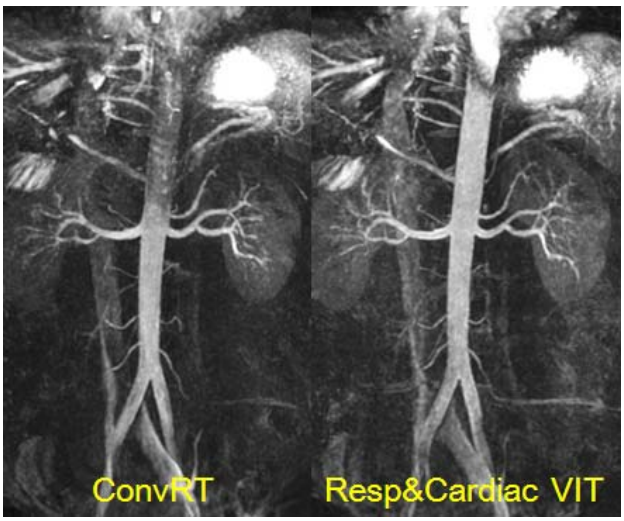


Figure.3 The comparison result with respiratory trigger with conventional constant inversion time and proposed VIT

[1] Katoh M, et al., Kidney International 2004, 66: 1272-1278. [2] Glockner et al, JMRI, 31:1411–1418 (2010). [3] Wei, Li et al, Radiology, 2004, 230: 569-575